The 4p1000 initiative: a tropical agroecological point of view

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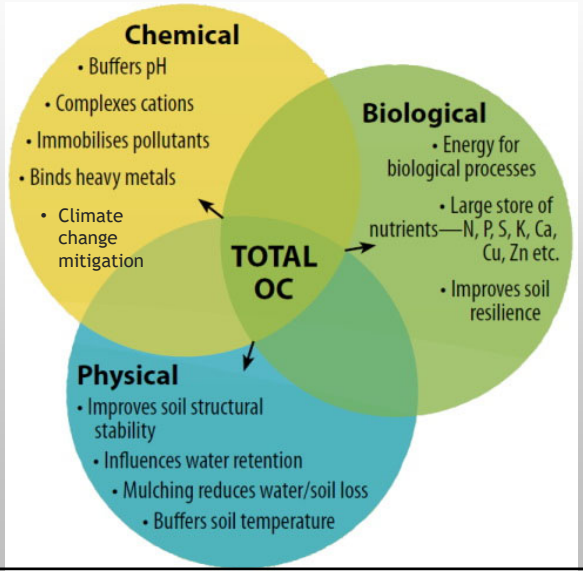
Synopsis

1. Limits for C as a soil quality indicator
2. Flaws in the 4p1000 hypotheses
3. The ethical problems with the AFOLU negative emissions approaches

1.
Limits to C as a soil quality indicator

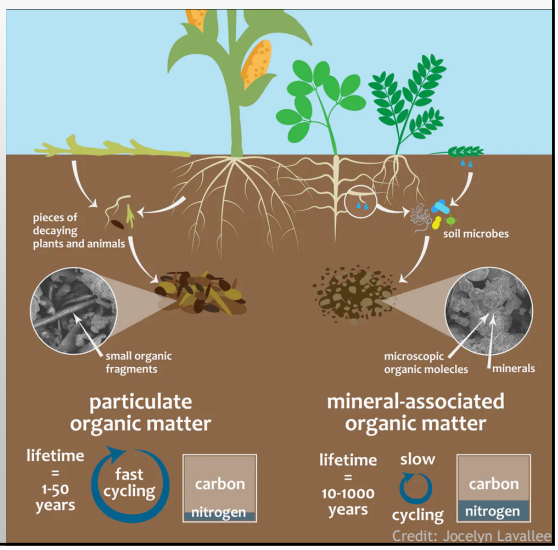
SOC: a driver of some soil properties



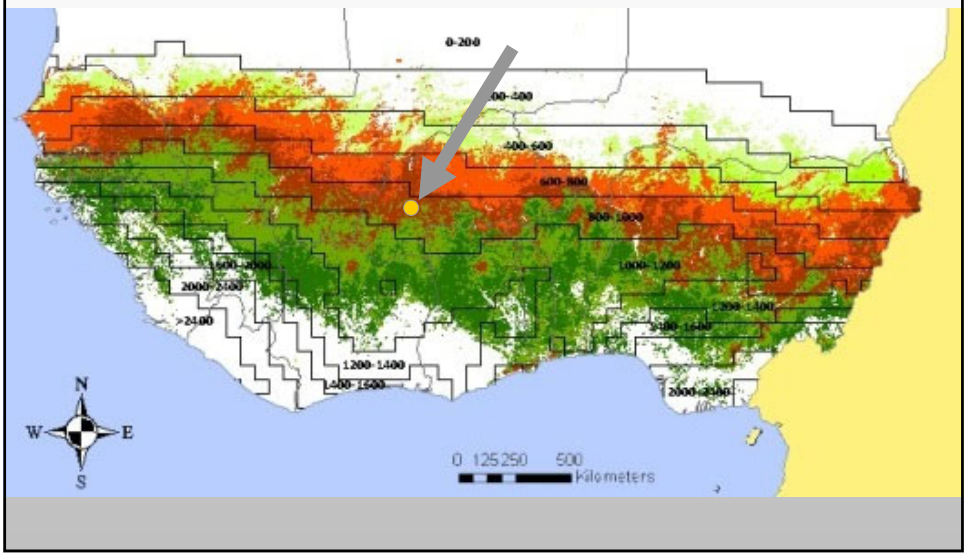
Adapted from soilquality.org.au

Partly tautological thinking

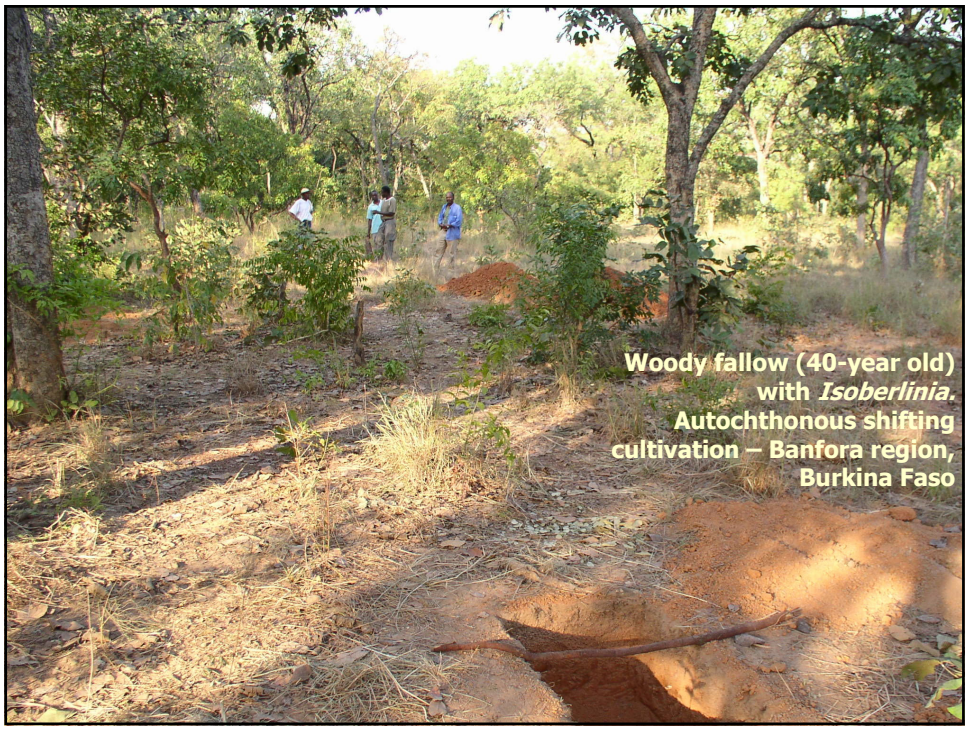
- Fertile: “able to support the growth of a large number of strong healthy plants” (collinsdictionary.com)
- SOC = by-product of plant activity ➔ SOC as a soil fertility indicator is ‘self referencing’ (Crétenet, 1996)



Case study 1: Banfora region, Burkina-Faso

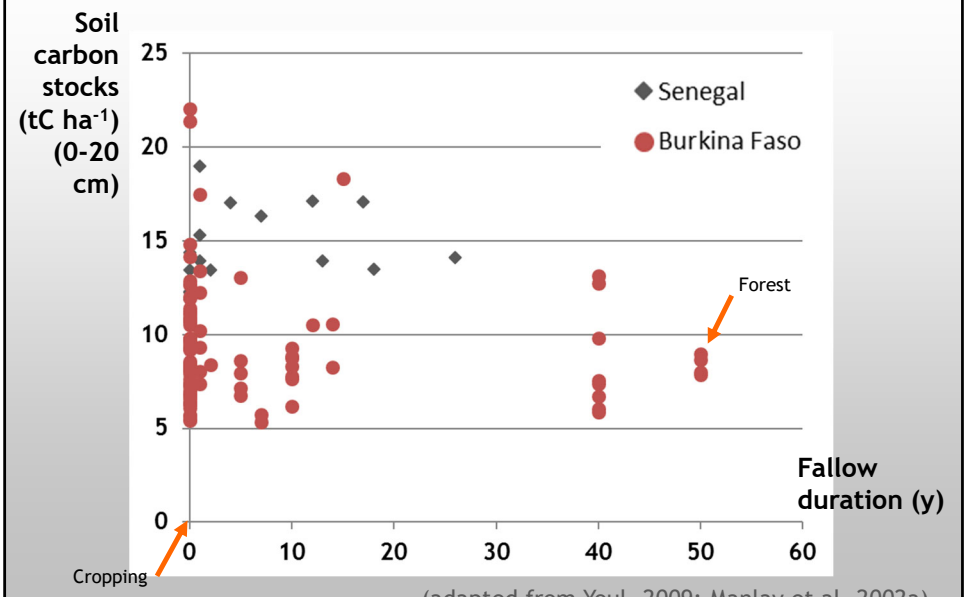


Yam (*Dioscorea*) field (1-year old).
Autochthonous shifting cultivation – Banfora region, Burkina Faso



Woody fallow (40-year old) with *Isoberlinia*.
Autochthonous shifting cultivation – Banfora region, Burkina Faso

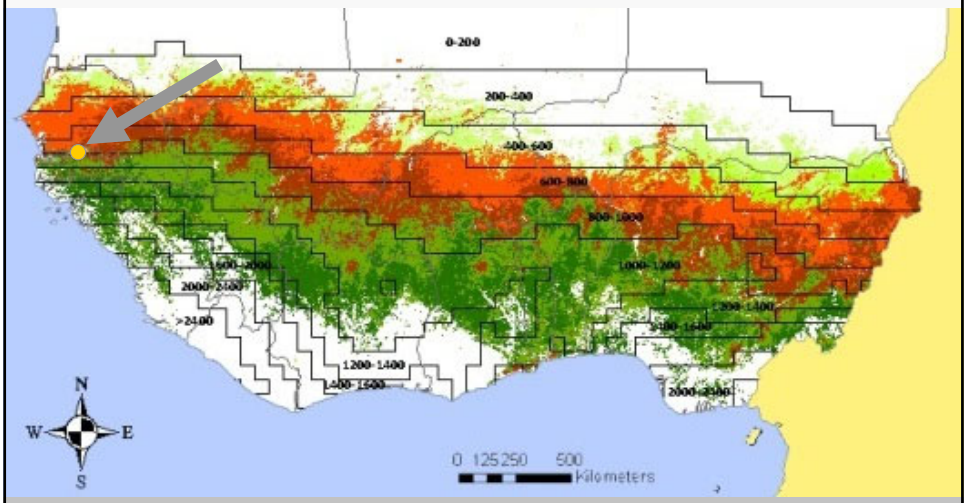
Soil carbon stocks under fallow



(adapted from Youl, 2009; Manlay et al. 2002a)

Branch fragmentation by termites Ouahigouya, Burkina Faso

Case study 2:
High Casamance, Senegal

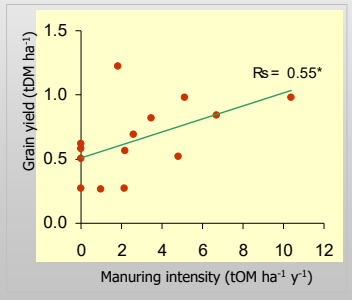


Compound fields (manured). Millet harvest.
Upper Casamance, Senegal

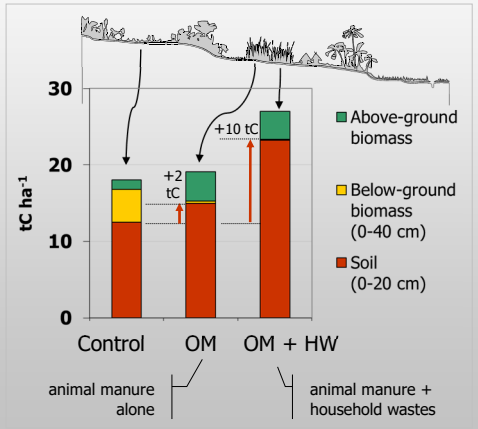
Compound fields. Drift pasture on crop residues.
Upper Casamance, Senegal

Compound fields. Crop residues left after drift pasture.
Upper Casamance, Senegal

- Manuring: a nutrient management strategy
  - Distinct effects on plant and soil



Manuring and millet performance

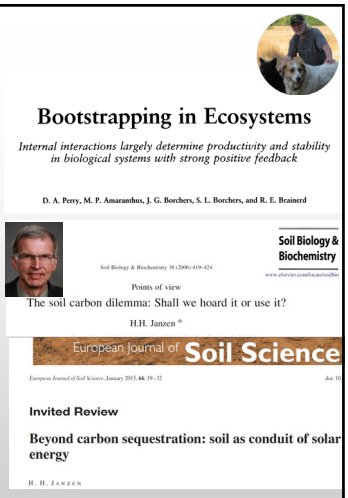


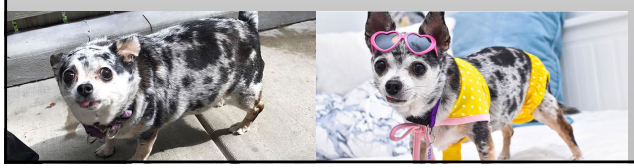
Manuring and soil organic status

(Manlay et al. 2002b)

Trade-offs between C flows and C stocks

- Nutrient availability for the plant (Janzen, 2006)
- Energy supply to soil biota (Perry et al., 1989; Janzen, 2015)
- Thermodynamic aspects: "biosystems which do not increase their total dissipation, are organisms dedicated to death" (Toussaint and Schneider, 1998)





The more the better?
Credit: Instagram/lusealdog

2. Flaws in the 4p1000 concept

"Anyone criticizing the promotion of increasing soil C stocks must be a 'Khmer vert'"

An agronomist at a CSFD meeting in Montpellier in 2017

Credit: David A. Feingold and Shari Robertson

A fuzzy concept

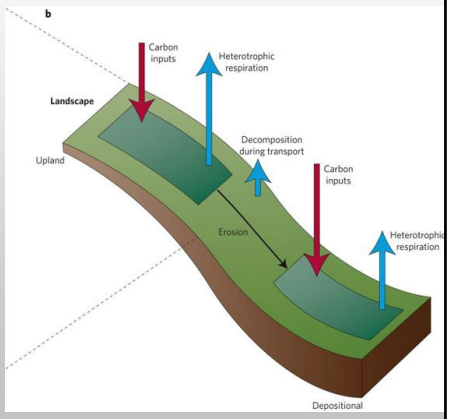
Source	Emissions to be compensated for					Soil boundaries		Soil stock (PgC)		Annual sequestration needed	
	GHG	Source	Nature (emissions/accretion)	Period	Annual flux (PgC y-1)	Land use	Depth (cm)	Value 1	Value 2	(% y-1)	(tC ha-1 y-1)
Balesdent and Arrouays (1999)	CO2	Fossil fuels	Emissions	?	?	?	?	1500		**0.4**	
→ http://4p1000.org	CO2	Anthropogenic all	Accretion	?	4.3	All	0-100	1500		**0.29**	
http://www6.inra.fr/4p1000science	CO2	Anthropogenic all	Accretion	?	4.3	All	0-40	860		**0.5**	
→ Ademe 2015	CO2	Fossil (fuels + cement)	Emissions	2013	9.5	All	0-100	1500	2400	**0.4-0.64**	
Minasny et al 2017	CO2	Fossil (fuels + cement)	Emissions	2004-2013	8.9	All	0-200	2400		**0.37**	0.6
Minasny et al 2017	CO2	Fossil (fuels + cement)	Emissions	2004-2013	8.9	Managed agricultural	0-100	480	790	**1.13-1.85**	
Lal 2016	retains	http://www6.inra.fr/4p1000science hypotheses									
http://agriculture.gouv.fr/agriculture-et-foret/environnement-et-climat			Accretion	?	?	All?	?	1500		**0.4**	

4p1000 initiative: offset CO_2 accretion from all sources

Ademe: offset CO_2 emissions from fossil sources only

4p1000 flaws: hypotheses

- No saturation + constant fixation: (hotly) debated
- Eroded C has no benefit for climate or food production: wrong
- No non-CO_2 GHG emissions: wrong



(Sanderman & Berhe, 2017)

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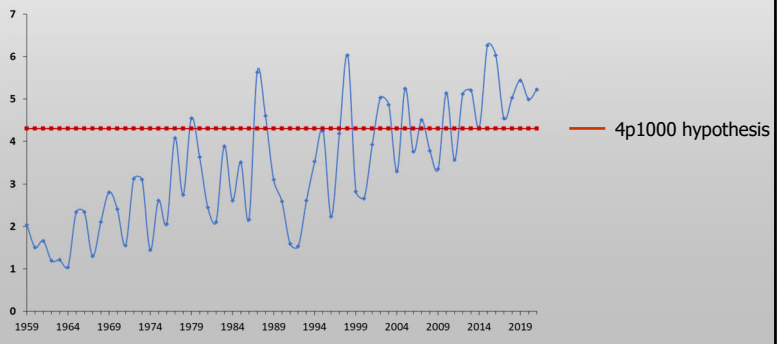
4p1000 flaws: hypotheses

- Mitigation target understated
  - Increase in CO_2 atmospheric content considered at 4p1000.org: 4.3 PgC y^{-1}

Atmospheric growth (in GtC y-1)*

www.globalcarbonbudget.org; Friedlingstein & al., 2022

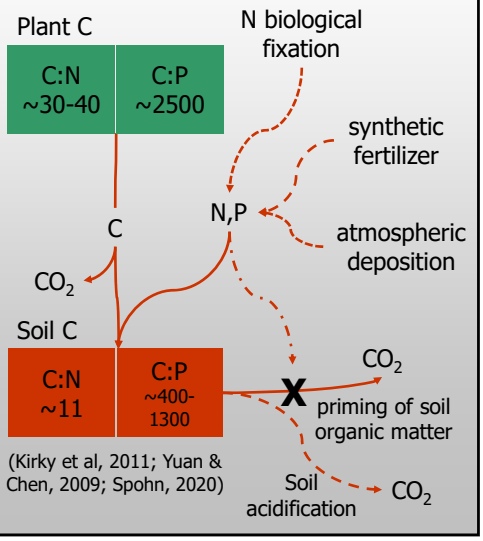


4p1000 flaws: hypotheses

- Pool boundaries
  - Soil depth considered = 1m: wrong
  - Manageable land = all: wrong

4p1000 flaw: no nutrient toll

- Stoichiometric constraints
  - Competition with other services: nutrient immobilization and the priming effect hazard (Janzen, 2006; van Groenigen et al., 2017; Spohn, 2020)
  - C footprint of fertilization



(Kirky et al, 2011; Yuan & Chen, 2009; Spohn, 2020)

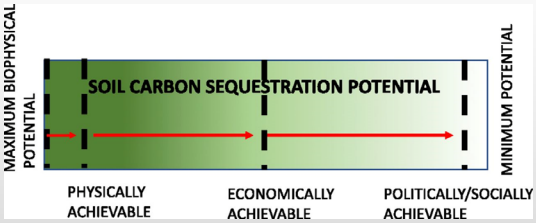
4/1000: a meaningless value

- Reassessing the 4/1000 initiative
  - 2015-2019 increase in atmospheric C stock: 5.5 Pg C (28% more than the 4/1000 hyp) (Friedlingstein & al., 2020)
  - only 26.2% of land can be managed (Latham et al., 2014)
  - 699 Pg C in the soil top 0-30cm
  - Consideration of stoichiometric constraints
  - 100% efficiency of N fertilizers

➔ **The 4/1000 becomes 50/1000**

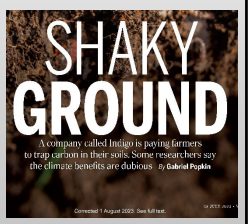
Overlooked human issues

(Amundson and Biardeau, 2018, Demenois et al., 2021)



- Monitoring (in a changing ➔ biosphere)
- Transaction costs
- Lack of technical assistance
- Conservatism

+ Tenure (in the Global South)



(Popkin, 2023)

3.
The ethical problems with the AFOLU negative emissions approaches

4 per 1000: rooted in the political agenda

Contribution de l'agriculture à la lutte contre le changement climatique : Stéphane LE FOLL annonce le lancement d'un projet de recherche international : le « 4 pour 1000 »

Paris
17/03/2015

J'aime 19 Tweeter 8+1 3

Stéphane LE FOLL, Ministre de l'agriculture, de l'agroalimentaire et de la forêt, Porte-parole du Gouvernement participait mardi 17 mars à la conférence scientifique internationale « Agriculture intelligente face au climat ».

Global Science Conference on Climate Smart Agriculture

2015 Montpellier

CLIMATE-SMART Agriculture 2015

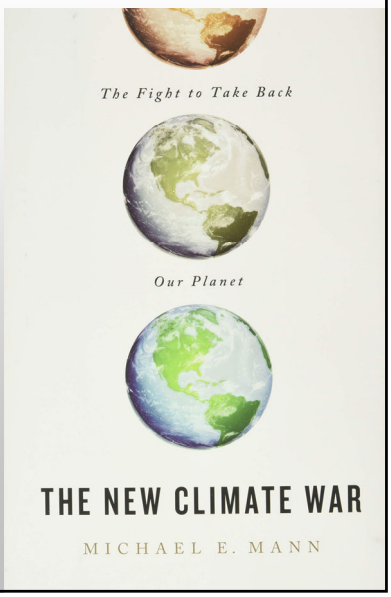
COP21 · CMP11
PARIS 2015
UN CLIMATE CHANGE CONFERENCE

In defence of the 4p1000, a senior soil scientist's post on the AFES forum, July 2022:
"*Science needs slogans and metaphors to make itself understood by politicians and the public*"

Greening the planet (including SOC sequestration), a non-solution solution?

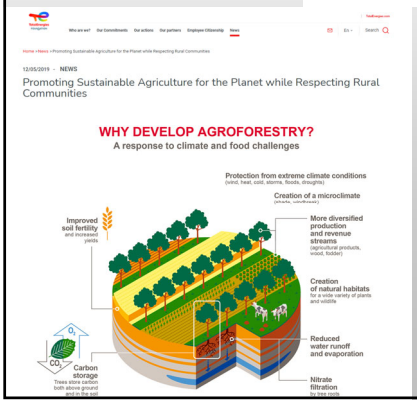
- Buying time and postponing effective and courageous policies (emissions reductions)
- Feeding greenwashing strategies ➔

(Mann, 2021)



Research's embarrassing sponsors

TotalEnergies FOUNDATION



DSCATT project - "Agricultural Intensification and Soil Carbon Sequestration in Tropical and Temperate Farming Systems" https://dscatt.net

Thank you!

« Voilà toute la beauté du « quatre pour mille » :
on ne sait trop si c'est ~~l'agriculture~~ le sol qui sauvera le climat, ou si c'est la cause climatique qui sauvera le sol ~~l'agriculture~~ »

(adapté de Foucard, 2015)

References

- Ademe, 2015. *Organic Carbon in Soils, Meeting Climate Change and Food Security Challenges. Angers, France, Agence de l'environnement et de la maîtrise de l'énergie (Ademe). 32 p.*
- Amundson R. & Biardeau L., 2018. Opinion: Soil carbon sequestration is an elusive climate mitigation tool. *Proceedings of the National Academy of Sciences*, 115 (46), 11652-11656.
- Balesdent J. & Arrouays D., 1999. Usage des terres et stockage de carbone dans les sols du territoire francais. Une estimation des flux nets annuels pour la periode 1900-1999. *Comptes Rendus - Académie D'Agriculture De France, 85 (6), 265-277.*
- Crétenet M., 1996. Expérimentation des systèmes de culture dans les pays tropicaux : cas des zones cotonnières d'Afrique Noire. *In*: A. Budelman (Ed.) *Agricultural R&D at the Crossroads. Merging Systems Research and Social Actor Approaches.* Royal Tropical Institute, Amsterdam, pp. 69-80.
- Demenois J., Dayet A. & Karsenty A., 2021. Surviving the jungle of soil organic carbon certification standards: an analytic and critical review. *Mitigation and Adaptation Strategies for Global Change*, 27 (1), 1.
- Foucart S., 2015. « Quatre pour mille » - le pari osé du ministre de l'agriculture. *Le Monde (Paris, France), 11/05/2015.*
- Friedlingstein P., O'Sullivan M., Jones M. W., Andrew R. M., Hauck J., Olsen A., Peters G. P., Peters W., Pongratz J., Sitch S., Le Quere C., Canadell J. G., Ciais P., Jackson R. B., Alin S., Aragao L., Arneth A., Arora V., Bates N. R., Becker M., Benoit-Cattin A., Bittig H. C., Bopp L., Bultan S., Chandra N., Chevallier F., Chini L. P., Evans W., Florentie L., Forster P. M., Gasser T., Gehlen M., Gilfillan D., Gkritzalis T., Gregor L., Gruber N., Harris I., Hartung K., Haverd V., Houghton R. A., Ilyina T., Jain A. K., Joetzjer E., Kadono K., Kato E., Kitidis V., Korsbakken J. I., Landschutzer P., Lefevre N., Lenton A., Lienert S., Liu Z., Lombardozzi D., Marland G., Metzl N., Munro D. R., Nabel J., Nakaoka S. I., Niwa Y., O'Brien K., Ono T., Palmer P. I., Pierrot D., Poulter B., Resplandy L., Robertson E., Rodenbeck C., Schwinger J., Seferian R., Skjelvan I., Smith A. J. P., Sutton A. J., Tanhua T., Tans P. P., Tian H., Tilbrook B., Van der Werf G., Vuichard N., Walker A. P., Wanninkhof R., Watson A. J., Willis D., Wiltshire A. J., Yuan W. P., Yue X. & Zaehle S., 2020. Global Carbon Budget 2020. *Earth System Science Data*, 12 (4), 3269-3340.

References

- Friedlingstein P., Jones M. W., O'Sullivan M., Andrew R. M., Bakker D. C. E., Hauck J., Le Quéré C., Peters G. P., Peters W., Pongratz J., Sitch S., Canadell J. G., Ciais P., Jackson R. B., Alin S. R., Anthoni P., Bates N. R., Becker M., Bellouin N., Bopp L., Chau T. T. T., Chevallier F., Chini L. P., Cronin M., Currie K. I., Decharme B., Djeutchouang L. M., Dou X., Evans W., Feely R. A., Feng L., Gasser T., Gilfillan D., Gkritzalis T., Grassi G., Gregor L., Gruber N., Gürses Ö., Harris I., Houghton R. A., Hurtt G. C., Iida Y., Ilyina T., Luijkx I. T., Jain A., Jones S. D., Kato E., Kennedy D., Klein Goldewijk K., Knauer J., Korsbakken J. I., Körtzinger A., Landschützer P., Lauvset S. K., Lefèvre N., Lienert S., Liu J., Marland G., McGuire P. C., Melton J. R., Munro D. R., Nabel J. E. M. S., Nakaoka S. I., Niwa Y., Ono T., Pierrot D., Poulter B., Rehder G., Resplandy L., Robertson E., Rödenbeck C., Rosan T. M., Schwinger J., Schwingshackl C., Séférian R., Sutton A. J., Sweeney C., Tanhua T., Tans P. P., Tian H., Tilbrook B., Tubiello F., van der Werf G. R., Vuichard N., Wada C., Wanninkhof R., Watson A. J., Willis D., Wiltshire A. J., Yuan W., Yue C., Yue X., Zaehle S. & Zeng J., 2022. Global Carbon Budget 2021. *Earth Syst. Sci. Data*, 14 (4), 1917-2005.
- Janzen H. H., 2006. The soil carbon dilemma: Shall we hoard it or use it? *Soil Biology & Biochemistry, 38 (3), 419-424.*
- Janzen H. H., 2015. Beyond carbon sequestration: soil as conduit of solar energy. *European Journal of Soil Science, 66 (1), 19-32.*
- Kirkby C. A., Kirkegaard J. A., Richardson A. E., Wade L. J., Blanchard C. & Batten G., 2011. Stable soil organic matter: A comparison of C:N:P:S ratios in Australian and other world soils. *Geoderma, 163 (3), 197-208.*
- Lal R., 2016. Beyond COP 21: Potential and challenges of the "4 per Thousand" initiative. *Journal of Soil and Water Conservation, 71 (1), 20A-25A.*
- Latham J., Cumani R., Rosati I. & Bloise M., 2014. *Global Land Cover SHARE (GLC-SHARE) database Beta-Release Version 1.0-2014. Rome, Food and Agriculture Organization of the United Nations. 39 p.*
- Mann M., 2021. *The New Climate War. The Fight to Take Back Our Planet* PublicAffairs, New York, USA, 272 p.

References

- Manlay R. J., Masse D., Chotte J.-L., Feller C., Kaïré M., Fardoux J. & Pontanier R., 2002a. Carbon, nitrogen and phosphorus allocation in agro-ecosystems of a West African savanna II. The soil component under semi-permanent cultivation. *Agriculture Ecosystems & Environment, 88 (3), 233-248.*
- Manlay R. J., Chotte J.-L., Masse D., Laurent J.-Y. & Feller C., 2002b. Carbon, nitrogen and phosphorus allocation in agro-ecosystems of a West African savanna III. Plant and soil components under continuous cultivation. *Agriculture Ecosystems & Environment, 88 (3), 249-269.*
- Minasny B., Malone B. P., McBratney A. B., Angers D. A., Arrouays D., Chambers A., Chaplot V., Chen Z.-S., Cheng K., Das B. S., Field D. J., Gimona A., Hedley C. B., Hong S. Y., Mandal B., Marchant B. P., Martin M., McConkey B. G., Mulder V. L., O'Rourke S., Richer-de-Forges A. C., Odeh I., Padarian J., Paustian K., Pan G., Poggio L., Savin I., Stolbovoy V., Stockmann U., Sulaeman Y., Tsui C.-C., Vågen T.-G., van Wesemael B. & Winowiecki L., 2017. Soil carbon 4 per mille. *Geoderma, 292 (Supplement C), 59-86.*
- Perry D. A., Amaranthus M. P., Borchers J. G., Borchers S. L. & Brainerd R. E., 1989. Bootstrapping in ecosystems. *Bioscience, 39 (4), 230-237.*
- Popkin G., 2023. Shaky ground. *Science*, 381 (6656), 369-373.
- Sanderman J. & Berhe A. A., 2017. The soil carbon erosion paradox. *Nature Climate Change*, 7, 317.
- Spohn M., 2020. Increasing the organic carbon stocks in mineral soils sequesters large amounts of phosphorus. *Global Change Biology*, 26 (8), 4169-4177.
- Toussaint O. & Schneider E. D., 1998. The thermodynamics and evolution of complexity in biological systems. *Comparative Biochemistry and Physiology A*, 120 (1), 3-11.
- van Groenigen J. W., van Kessel C., Hungate B. A., Oenema O., Powlson D. S. & van Groenigen K. J., 2017. Sequestering Soil Organic Carbon: A Nitrogen Dilemma. *Environmental Science & Technology, 51 (9), 4738-4739.*
- *Environmental Science & Technology, 42 (10), 3508-3513.*
- Youl S., 2009. *Dynamique et modélisation de la dynamique du carbone dans un agrosystème de savane de l'Ouest du Burkina Faso.* PhD thesis, Université Polytechnique of Bobo-Dioulasso, Bobo-Dioulasso, 193 p.
- Yuan Z. & Chen H. Y. H., 2009. Global trends in senesced-leaf nitrogen and phosphorus. *Global Ecology and Biogeography*, 18 (5), 532-542.