

# バイオマス持続可能性の基礎



Göran Berndes, IEA Bioenergy & Chalmers University, Sweden

*Renewable Energy Institute event, 18 January 2024*

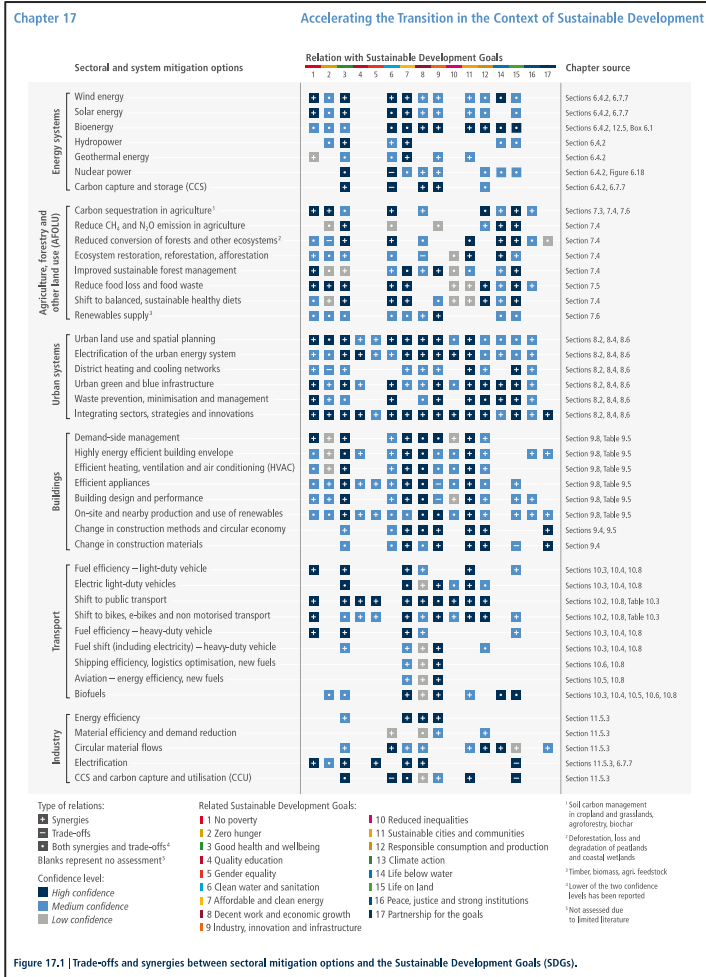
*Biomass for Net Zero - Deployment in Japan in Light of Latest Global Discussions*



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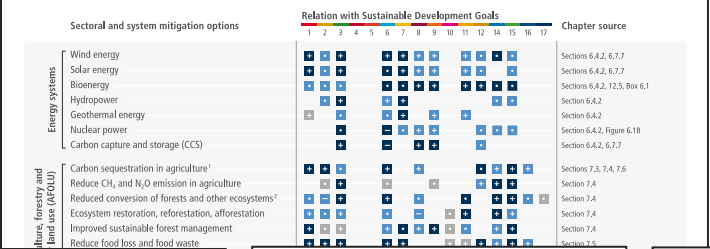
- バイオエネルギーは全てのセクターで有効
- バイオエネルギーとSDGの多様な繋がり
- 相乗効果とトレードオフ
- ガバナンスが重要



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## Chapter 17 Accelerating the Transition in the Context of Sustainable Development



Approaches to sustainability compliance and verification for forest biomass

Project report

IEA Bioenergy, Task 45  
January 2023

Technology Collaboration Programme

Article

Contribution of Biomass Supply Chains for Bioenergy to Sustainable Development Goals

M. Jean Blaz, Blora Gagnon, Andrew Khan and Bjørna Kullid

Special Issue  
Renewable Energy

Edited by  
Dr. Rüdiger van der Helm, Dr. Annette Cowie and Prof. Dr. Daniela Thies

Technology Collaboration Programme

How can biomass supply for bioenergy deliver multiple benefits and contribute to sustainable development goals?

Report from Joint IEA Bioenergy and GBEP Workshop  
held online on 15-16 June 2021

IEA Bioenergy  
February 2022

Technology Collaboration Programme

Renewable and Sustainable Energy Reviews 146 (2022) 103498

Renewable and Sustainable Energy Reviews

Land use for bioenergy: Synergies and trade-offs between sustainable development goals

Iran Vero<sup>a,\*</sup>, Hika Wicko<sup>b</sup>, Patrick Lamers<sup>c</sup>, Annette Cowie<sup>d</sup>, Anna Reço<sup>e</sup>, Ben Heukels<sup>f</sup>, Carlos Zamal<sup>g</sup>, David Mayer<sup>h</sup>, Esther Ramen<sup>i</sup>, Françoise Chazotte<sup>j</sup>, Ghislain Bernier<sup>k</sup>, Hennerle Jäger<sup>l</sup>, Luis Sebeiros<sup>m</sup>, Martin Junginger<sup>n</sup>, Miguel Brandão<sup>o</sup>, Nidra Scott Bosteen<sup>p</sup>, Vanessa Domingos<sup>q</sup>, Zoe Harris<sup>r</sup>, Flor van der Wal<sup>s</sup>

Abstract

Bioenergy offers a viable greenhouse gas (GHG) reduction and sustainable energy supply alternative to fossil fuels. However, agricultural land conversion to bioenergy production might impact on other Sustainable Development Goals (SDGs) and other stakeholders' interests. Identifying and quantifying synergies and trade-offs between SDGs and other stakeholders' interests is essential to ensure that bioenergy production contributes to sustainable development. This article reviews the synergies and trade-offs between bioenergy production and other SDGs and stakeholders' interests. The article identifies synergies and trade-offs between bioenergy production and other SDGs and stakeholders' interests. The article identifies synergies and trade-offs between bioenergy production and other SDGs and stakeholders' interests.

Keywords: Bioenergy, Land use, Sustainable development, Synergies, Trade-offs, Stakeholders' interests

Technology Collaboration Programme

Sustainability governance of bioenergy and the broader bioeconomy

Technical Paper prepared for IEA Bioenergy Task 45 and the Global Bioenergy Partnership (GBEP) Task Force on Sustainability

Final draft

prepared by

Leite Horta, Uwe R. Fritsche & Joha van Dam

IINAS - International Institute for Sustainable Energy and Strategy

Prepared with funding from the German Ministry for Food and Agriculture (BMEL) and IEA Bioenergy Task 45

Potsdam, Darmstadt & Utrecht, August 2023



Figure 17.1 | Trade-offs and synergies between sectoral mitigation options and the Sustainable Development Goals (SDGs).

# 本日は...

バイオマス, 炭素サイクル, 気候

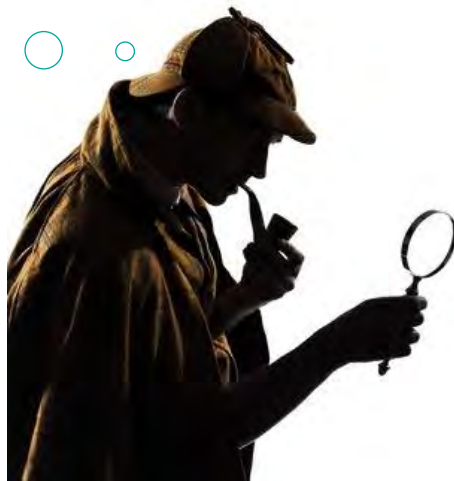


有益な土地利用変化



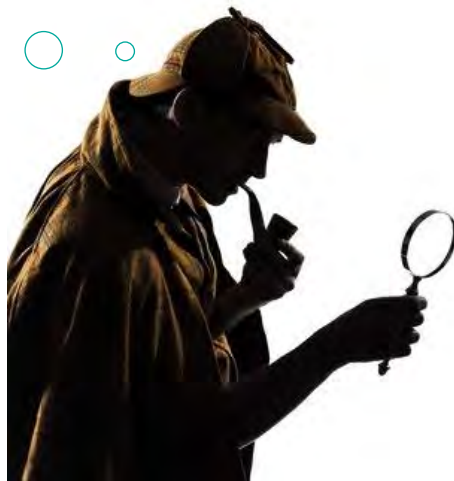
# バイオマス、炭素サイクル、気候

~~世界を温暖化させるCO<sub>2</sub>排出について、両方の車からの違いはない...~~



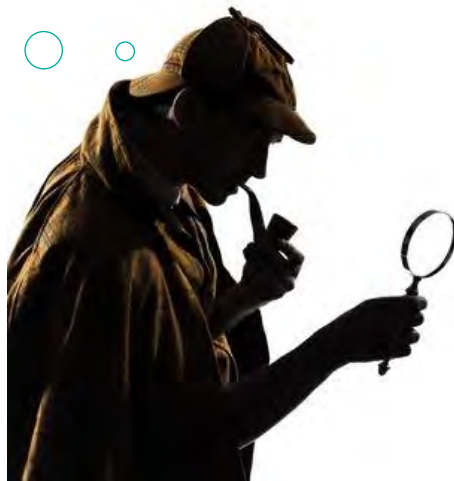
# バイオマス、炭素サイクル、気候

~~バイオ燃料を利用するときの  
サプライチェーン排出以外に  
排出されたCO<sub>2</sub>は、大気から  
除去されるため、バイオ燃料  
の使用は気候変動に影響しない...~~



# バイオマス、炭素サイクル、気候

~~バイオ燃料の使用は、炭素の  
機会費用のため、大量のCO<sub>2</sub>  
排出を引き起こす...~~



# 図解

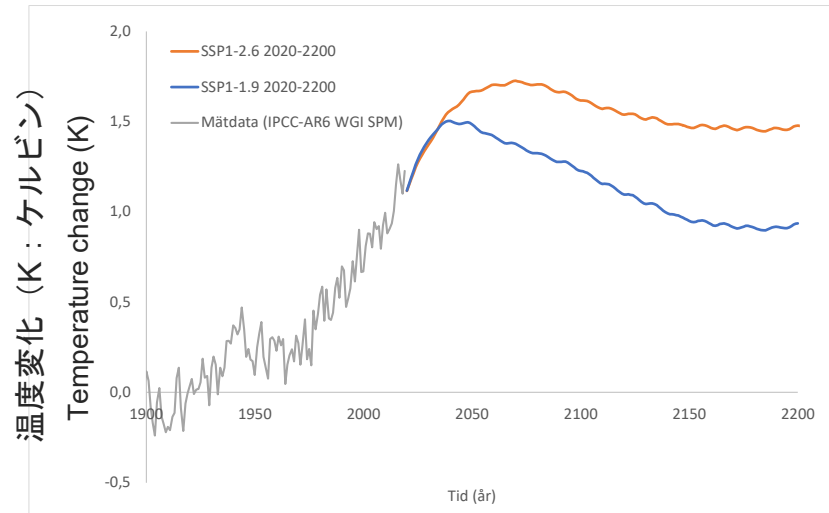
以降のスライドは、化石燃料とバイオマス燃料の利用が、世界の平均気温にどのように影響するかを示す

燃料の中の化石/バイオマスの炭素に注目する



以下のグラフは、IPCCの第6次影響評価レポートに関連した気候モデルと研究に用いられたIPCCのSSP1-1.9とSSP1-2.6シナリオにおいて、世界の平均気温が時間とともにどのように変化するかを示す。

これらのIPCCシナリオは、化石燃料とバイオエネルギー利用による気温への影響を図解するために用いられる。

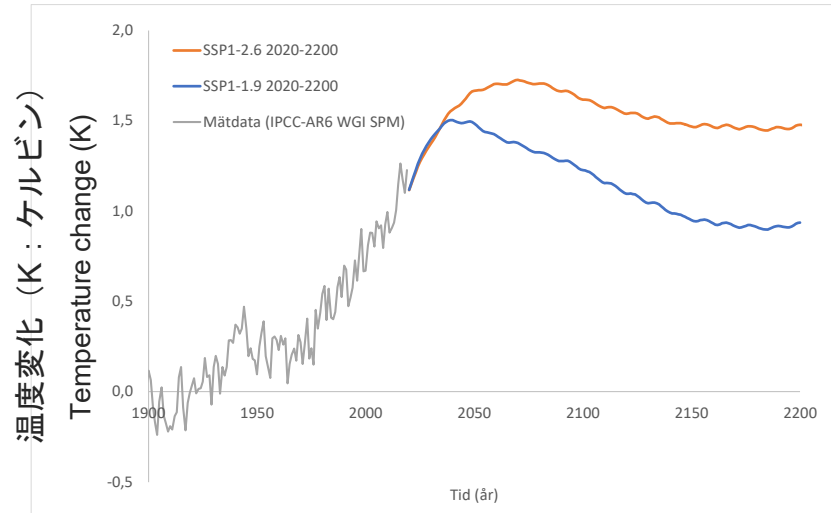




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問い:

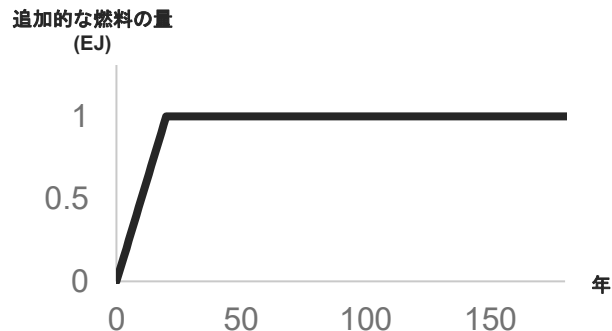
より多くの燃料が使用されたとき、世界の平均気温は、図に示された展開から、どのように変化していくだろうか？



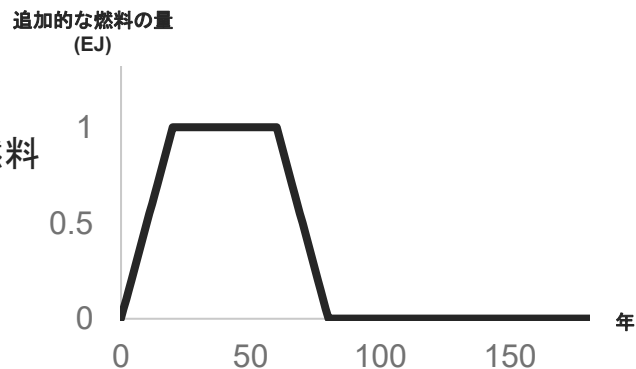
## 二種類のシナリオ, 下記のとおり

より多くの燃料は石炭、天然ガス、もしくは（主として）製材とパルプ材の生産のための管理された森林から得られるバイオマス由来の燃料とする。

「永遠に」より多くの燃料



「しばらくの間」より多くの燃料





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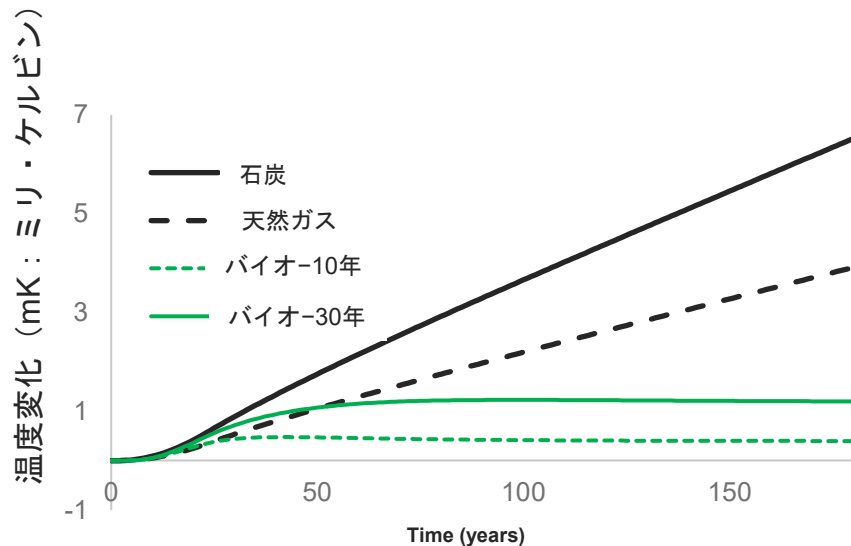
バイオマス由来の燃料の生産は、下記のバイオマスから行われる:

- エネルギー利用がなければ、森林内で10年と30年以内で分解される森林残渣
- 社会の中で10年もしくは30年の残存期間を持つ他の製品を生産するために使用されるであろう木材

エネルギー利用される森林バイオマスの増加を除いては、森林セクターの変化なし



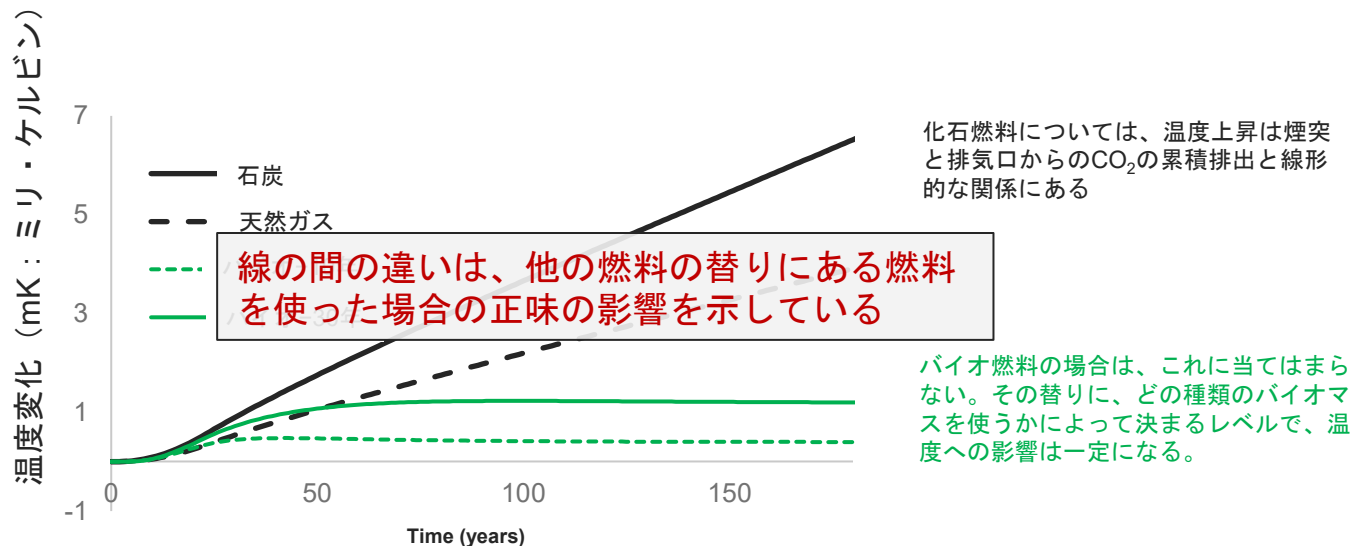
# 燃料を「永遠に」使う場合の気温への影響



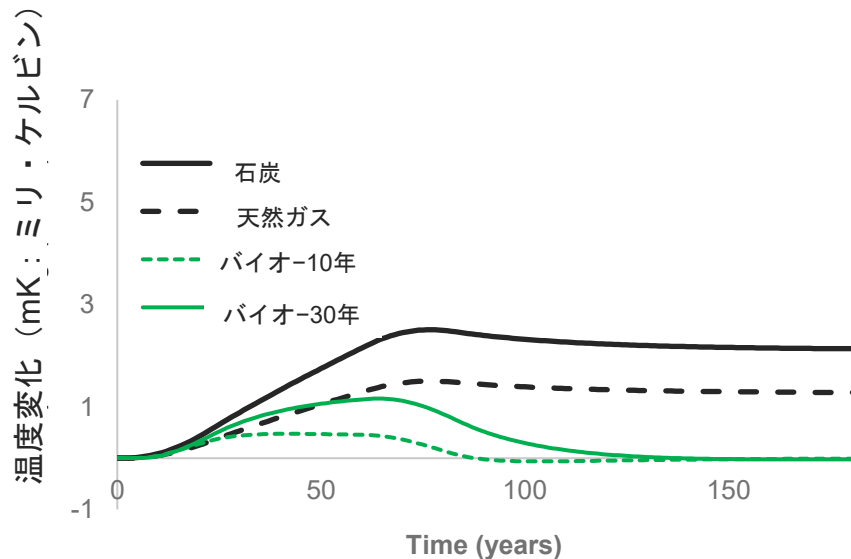
化石燃料については、温度上昇は煙突と排気口からのCO<sub>2</sub>の累積排出と線形的な関係にある

バイオ燃料の場合は、これに当てはまらない。その替りに、どの種類のバイオマスを使うかによって決まるレベルで、温度への影響は一定になる。

# 燃料を「永遠に」使う場合の気温への影響



# 燃料を「しばらくの間」使う場合の気温への影響

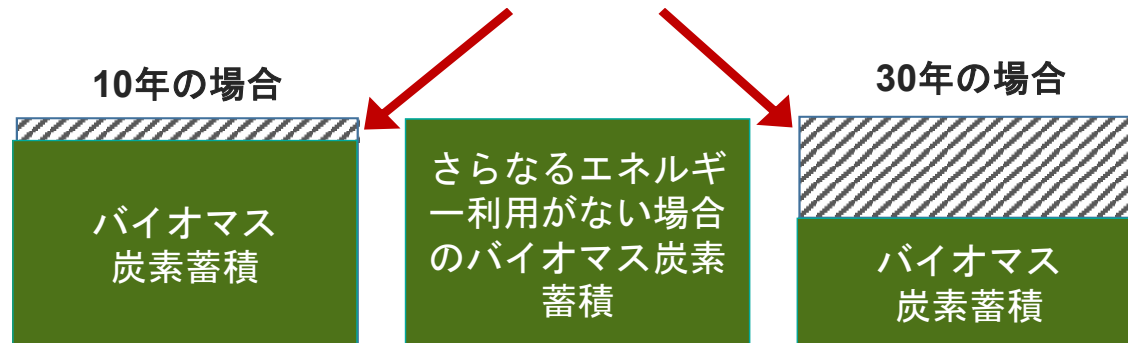


化石燃料利用にともなう温度への影響は、燃料利用が停止した後も長期間継続する

バイオマス燃料の場合は、燃料利用が終わった後、温度影響はゼロに向かって減少する

気温への影響は、土壌と植生、バイオマス由来の製品中の炭素蓄積量の変化で決定されるが、どのバイオマスが燃料生産に使われるかに依存する

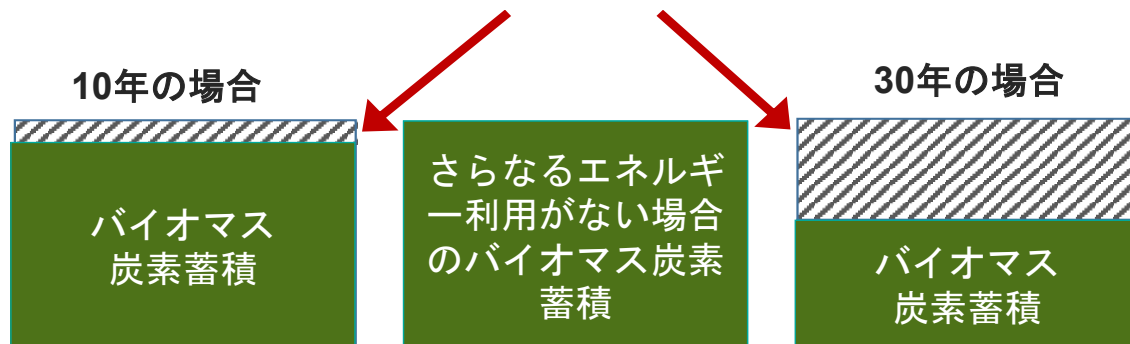
網掛け = 大気中にCO<sub>2</sub>として  
放出されるバイオマス炭素





森林セクターには、エネルギー利用される森林バイオマスの増加を除いては、その他の変化がないと想定

網掛け = 大気中にCO<sub>2</sub>として  
放出されるバイオマス炭素



森林セクターには、エネルギー利用される森林バイオマスの増加を除いては、その他の変化がないと想定

しかし、森林セクターは他の方法でも変化するかもしれない



## バイオマス, 炭素サイクル, 気候



- バイオエネルギーのサプライチェーン排出は大幅に削減できるが、**生物起源炭素のバランスは気候便益の重要な決定要素であり続ける**
- 植生、土壌、バイオマス由来製品中の炭素蓄積は、土地セクターがより多くのバイオマスをエネルギーのために供給するとき、増加することも減少することもありえる
- バイオマス、炭素サイクル、気候を巡る混乱：**要点を説明し、誤解を解くことが大切**

# 時間があれば...

バイオマス, 炭素サイクル, 気候



有益な土地利用変化



# 有益な土地利用変化

Global Environmental Change

**Beneficial land use change: Strategic expansion of semi-natural plantations can reduce environmental impacts from EU agriculture**

Other Egholm<sup>1,2</sup>, Pål Björnsjö<sup>3</sup>, Göran Brodeur<sup>4</sup>, Nicolle Scarlat<sup>5</sup>, José-Francisco Infante<sup>6</sup>, Brian Glaser<sup>7</sup>, Anders Odenberger<sup>8</sup>, Elin Malm-Lager<sup>9</sup>, Fernando J. Díaz<sup>10</sup>

**Abstract**

While there are limited options for increasing biomass production to meet the future demands for food, livestock and bioenergy, other alternatives for expansion of crop and forage production are the diversification of agricultural systems and the expansion of semi-natural plantations. Strategic expansion of semi-natural plantations can reduce environmental impacts from EU agriculture by reducing greenhouse gas emissions, increasing carbon sequestration, and reducing water and nutrient losses. Strategic expansion of semi-natural plantations can also reduce environmental impacts from EU agriculture by reducing greenhouse gas emissions, increasing carbon sequestration, and reducing water and nutrient losses.

**Large-scale deployment of grass in crop rotations as a multifunctional climate mitigation strategy**

Other Egholm<sup>1,2</sup>, Elin Malm-Lager<sup>3,4</sup>, Pål Björnsjö<sup>5</sup>, Christel Cederberg<sup>6</sup>, J. Gunnar Berntsson<sup>7</sup>

**Abstract**

The agricultural sector can contribute to climate change mitigation by reducing its greenhouse gas (GHG) emissions, improving carbon sequestration in agricultural soils, and providing biomass to substitute for fossil fuels and other GHG-intensive products. The current study aims to address water, soil, and biodiversity topics in addition to GHG emissions and carbon sequestration. Strategic EU policies create incentives for cultivation of permanent grasses that provide biomass along with environmental benefits. On- and off-farm options to sustain Europe's GHG emissions and carbon sequestration are evaluated. Strategic expansion of semi-natural plantations can reduce environmental impacts from EU agriculture by reducing greenhouse gas emissions, increasing carbon sequestration, and reducing water and nutrient losses.

**communications earth & environment**

**Strategic deployment of riparian buffers and windbreaks in Europe can co-deliver biomass and environmental benefits**

Other Egholm<sup>1,2</sup>, Pål Björnsjö<sup>3</sup>, Elin Malm-Lager<sup>4</sup>, Göran Brodeur<sup>5</sup>, Nicolle Scarlat<sup>6</sup>, Christel Cederberg<sup>7</sup>, Elin Malm-Lager<sup>8</sup>

**Abstract**

With the onset of the new Common Agricultural Policy of the European Union, a culture of multifunctional biomass production is advocated for farmers to deploy practices that are beneficial to climate, water, soil, and biodiversity. Such practices include windbreaks and riparian buffers. Strategic EU policies create incentives for cultivation of permanent grasses that provide biomass along with environmental benefits. On- and off-farm options to sustain Europe's GHG emissions and carbon sequestration are evaluated. Strategic expansion of semi-natural plantations can reduce environmental impacts from EU agriculture by reducing greenhouse gas emissions, increasing carbon sequestration, and reducing water and nutrient losses.

**Land conversion from annual to perennial crops: A win-win strategy for biomass yield and soil organic carbon and total nitrogen sequestration**

Ji Chen<sup>1,2,3</sup>, Paul Erik Larue<sup>4,5</sup>, Ulte Jørgensen<sup>6,7</sup>

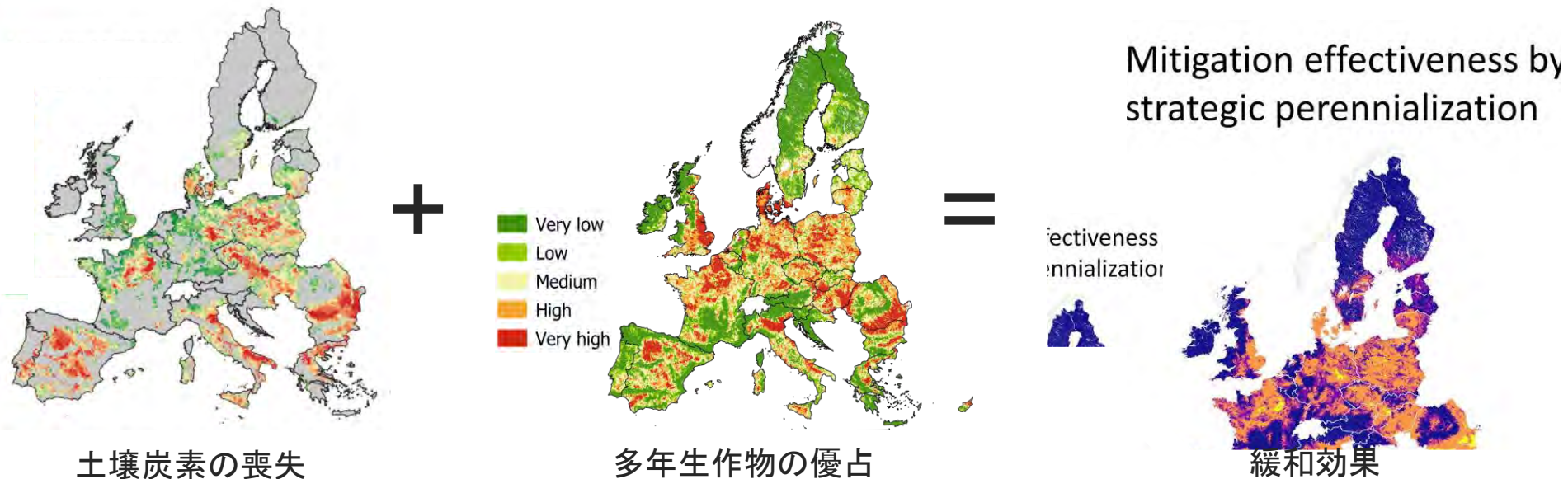
**Abstract**

Land conversion from annual to perennial crops is a win-win strategy for biomass yield and soil organic carbon and total nitrogen sequestration. This study shows that these crops can effectively reduce nitrogen emissions to water and soil, and they can also contribute to soil carbon sequestration. Strategic EU policies create incentives for cultivation of permanent grasses that provide biomass along with environmental benefits. On- and off-farm options to sustain Europe's GHG emissions and carbon sequestration are evaluated. Strategic expansion of semi-natural plantations can reduce environmental impacts from EU agriculture by reducing greenhouse gas emissions, increasing carbon sequestration, and reducing water and nutrient losses.

**Towards multifunctional landscapes coupling low carbon feed and bioenergy production with restorative agriculture: Economic deployment of grass-based bioenergies**

Julien Van Ieperen<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100,101,102,103,104,105,106,107,108,109,110,111,112,113,114,115,116,117,118,119,120,121,122,123,124,125,126,127,128,129,130,131,132,133,134,135,136,137,138,139,140,141,142,143,144,145,146,147,148,149,150,151,152,153,154,155,156,157,158,159,160,161,162,163,164,165,166,167,168,169,170,171,172,173,174,175,176,177,178,179,180,181,182,183,184,185,186,187,188,189,190,191,192,193,194,195,196,197,198,199,200,201,202,203,204,205,206,207,208,209,210,211,212,213,214,215,216,217,218,219,220,221,222,223,224,225,226,227,228,229,230,231,232,233,234,235,236,237,238,239,240,241,242,243,244,245,246,247,248,249,250,251,252,253,254,255,256,257,258,259,260,261,262,263,264,265,266,267,268,269,270,271,272,273,274,275,276,277,278,279,280,281,282,283,284,285,286,287,288,289,290,291,292,293,294,295,296,297,298,299,300,301,302,303,304,305,306,307,308,309,310,311,312,313,314,315,316,317,318,319,320,321,322,323,324,325,326,327,328,329,330,331,332,333,334,335,336,337,338,339,340,341,342,343,344,345,346,347,348,349,350,351,352,353,354,355,356,357,358,359,360,361,362,363,364,365,366,367,368,369,370,371,372,373,374,375,376,377,378,379,380,381,382,383,384,385,386,387,388,389,390,391,392,393,394,395,396,397,398,399,400,401,402,403,404,405,406,407,408,409,410,411,412,413,414,415,416,417,418,419,420,421,422,423,424,425,426,427,428,429,430,431,432,433,434,435,436,437,438,439,440,441,442,443,444,445,446,447,448,449,450,451,452,453,454,455,456,457,458,459,460,461,462,463,464,465,466,467,468,469,470,471,472,473,474,475,476,477,478,479,480,481,482,483,484,485,486,487,488,489,490,491,492,493,494,495,496,497,498,499,500,501,502,503,504,505,506,507,508,509,510,511,512,513,514,515,516,517,518,519,520,521,522,523,524,525,526,527,528,529,530,531,532,533,534,535,536,537,538,539,540,541,542,543,544,545,546,547,548,549,550,551,552,553,554,555,556,557,558,559,560,561,562,563,564,565,566,567,568,569,570,571,572,573,574,575,576,577,578,579,580,581,582,583,584,585,586,587,588,589,590,591,592,593,594,595,596,597,598,599,600,601,602,603,604,605,606,607,608,609,610,611,612,613,614,615,616,617,618,619,620,621,622,623,624,625,626,627,628,629,630,631,632,633,634,635,636,637,638,639,640,641,642,643,644,645,646,647,648,649,650,651,652,653,654,655,656,657,658,659,660,661,662,663,664,665,666,667,668,669,670,671,672,673,674,675,676,677,678,679,680,681,682,683,684,685,686,687,688,689,690,691,692,693,694,695,696,697,698,699,700,701,702,703,704,705,706,707,708,709,710,711,712,713,714,715,716,717,718,719,720,721,722,723,724,725,726,727,728,729,730,731,732,733,734,735,736,737,738,739,740,741,742,743,744,745,746,747,748,749,750,751,752,753,754,755,756,757,758,759,760,761,762,763,764,765,766,767,768,769,770,771,772,773,774,775,776,777,778,779,780,781,782,783,784,785,786,787,788,789,790,791,792,793,794,795,796,797,798,799,800,801,802,803,804,805,806,807,808,809,810,811,812,813,814,815,816,817,818,819,820,821,822,823,824,825,826,827,828,829,830,831,832,833,834,835,836,837,838,839,840,841,842,843,844,845,846,847,848,849,850,851,852,853,854,855,856,857,858,859,860,861,862,863,864,865,866,867,868,869,870,871,872,873,874,875,876,877,878,879,880,881,882,883,884,885,886,887,888,889,890,891,892,893,894,895,896,897,898,899,900,901,902,903,904,905,906,907,908,909,910,911,912,913,914,915,916,917,918,919,920,921,922,923,924,925,926,927,928,929,930,931,932,933,934,935,936,937,938,939,940,941,942,943,944,945,946,947,948,949,950,951,952,953,954,955,956,957,958,959,960,961,962,963,964,965,966,967,968,969,970,971,972,973,974,975,976,977,978,979,980,981,982,983,984,985,986,987,988,989,990,991,992,993,994,995,996,997,998,999,1000</sup>

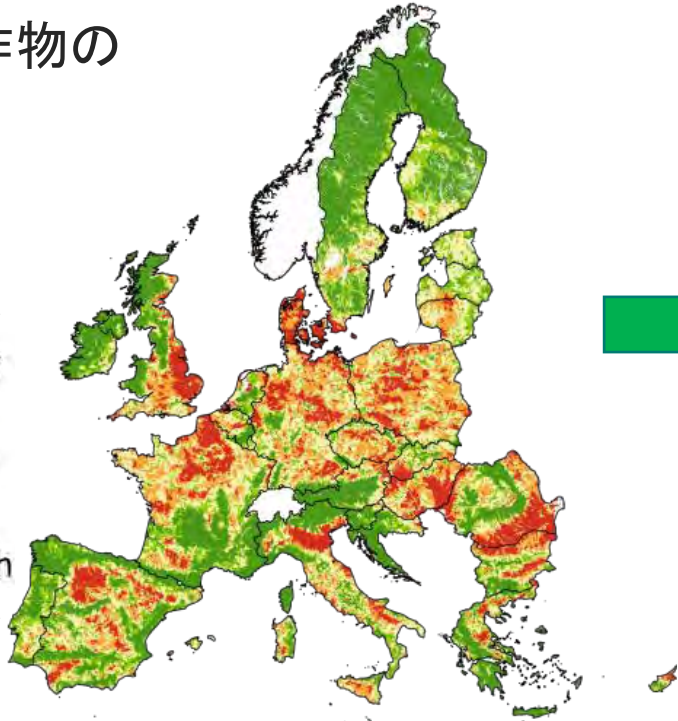
# 多年生作物の戦略的な統合



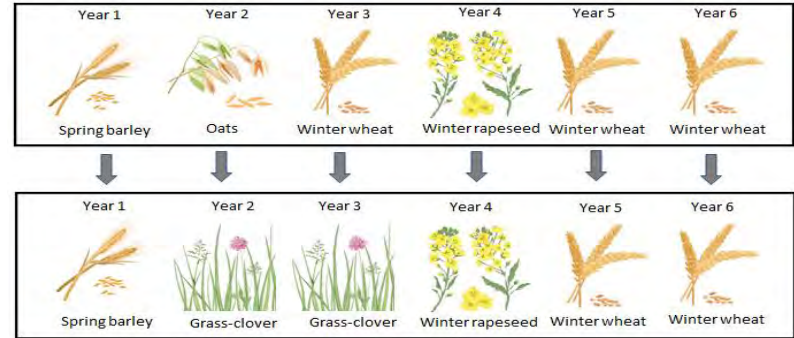
# 多年生作物の戦略的な統合

多年生作物の  
優占

非常に低い  
Very low  
Low  
Medium  
High  
Very high  
非常に高い



調整された作物の輪作



# 多年生作物の戦略的な統合

多年生作物の  
優占

非常に低い  
Very low  
Low  
Medium  
High  
非常に高い  
Very high



調整された作物の輪作

- より多くの土壌炭素と改善された土壌肥沃度
- よりよい雑草と病気の管理
- より高く安定した収量（干ばつの影響は低く）
- ほ場および景観レベルの両方での生物多様性の改善

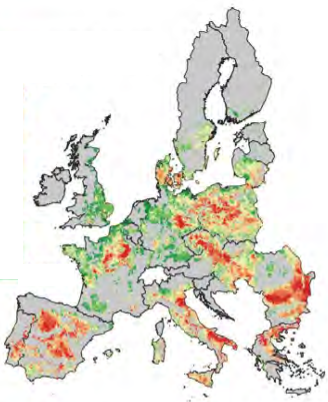




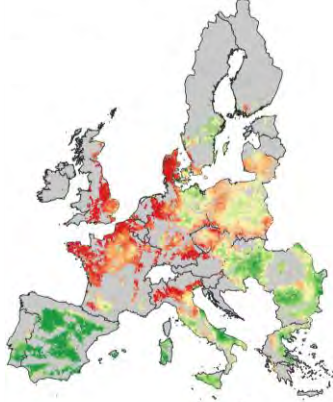
# 多年生作物の戦略的な統合

最も高い影響

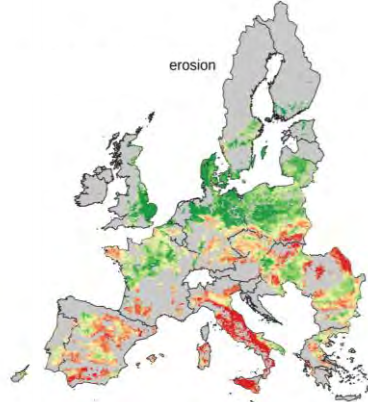
最も低い影響



土壤炭素喪失



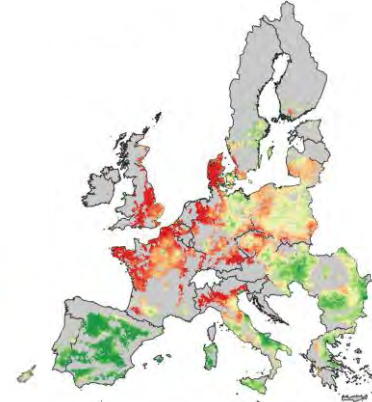
水系への窒素流亡



繰り返される洪水



水による侵食



風による侵食

# バイオマス持続可能性の基礎

Thank you for listening!

Göran Berndes, IEA Bioenergy & Chalmers University, Sweden

*Renewable Energy Institute event, 18 January 2024*

*Biomass for Net Zero - Deployment in Japan in Light of Latest Global Discussions*