



The potential of carbon farming in Europe

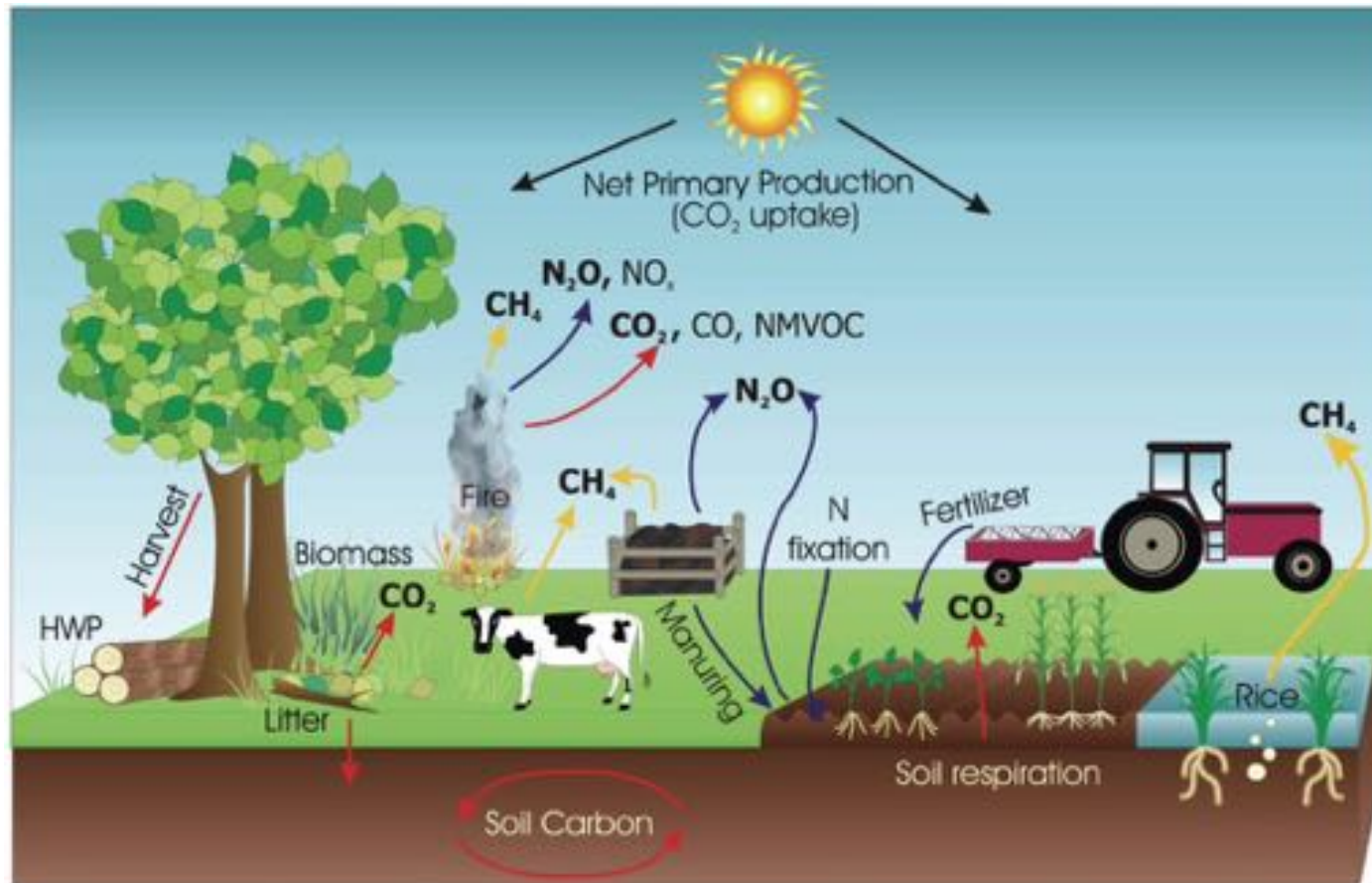


Claire Chenu, INRAE

Carbon farming = managing carbon pools, flows and greenhouse gases at farm level to mitigate climate change

Sustainable
Carbon Cycles
Conference

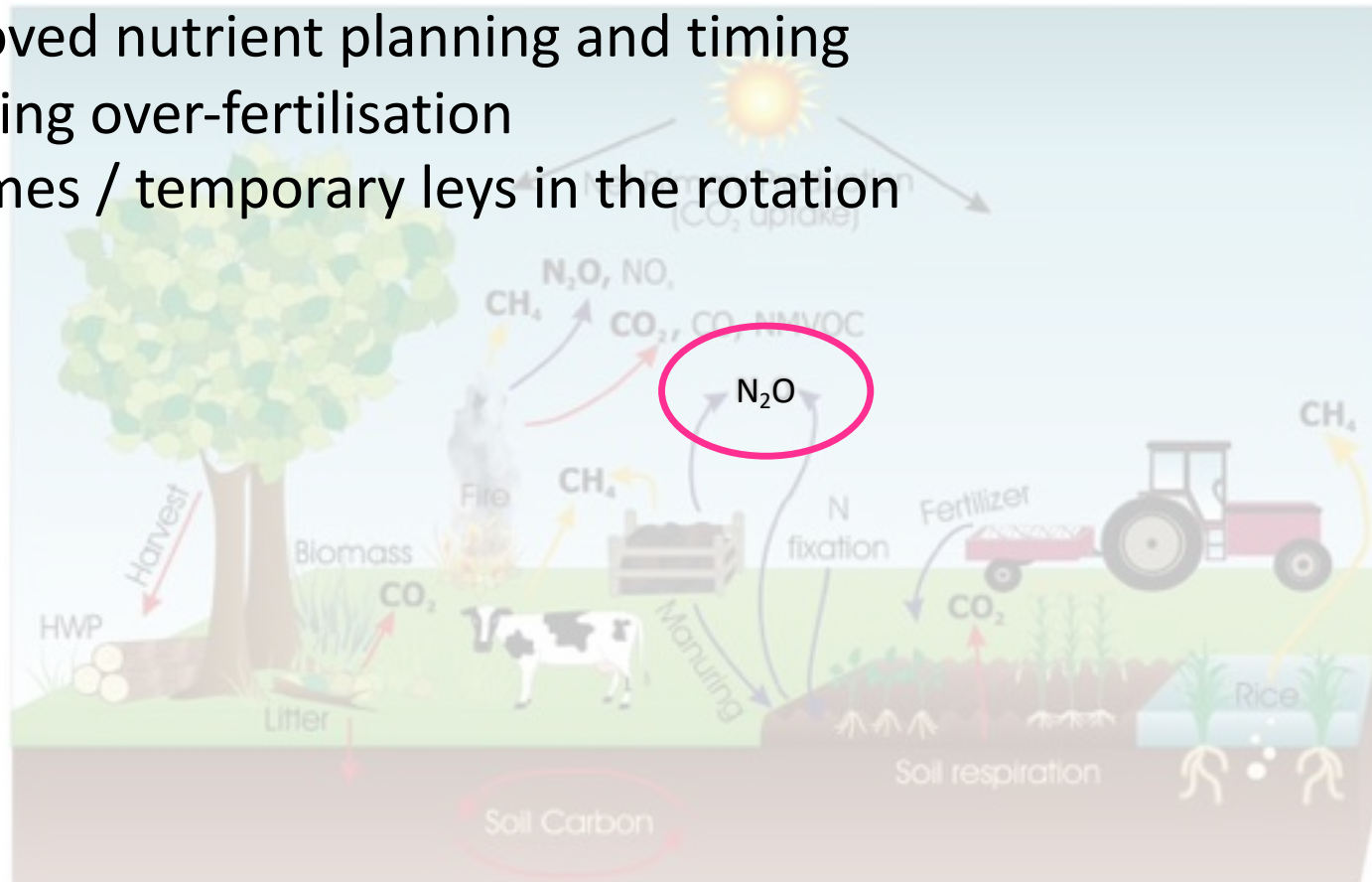
ONLINE
31 JANUARY 2022



©IPCC, 2006

Nutrient management on croplands and grasslands

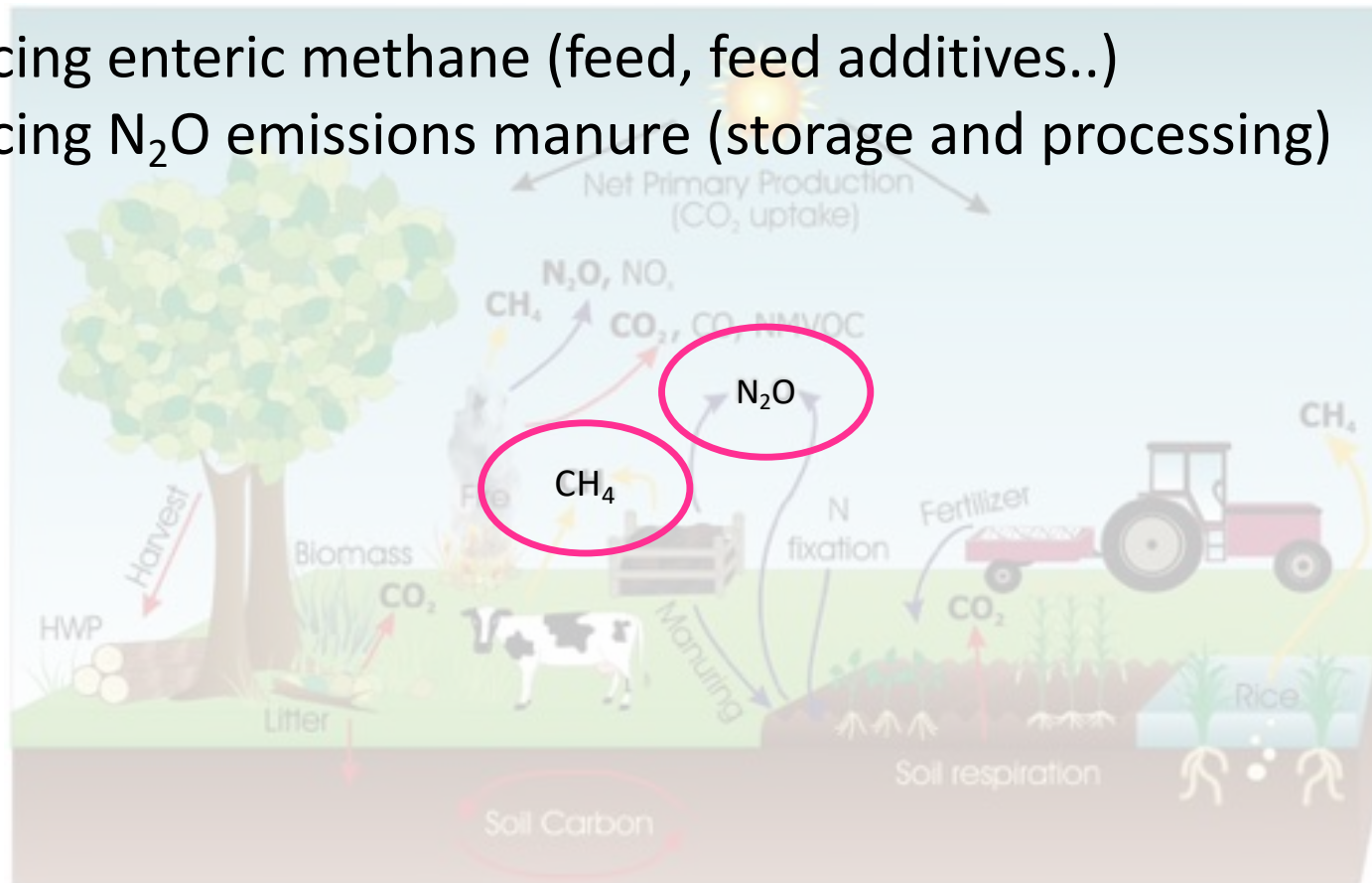
- Improved nutrient planning and timing
- Avoiding over-fertilisation
- Legumes / temporary leys in the rotation



©IPCC, 2006

Livestock and manure management

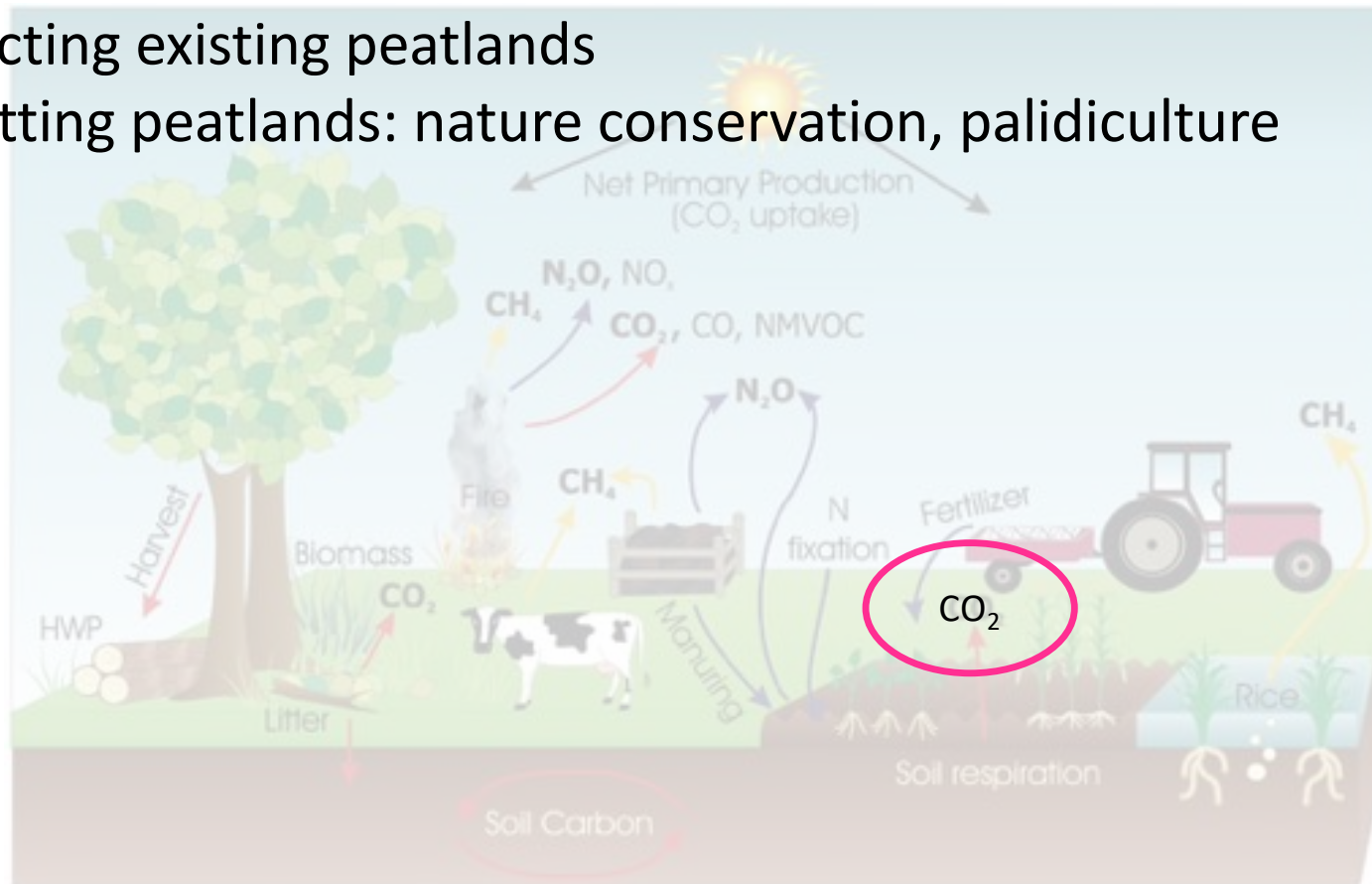
- Reducing enteric methane (feed, feed additives..)
- Reducing N₂O emissions manure (storage and processing)



©IPCC, 2006

Managing peatlands

- Protecting existing peatlands
- Rewetting peatlands: nature conservation, palidiculture

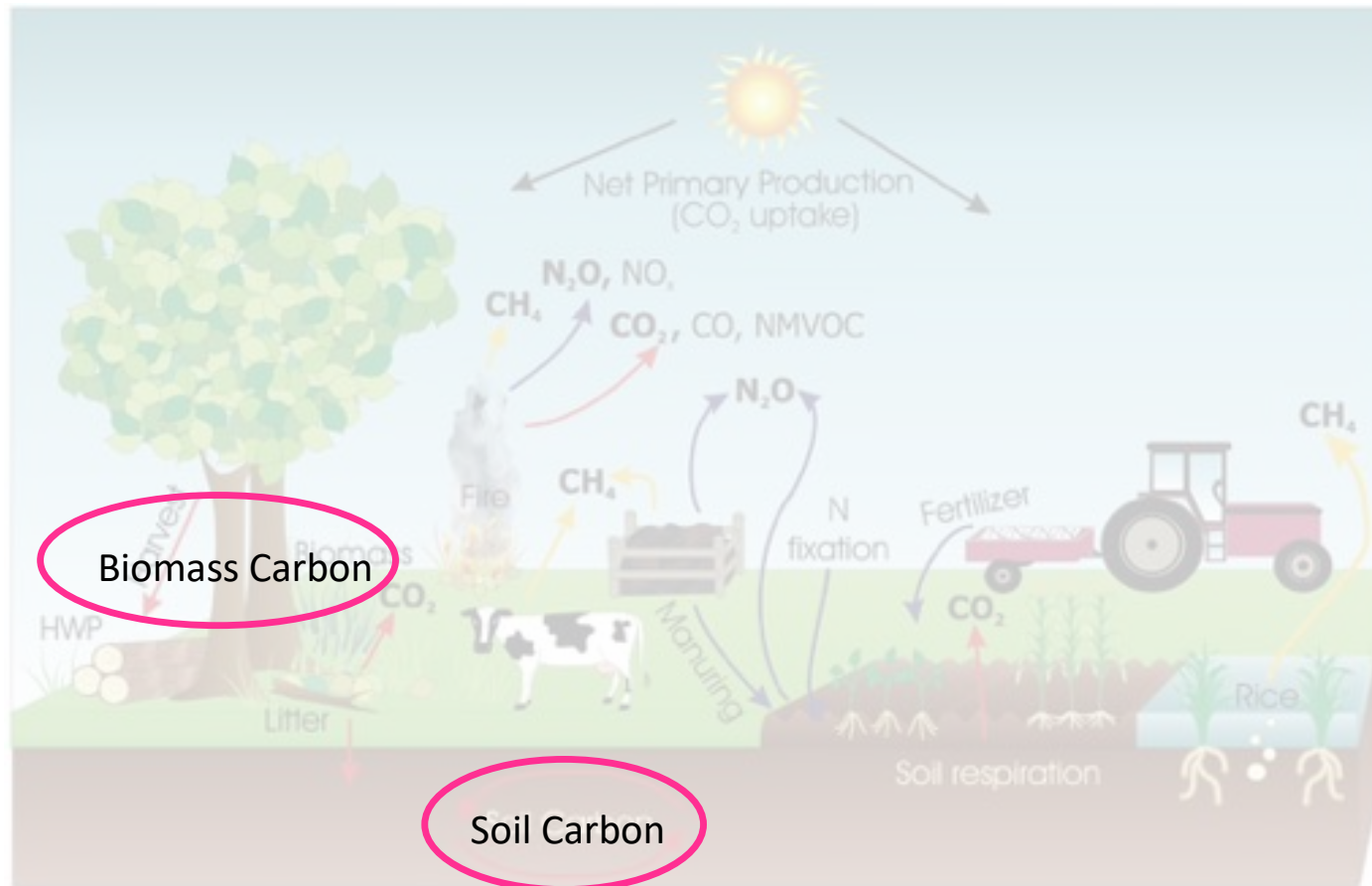


©IPCC, 2006

Developing agroforestry and hedges

Sustainable
Carbon Cycles
Conference

ONLINE
31 JANUARY 2022

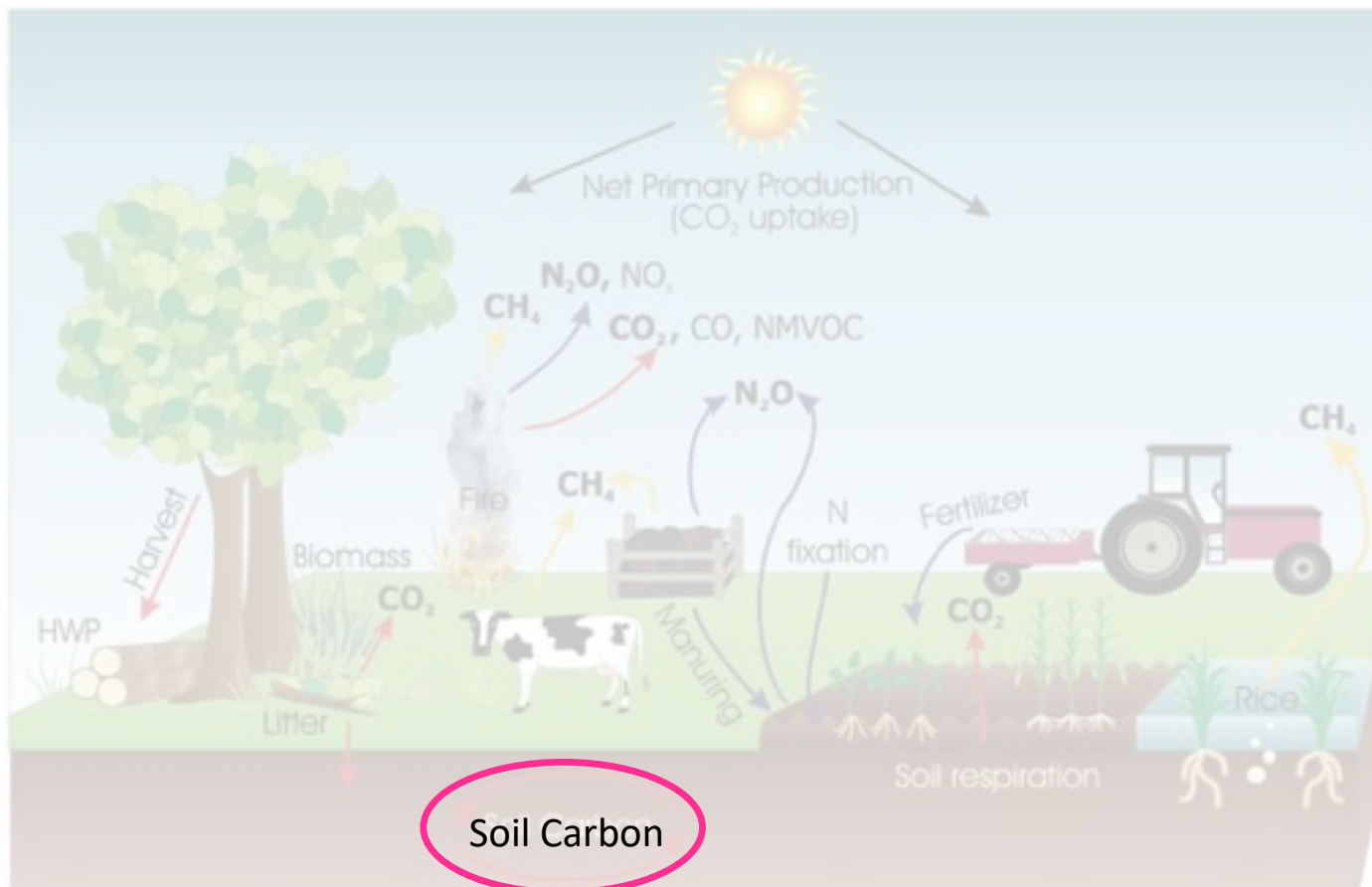


©IPCC, 2006

Sequestering carbon in mineral soils

Sustainable
Carbon Cycles
Conference

ONLINE
31 JANUARY 2022



©IPCC, 2006

Store additional C in soils? Green the soils!



Carbon farming, C Chenu

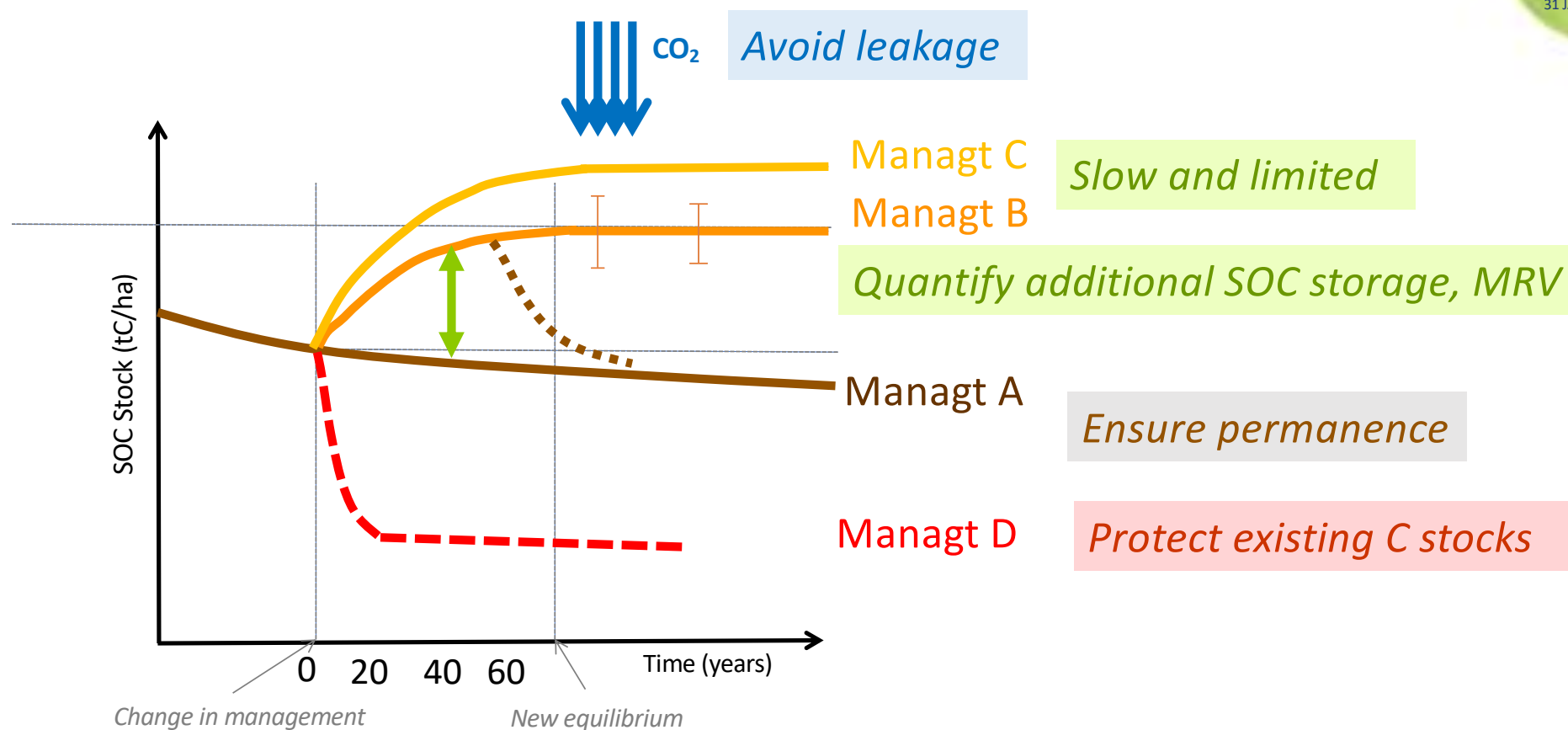
© R. Cardinael

© Chuki Wangmo

SOC storage for climate change mitigation

Sustainable
Carbon Cycles
Conference

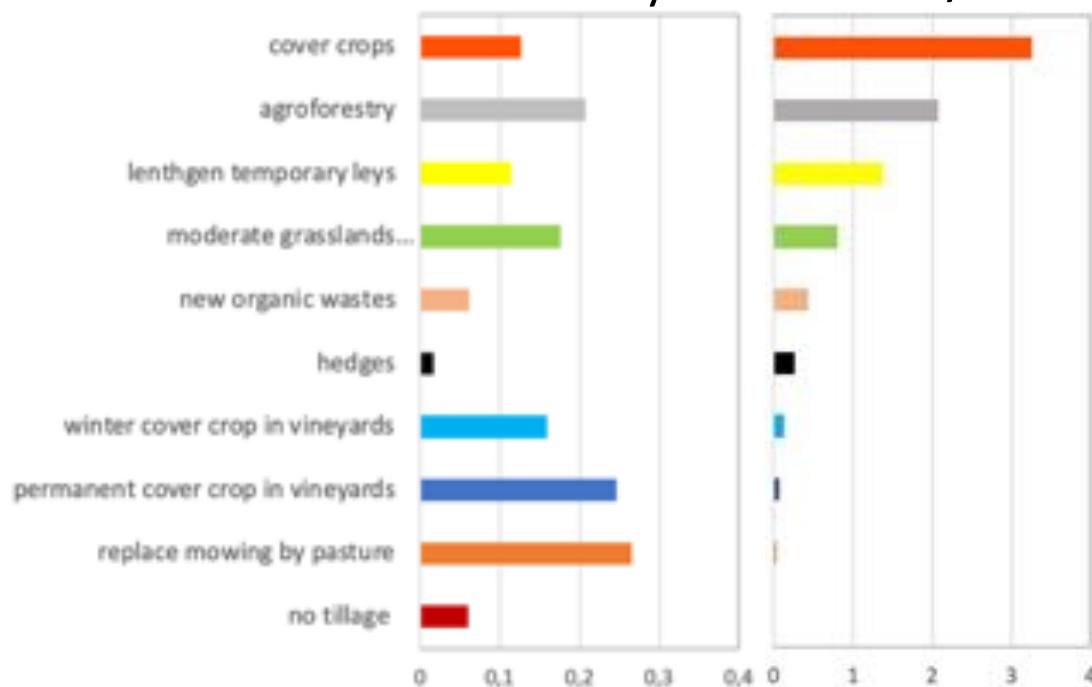
ONLINE
31 JANUARY 2022



SOC storage technical potential

Additional SOC storage mainland France, 2030

tC ha⁻¹ y⁻¹ MtC y⁻¹



Pellerin et al. 2019, 2020

INRAE 4p1000 assessment

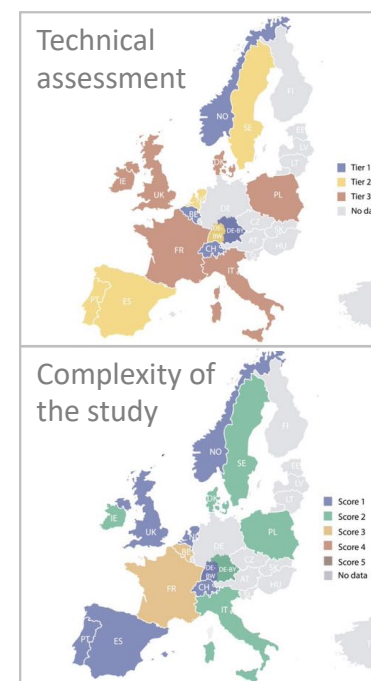
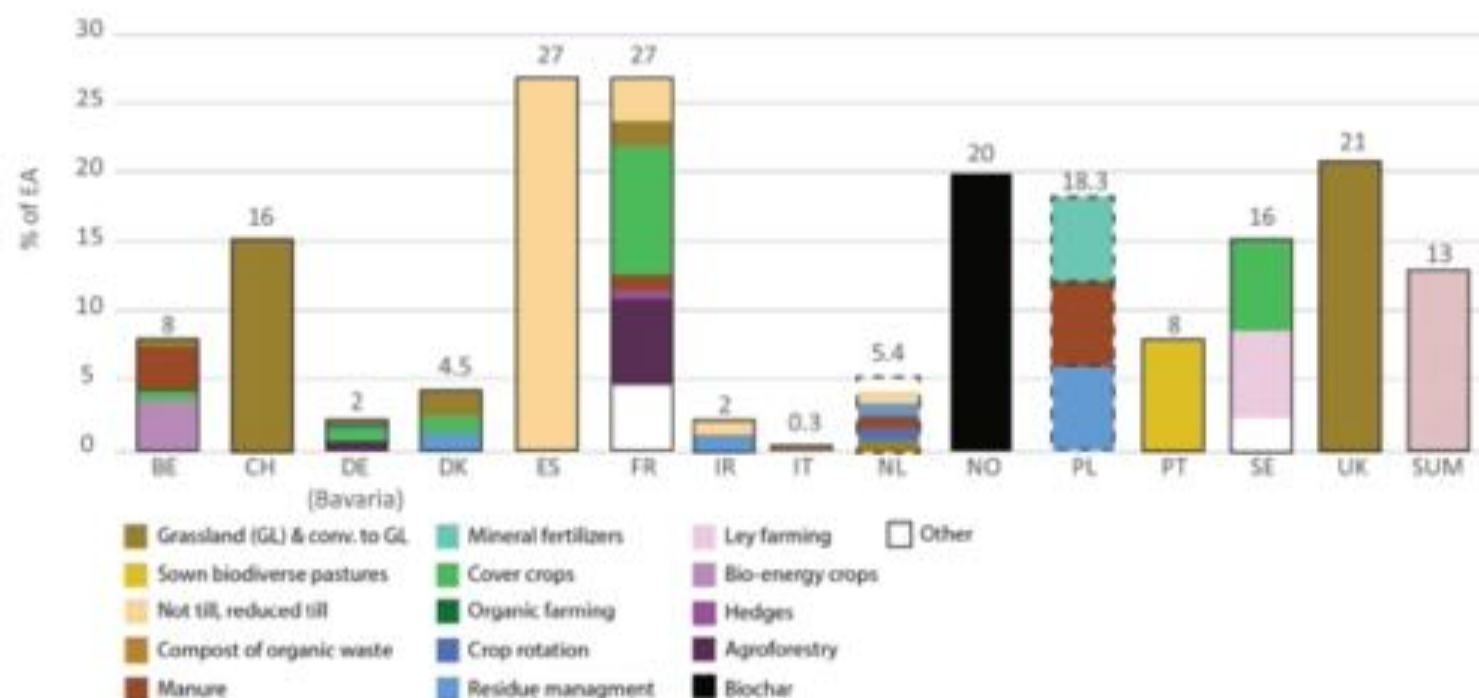
<https://www.inrae.fr/en/news/storing-4-1000-carbon-soils-potential-france>



SOC storage technical potential

Stocktake of existing studies at the national scale:

Potential for reducing annual National agricultural GHG emissions (%) by additional SOC storage



Rogrigues et al. 2021- GCB - EJP SOIL report D2.3

SOC storage economic potential

Sustainable
Carbon Cycles
Conference

ONLINE
31 JANUARY 2022

Additional SOC storage mainland France

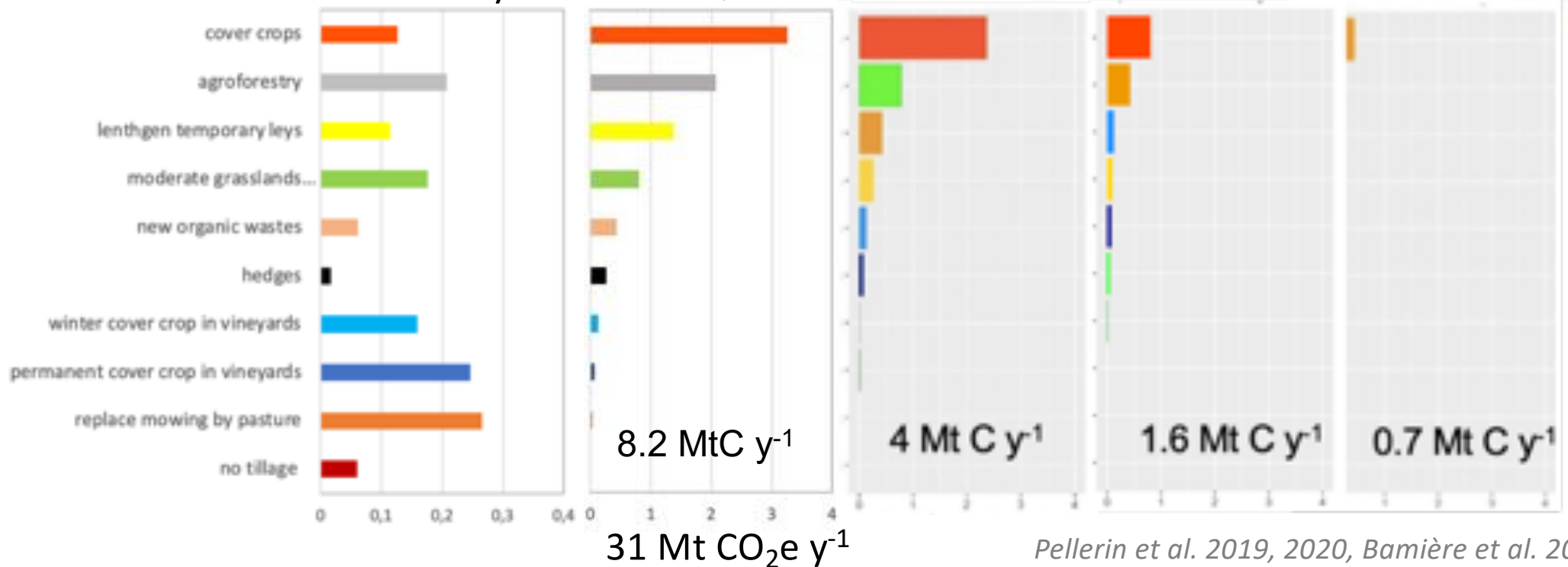
tC ha⁻¹ y⁻¹

MtC y⁻¹

55 €/t CO_{2e}

25 €/t CO_{2e}

0 €/t CO_{2e}



Pellerin et al. 2019, 2020, Bamière et al. 2021
INRAE 4p1000 assessment
<https://www.inrae.fr/en/news/storing-4-1000-carbon-soils-potential-france>

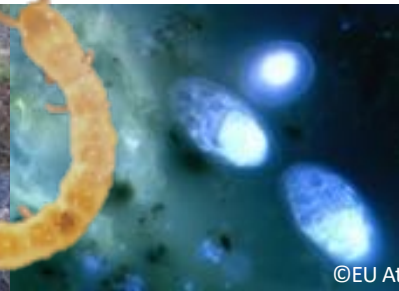
Benefits of SOC storage

Sustainable
Carbon Cycles
Conference

ONLINE
31 JANUARY 2022



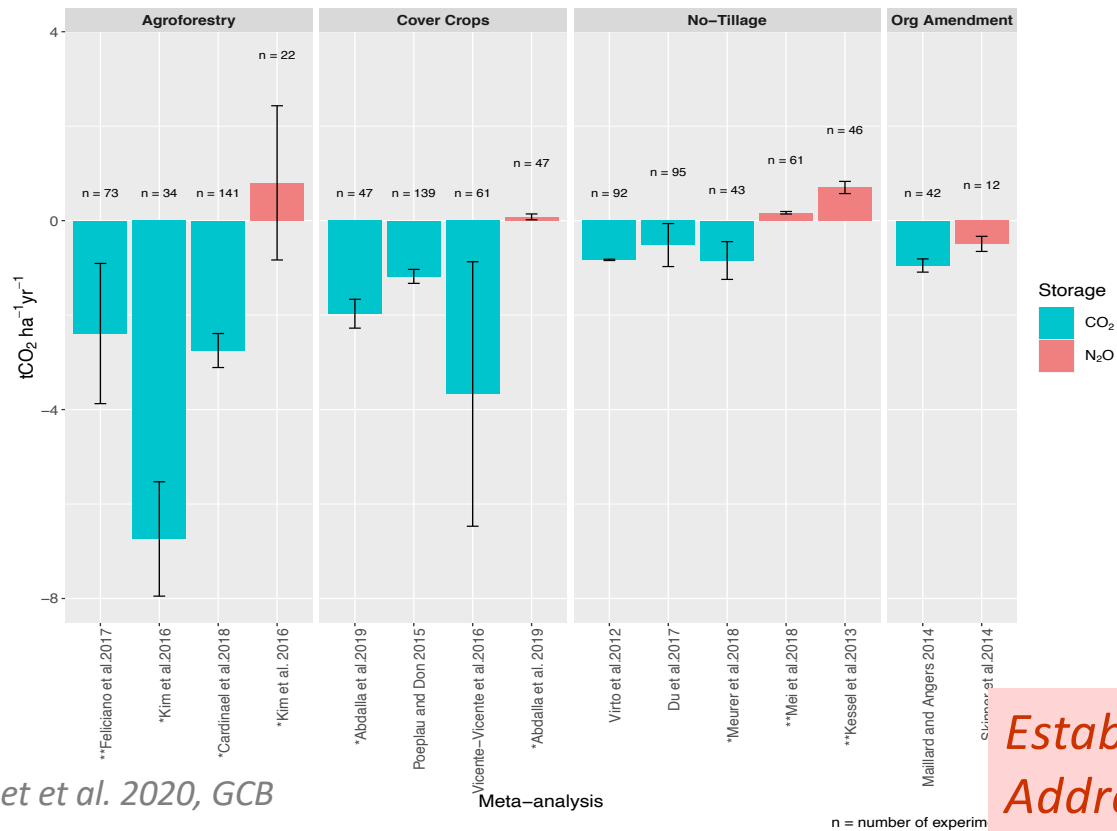
Better evaluate the co-benefits



©EU Atlas Soil

Tradeoffs of SOC storage

Additional SOC storage & N₂O emissions when implementing management options



Guenet et al. 2020, GCB

*Establish an full GHG balance
Address trade-offs. Protect natural resources*

Sustainable
Carbon Cycles
Conference

ONLINE
31 JANUARY 2022

Water?



Nutrients?



Biodiversity?



Technical/economic potentials: a summary for EU

**Sustainable
Carbon Cycles
Conference**

ONLINE
31 JANUARY 2022

Carbon management category	Technical potential (MtCO ₂ e/y)	Economic potential (MtCO ₂ e/y)*
Nutrient management		19 ⁽¹⁾
Livestock and manure management	45 ⁽²⁾	14 ⁽¹⁾
Managing peatland	61 ⁽³⁾	54 ⁽¹⁾
Agroforestry	8-235 ⁽⁴⁾ + 9 ⁽⁵⁾	
C storage in mineral soils	23-58 ⁽⁶⁾	70 ⁽¹⁾

* < 100 € t CO₂e

¹ Roe et al. 2021, extracted by Mc Donald et al. 2021

² Perez-Dominguez et al. 2021; ³ Dominguez et al. 2020, EC, 2020

⁴ Kay et al. 2019 only woody biomass ⁵ Cardinael et al. 2018 soils

⁶ Lugato et al. 2014

Mc Donald et al. 2021:

101-444 Mt CO₂e/y

≈ 3-12% EU total GHG emissions

≈ 26% EU agricultural emissions

An enabling environment for carbon farming

**Sustainable
Carbon Cycles
Conference**

ONLINE
31 JANUARY 2022

Overcoming barriers

Business models

Option	Actors	MRV action/ results based	e.g.
Land management practice payments	Public or NGO funder → 		CAP
Corporate supply chain	Agri-food company → 		SPAR
Voluntary market with intermediary	Private sector, individuals → Intermediary → 		Label Bas Carbone
Voluntary market exchange -based	Private sector, individuals → Certification mechanism → 		Verra

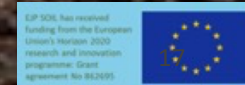
Adapted from Mc Donald et al. 2021



Carbon farming has the potential to be a success for climate, environment and farmers

- Reduce uncertainties. Context-specific solutions
- Intrinsic challenges: permanence, MRV, additionality
- Integrative view: not only carbon! Leakage, trade-offs, ecosystem services
- Farmers are the stewards : co-construction, fair and functional tools

Carbon farming, C.Chenu



References

- Bamière, L., Jayet, P.A., Kahindo, S., Martin, E., 2021. Carbon sequestration in French agricultural soils: A spatial economic evaluation. *Agricultural Economics* 52(2), 301-316.
- Cardinael, R., Umulisa, V., Toudert, A., Olivier, A., Bockel, L., Bernoux, M., 2018. Revisiting IPCC Tier 1 coefficients for soil organic and biomass carbon storage in agroforestry systems. *Environmental Research Letters* 13(12).
- Chenu, C., Angers, D.A., Barré, P., Derrien, D., Arrouays, D., Balesdent, J., 2019. Increasing organic stocks in agricultural soils: Knowledge gaps and potential innovations. *Soil and Tillage Research* 188, 41-52.
- Guenet, B., Gabrielle, B., Chenu, C., Arrouays, D., Balesdent, J.M., Bernoux, M., Bruni, E., Caliman, J.P., Cardinael, R., Chen, S.C., Ciais, P., Desbois, D., Fouche, J., Frank, S., Henault, C., Lugato, E., Naipal, V., Nesme, T., Obersteiner, M., Pellerin, S., Powelson, D.S., Rasse, D.P., Rees, F., Soussana, J.F., Su, Y., Tian, H.Q., Valin, H., Zhou, F., 2021. Can N2O emissions offset the benefits from soil organic carbon storage? *Global Change Biology* 27(2), 237-256.
- Kay, S., Graves, A., Palma, J.H.N., Moreno, G., Rocas-Díaz, J.V., Aviron, S., Chouvardas, D., Crous-Duran, J., Ferreiro-Domínguez, N., García de Jalón, S., Măcicășan, V., Mosquera-Losada, M.R., Pantera, A., Santiago-Freijanes, J.J., Szerencsits, E., Torralba, M., Burgess, P.J., Herzog, F., 2019. Agroforestry is paying off – Economic evaluation of ecosystem services in European landscapes with and without agroforestry systems. *Ecosystem Services* 36.
- Lugato, E., Bampa, F., Panagos, P., Montanarella, L., Jones, A., 2014. Potential carbon sequestration of European arable soils estimated by modelling a comprehensive set of management practices. *Global Change Biology* 20(11), 3557-3567.
- McDonald, H., Frelih-Larsen, A., Lóránt, A., Duin, L., Pyndt Andersen, S., Costa, G., Bradley, H., 2021. Carbon farming – Making agriculture fit for 2030. Study for the committee on Environment, Public Health and Food Safety (ENVI), Policy Department for Economic, Scientific and Quality of Life Policies, European Parliament, Luxembourg.
- Pellerin, S., Bamière, L., Angers, D., Béline, F., Benoit, M., Butault, J.-P., Chenu, C., Colnenne-David, C., De Cara, S., Delame, N., Doreau, M., Dupraz, P., Faverdin, P., Garcia-Launay, F., Hassouna, M., Henault, C., Jeuffroy, M.-H., Klumpp, K., Metay, A., Moran, D., Recous, S., Samson, E., Savini, I., Pardon, L., Chemineau, P., 2017. Identifying cost-competitive greenhouse gas mitigation potential of French agriculture. *Environmental Science & Policy* 77, 130-139.
- Pellerin, S., Bamière, L., Savini, I., Réchauchère, O. (Eds.), 2021. Stocker du carbone dans les sols français. Quel potentiel et à quel coût ? QUAE, 232 pp.. <https://www.inrae.fr/en/news/storing-4-1000-carbon-soils-potential-France>.
- Perez Dominguez, I., Fellmann, T., Witzke, H.P., Weiss, F., Hristov, J., Himics, M., Barreiro Hurlé, J., Gomez Barbero, M. and Leip, A., Economic assessment of GHG mitigation policy options for EU agriculture, EUR 30164 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-17855-2, doi:10.2760/552529, JRC120355.
- Rodrigues, L., Hardy, B., Huyghebeart, B., Fohrafellner, J., Fornara, D., Barancikova, G., Barcena, T.G., De Boever, M., Di Bene, C., Feiziene, D., Katterer, T., Laszlo, P., O'Sullivan, L., Seitz, D., Leifeld, J., 2021. Achievable agricultural soil carbon sequestration across Europe from country-specific estimates. *Glob Chang Biol* 27(24), 6363-6380.
- Roe, S., Streck, C., Beach, R., Busch, J., Chapman, M., Daioglou, V., Deppermann, A., Doelman, J., Emmet-Booth, J., Engelmann, J., Fricko, O., Frischmann, C., Funk, J., Grassi, G., Griscom, B., Havlik, P., Hanssen, S., Humpenoder, F., Landholm, D., Lomax, G., Lehmann, J., Mesnildrey, L., Nabuurs, G.J., Popp, A., Rivard, C., Sanderman, J., Sohngen, B., Smith, P., Stehfest, E., Woolf, D., Lawrence, D., 2021. Land-based measures to mitigate climate change: Potential and feasibility by country. *Glob Chang Biol* 27(23), 6025-6058.