Modelling P Soil Dynamics and P Budgets in European Agricultural Soils

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SOILS: WHERE FOOD BEGINS

Global Symposium on Soils for Nutrition | 26-29 July 2022

GLOBAL SOIL PARTNERSHIP

Motivation

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- Limited geological P deposits or organic sources

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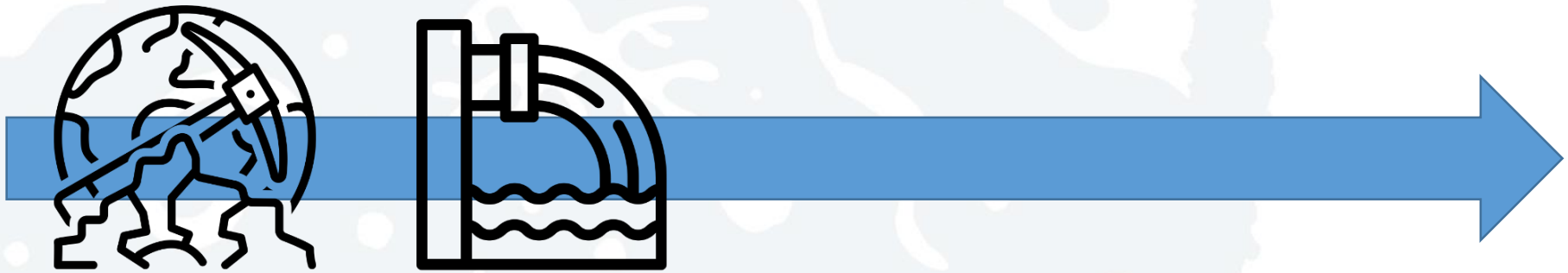
- > half of surface waters not in a good status (EEA 2018)



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- Limited geological P deposits or organic sources
- > half of surface waters not in a good status (EEA 2018)
- Policy tools affect the P cycle
- A lack Ecosystem process-based P models (Das et al.,2019)

Method

Method: DayCent P Submodel

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- Detailed soil biogeochemistry
- Tested C and N submodels at EU level
- Simulation of agricultural management
- Scenario analysis

(Del Grosso et al. 2001, Lugato et al. 2007, Lugato et al. 2018)

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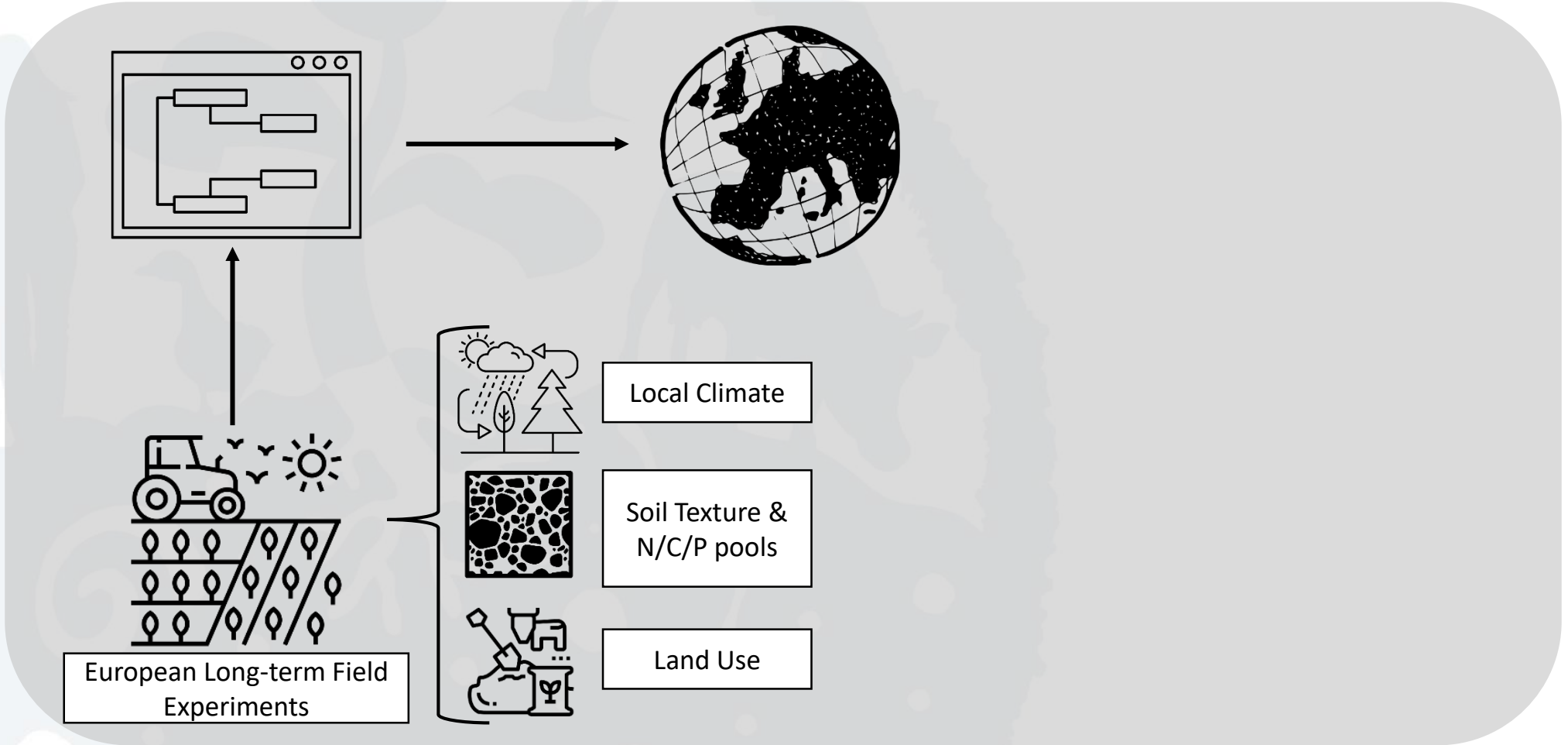
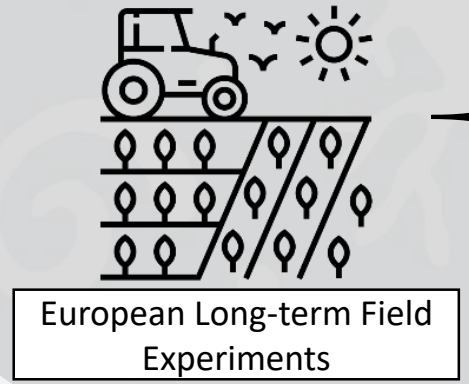
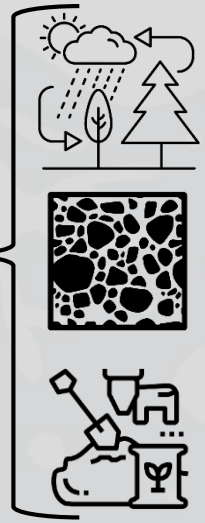


Method: DayCent P Submodel

4 Long-Term Experiments
2 Locations
88 Simulations
Mineral & Organic Fertilizers
Crop Rotations
Fertilizer Intensities



European Long-term Field Experiments



Local Climate

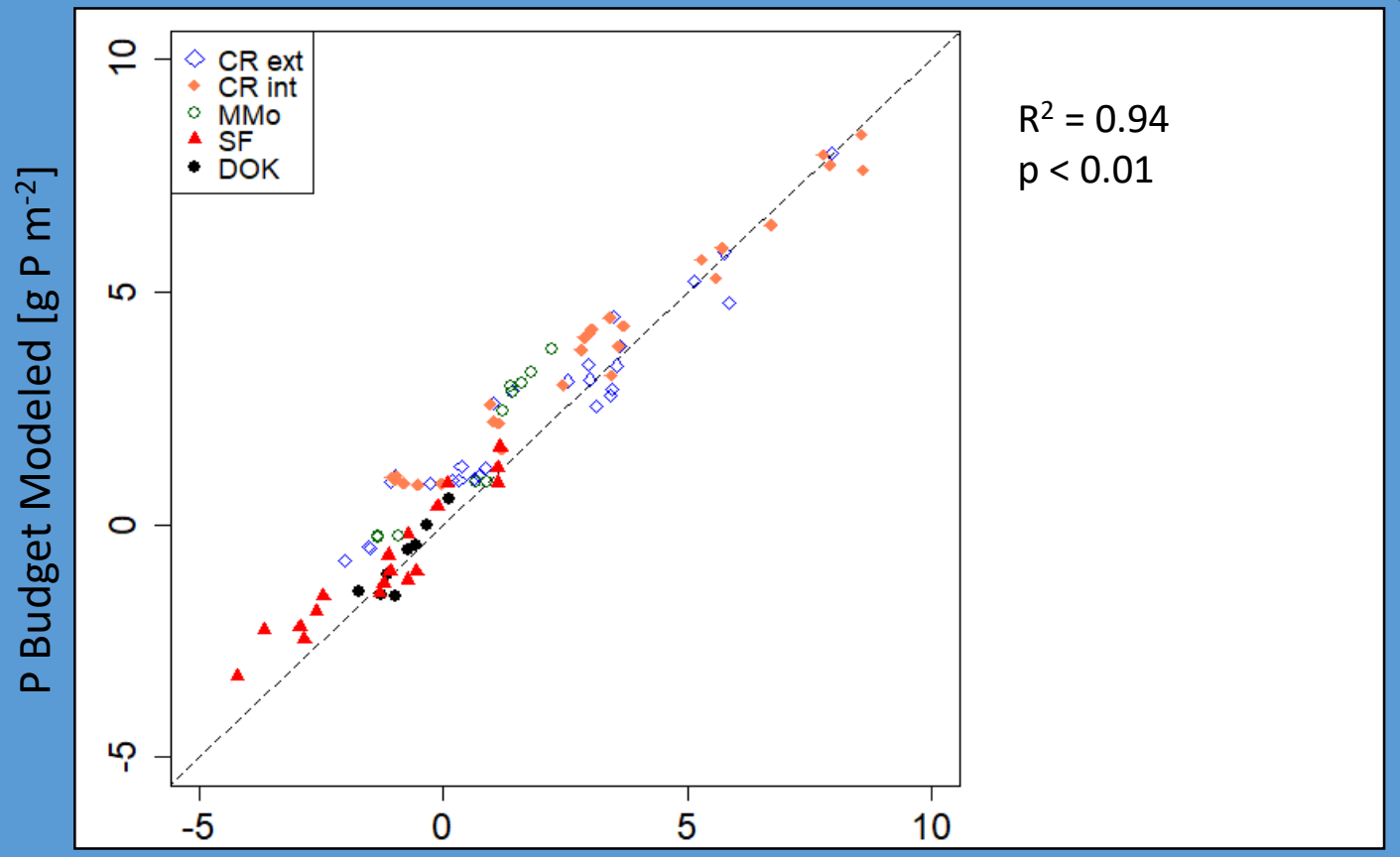
Soil Texture & N/C/P pools

Land Use

(Mäder et al. 2002, Giardini 2004, Muntwyler et al. 2022 (submitted))

Results: DayCent P Submodel

- 4 Long-term Experiments
- 5 soil types
- Various
  - Fertilizers (min/org)
  - Fertilizer intensities
  - Crop rotations



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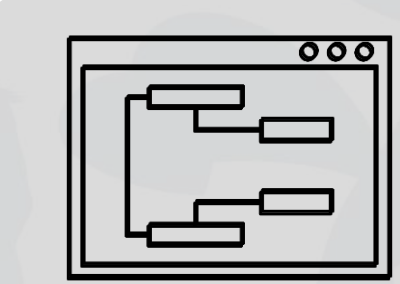
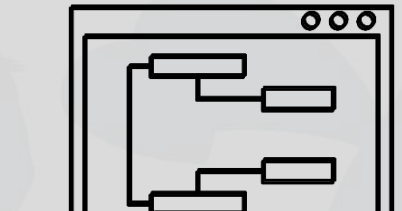


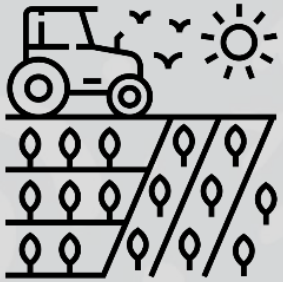
European Long-term Field Experiments

Input Layers for EU upscale

- Local Climate
- Crop Production Statistics
- Soil Texture
- Initial Soil P Pools
- Management Practices

Method: DayCent P Submodel





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Input Layers for EU upscale
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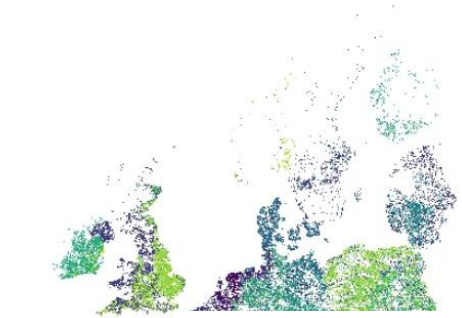
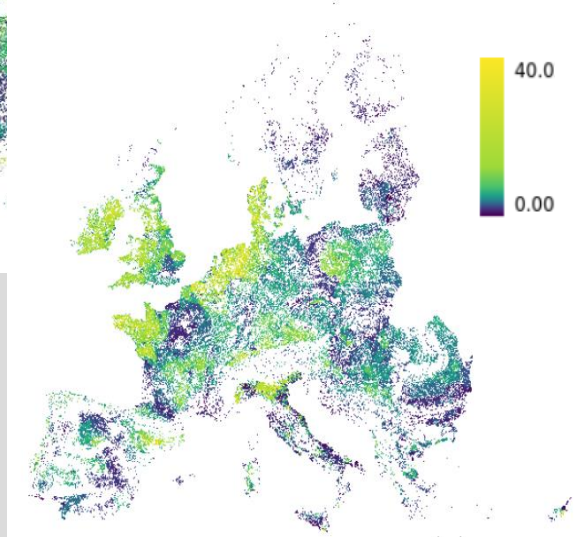
(EUROSTAT 2020, Gilbert et al. 2018)

Mineral Input



Organic Input



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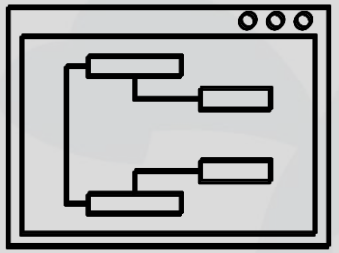

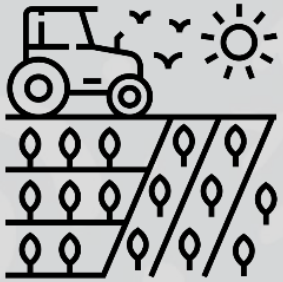

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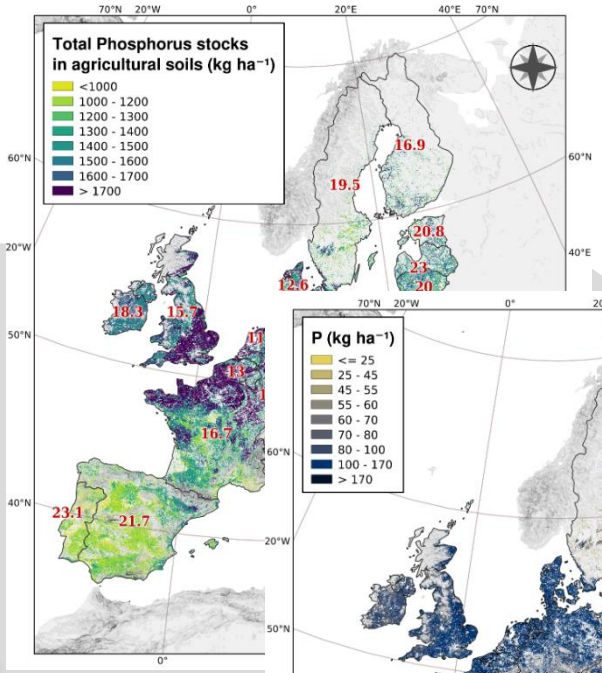
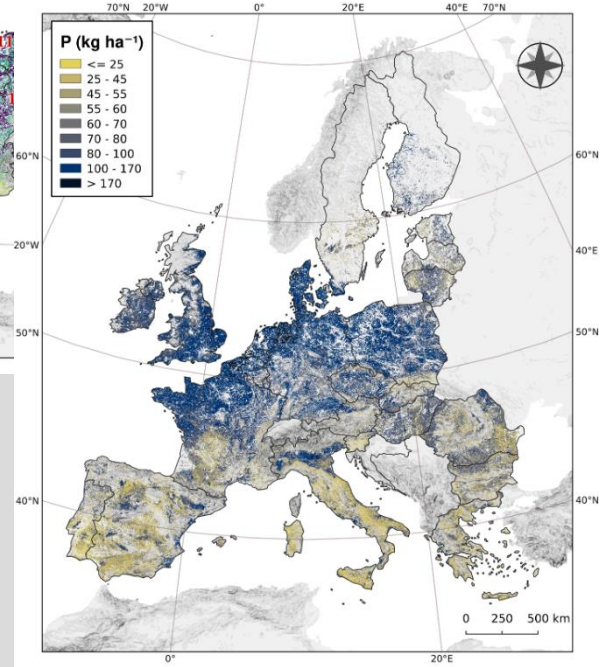
Total Soil P

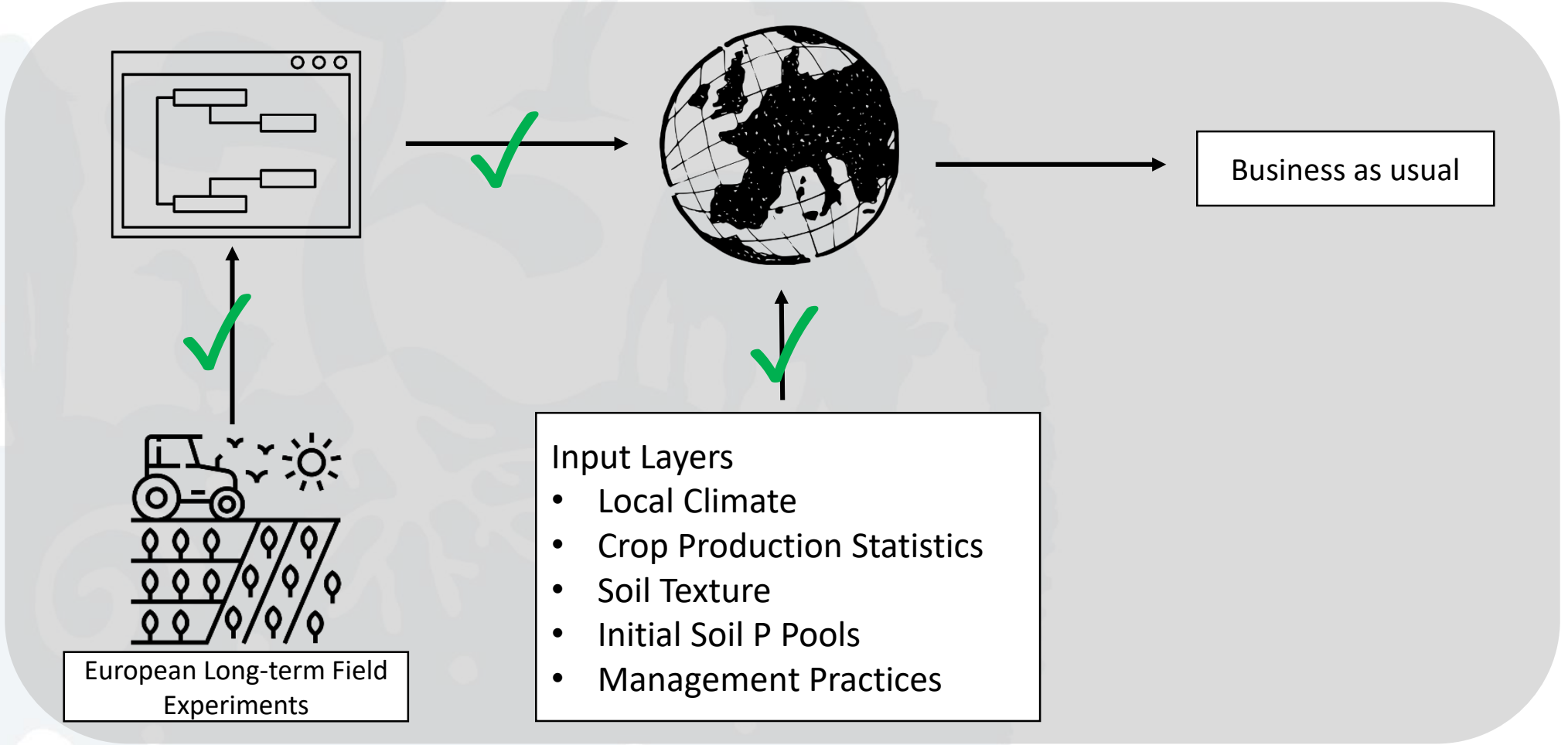


Available Soil P



(Ballabio et al. 2019;
Panagos et al. 2022 (in review))

P Modelling in European agricultural soils



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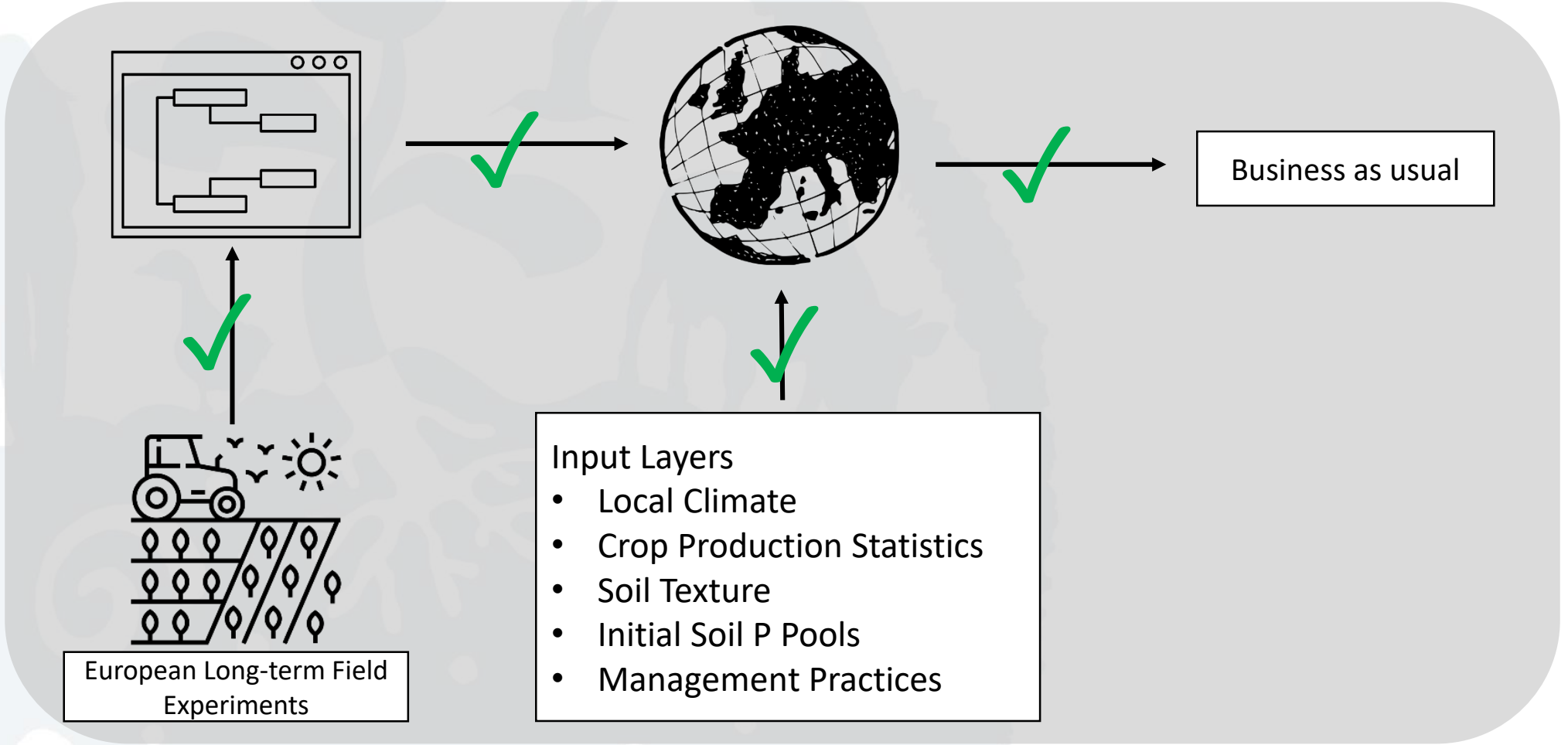

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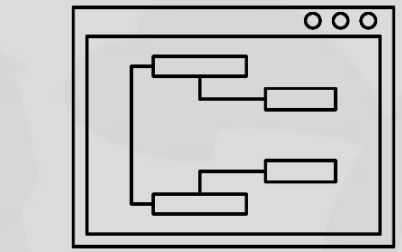
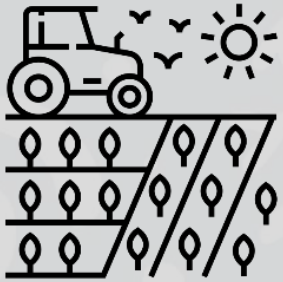


Business as usual

validation in progress



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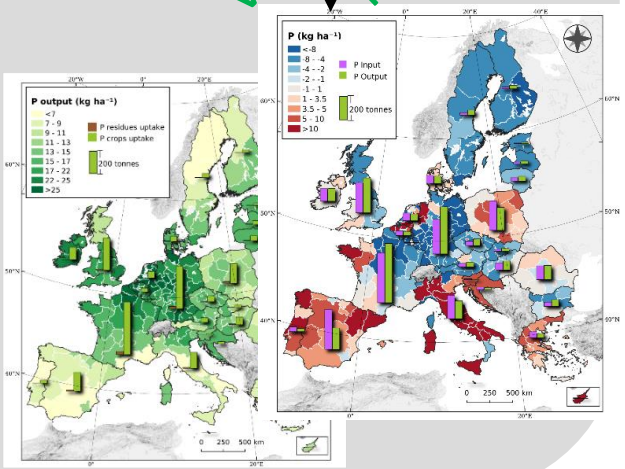

(Panagos et al. 2022a)

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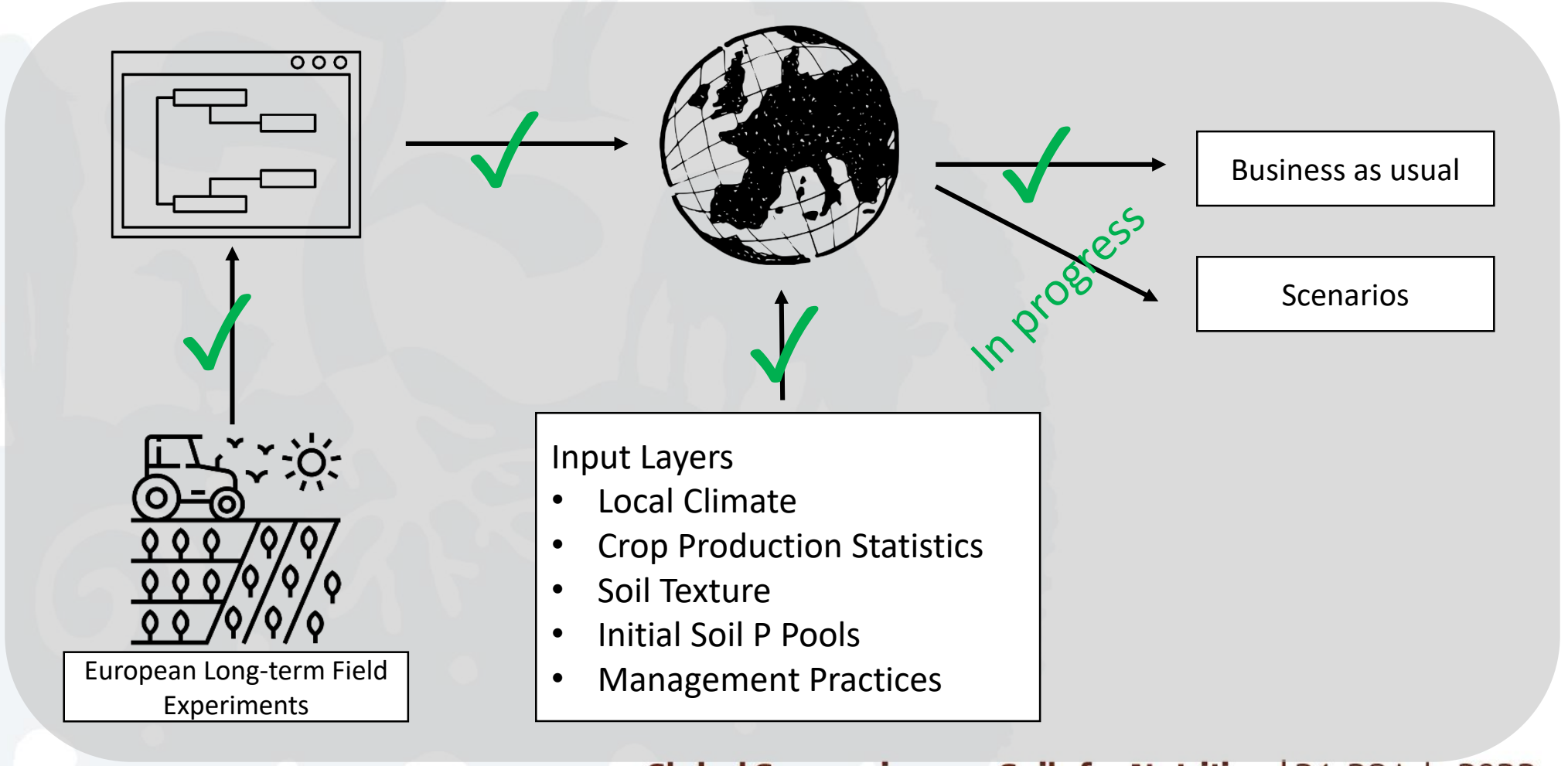

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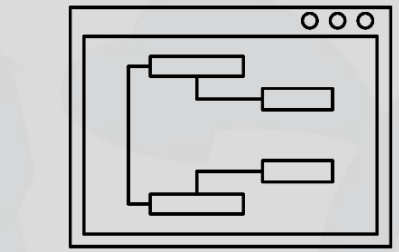

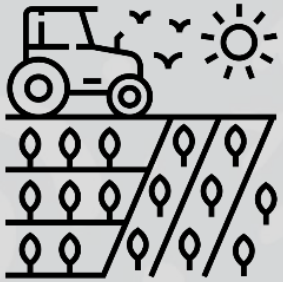

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Input Layers
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- Management Practices

In progress

Business as usual

Scenarios

Change agricultural management:
- Reduce P Input
- Change Fertilizer Type
- Change Cover Crop
- …

Conclusion

- Lack of P models in agricultural systems

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- DayCent can simulate P export and P budget well for Long-term Experiments

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Conclusion

- Lack of P models in agricultural systems
- DayCent can simulate P export and P budget well for Long-term Experiments
- Need to better understand P pool partitioning
- Large potential to model P scenarios in EU

Thank you !

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References

- Ballabio, Cristiano, Emanuele Lugato, Oihane Fernández-ugalde, Alberto Orgiazzi, Arwyn Jones, Pasquale Borrelli, Luca Montanarella, and Panos Panagos. 2019. “Geoderma Mapping LUCAS Topsoil Chemical Properties at European Scale Using Gaussian Process Regression.” Geoderma 355 (July): 113912. https://doi.org/10.1016/j.geoderma.2019.113912.
- Das, Bianca, Neil Huth, Merv Probert, Leo Condron, and Susanne Schmidt. 2019. “Soil Phosphorus Modeling for Modern Agriculture Requires Balance of Science and Practicality: A Perspective.” Journal of Environment Quality 48(5):1281.
- Del Grosso, S.J., Parton, W.J., Mosier, A.R., Hartman, M.D., Keough, C.A., Peterson, G.A., Ojima, D.S., Schimel, D.S., 2001. Simulated effects of land use, soil texture, and precipitation on N gas emissions using DAYCENT. In: R.F. Follett, R.F., Hatfield, J.L. (Eds.), Nitrogen in the Environment: Sources, Problems, and Management. Elsevier Science Publishers, The Netherlands, pp. 413-431.
- EEA. 2018. European Waters - Assessment of Status and Pressures.
- EUROSTAT, 2020. Eurostat statistics on Fertilizers.
- Giardini, L. "Productivity and sustainability of different cropping systems." Patron Editore: Bologna, Italy (2004).
- Gilbert, Marius, Gaëlle Nicolas, Giusepina Cinardi, Thomas P. Van Boeckel, Sophie O. Vanwambeke, G. R.William Wint, and Timothy P. Robinson. 2018. “Global Distribution Data for Cattle, Buffaloes, Horses, Sheep, Goats, Pigs, Chickens and Ducks in 2010.” *Scientific Data* 5: 1–11. https://doi.org/10.1038/sdata.2018.227.
- Lugato, E, K Paustian, and L Giardini. “Modelling Soil Organic Carbon Dynamics in Two Long-Term Experiments of North-Eastern Italy” 120 (2007): 423–32.
- Lugato, Emanuele, Adrian Leip, and Arwyn Jones. "Mitigation potential of soil carbon management overestimated by neglecting N 2 O emissions." Nature Climate Change 8.3 (2018): 219-223.
- Mäder, Paul, Andreas Fließbach, David Dubois, Lucie Gunst, Padruot Fried, and Urs Niggli. 2002. “Soil Fertility and Biodiversity in Organic Farming.” Science 296(5573):1694–97.
- Anna Muntwyler, Panos Panagos, Francesco Morari, Antonio Berti, Klaus A. Jarosch, Jochen Mayer, Emanuele Lugato. 2022. “Modelling phosphorus dynamics in four European long-term experiments” (submitted)
- Panagos, Panos, Anna Muntwyler, Leonidas Liakos, Pasquale Borrelli, Irene Biavetti, and Mariia Bogonos. 2022a. “Phosphorus Plant Removal from European Agricultural Land.” Journal of Consumer Protection and Food Safety (0123456789).
- Panos Panagos*, Julia Köningner, Cristiano Ballabio, Leonidas Liakos, Anna Muntwyler, Pasquale Borrelli, Emanuele Lugato 2022b. “Improving the Phosphorus budget of European agricultural soils “ in review.