Sustainable agriculture in the context of food security, climate change and biodiversity loss

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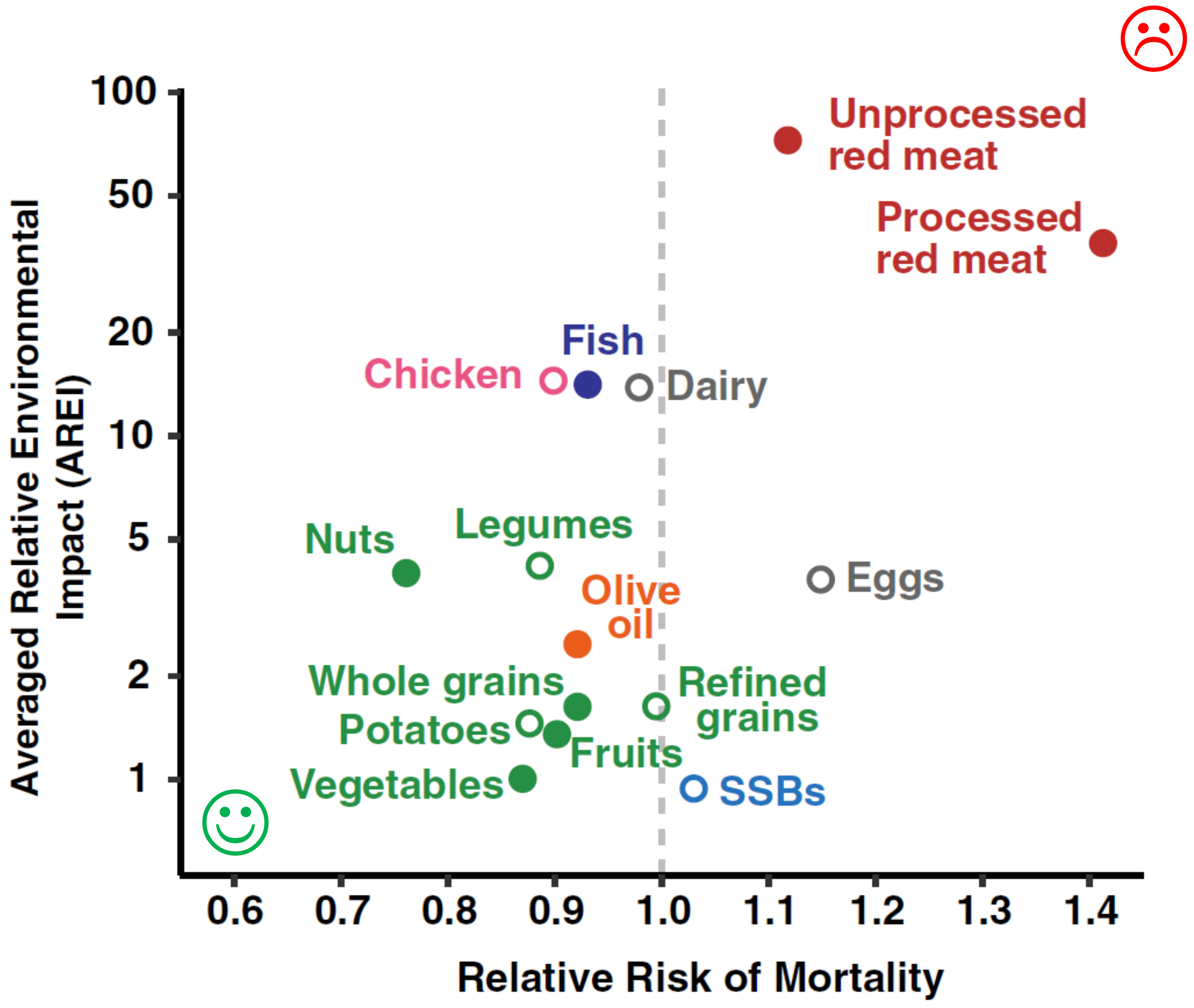
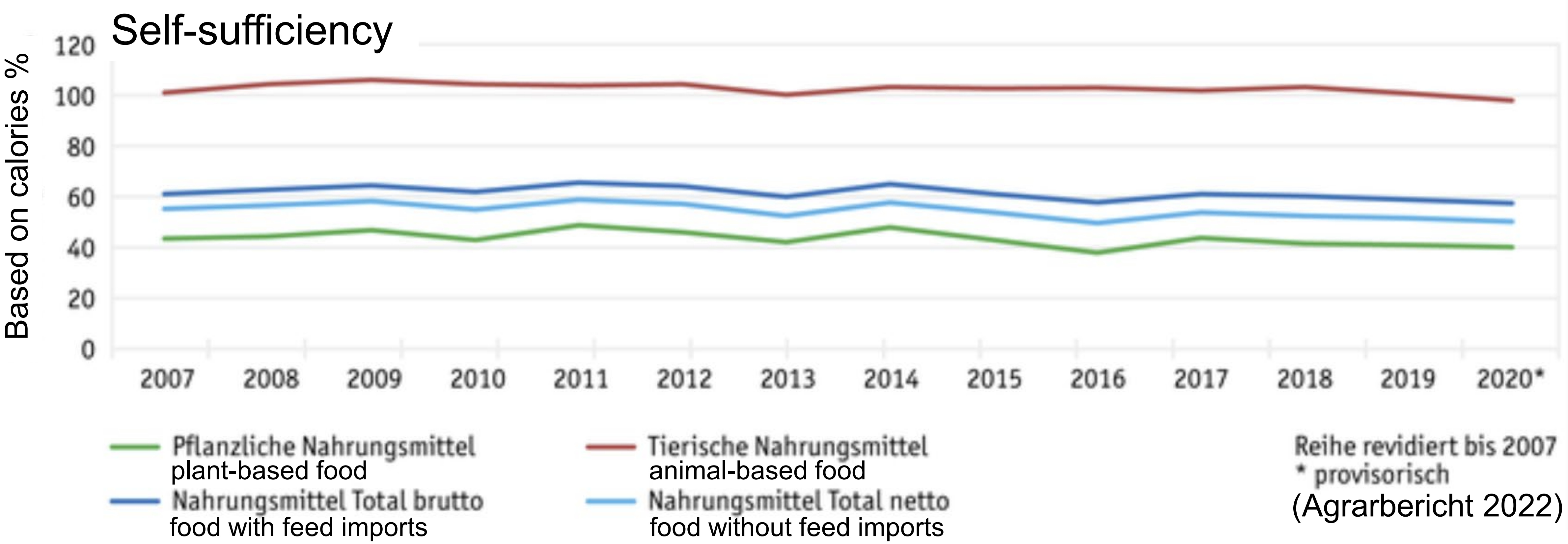
Food choices determine climate change and health



- We emit what we eat.
- We decide with our food choices about our health and environmental health (e.g., Planetary Health Diet).

(Clark et al. 2019)

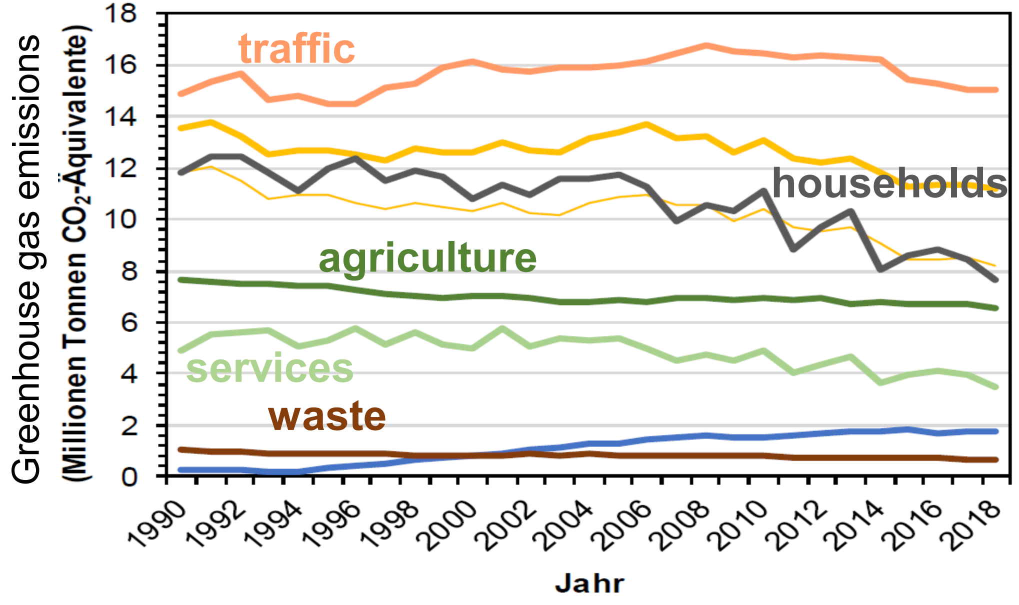
Agriculture in the context of global food security



- **Switzerland imports about half of its food, stable since long**
- **Self-sufficiency: plant production << animal production**

➢ **Trade-off between agriculture in CH vs. food imports from abroad**

Swiss agriculture in the context of climate change

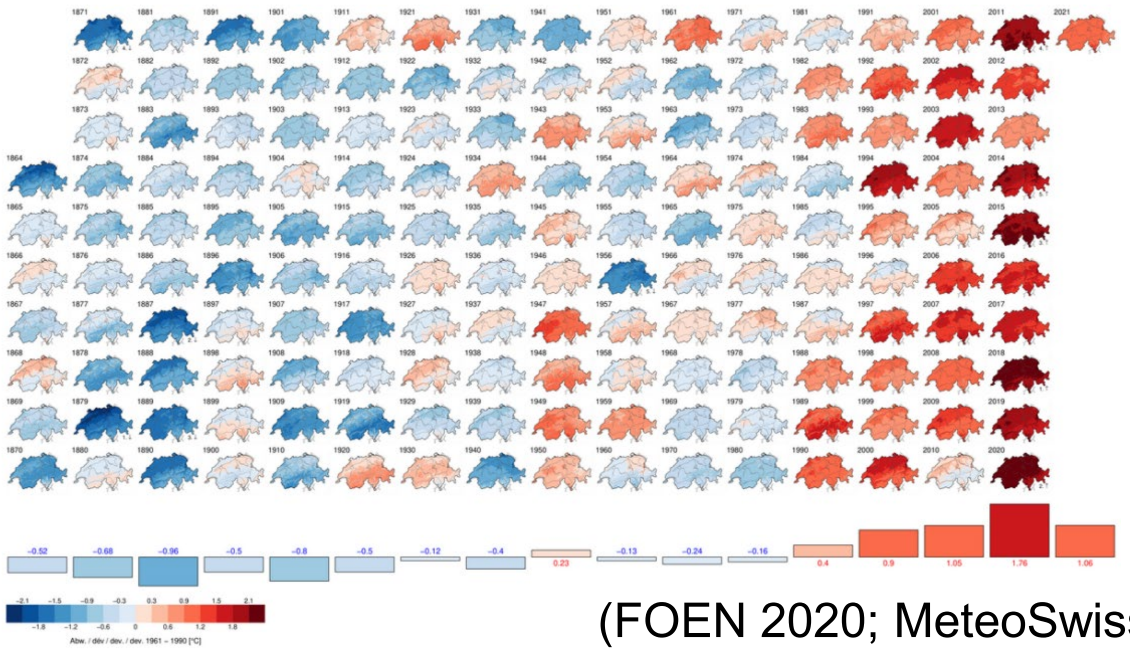


- Agriculture contributes about 13%, CH_4 and N_2O, livestock, manure/slurry, soils
- Trend: –14% since 1990
- Food contributes about 20-30%

➢ Agriculture = „driver of CC"

- Annual average temperatures: +2.1 ºC since 1864 (global: +0.9 º)
- Precipitation: ±, seasonal droughts
- Future: warm and dry, esp. in summer

➢ Agriculture = „driven by CC"



(FOEN 2020; MeteoSwiss 2022)

Drought changes species composition in grasslands

Grassland: 70% of Swiss agricultural area

- **Increased weed pressure**
- **Change in species composition**
- **Change in forage quality**

(Gilgen & Buchmann 2009; Gilgen et al. 2010)

Drought reduces yields in grasslands and croplands

- **Up to 30% reduction in yields, highly site-specific**
- **Fast recovery after drought ceased, i.e., after next rainfall event → high resilience**

➢ **High species diversity can reduce profit reductions in grasslands**

(Gilgen & Buchmann 2009; Prechsl et al. 2015; Finger et al. 2013; Schaub et al. 2020)

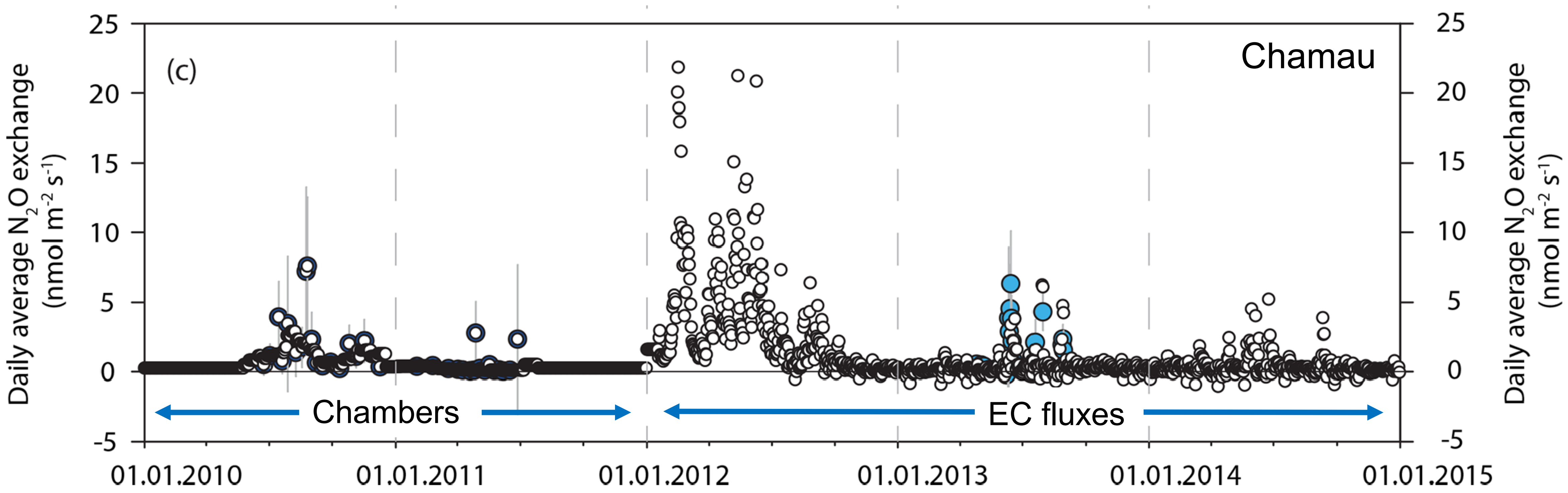
Grassland = C sink

- CO_2 fluxes depend on management and environment
- Over 16 years, C sink of about 0.7 t C/ha/yr (renewal ☹; 0.9 t C/ha/yr), validated with soil C stocks

➢ Avoid renewal, rather direct seeding

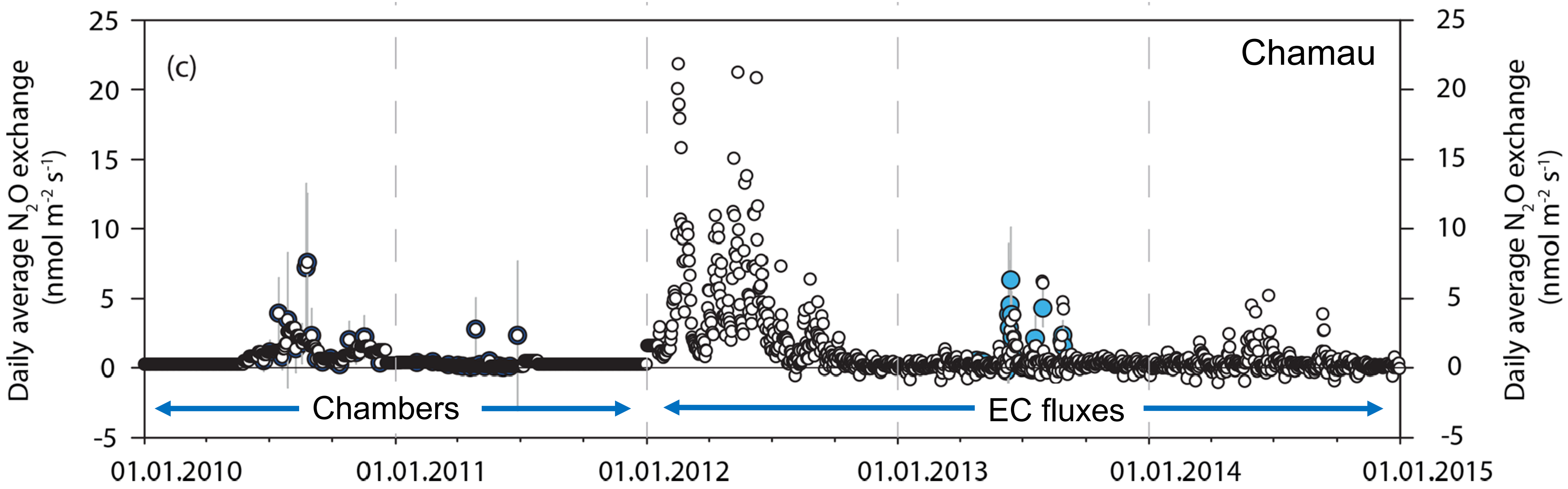
(Feigenwinter et al., rev.)

Grassland renewal: N_2O fluxes overcompensate CO_2 fluxes



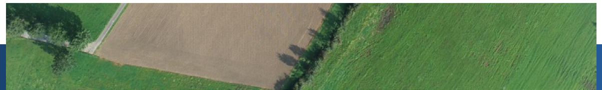
Merbold et al. (2020)

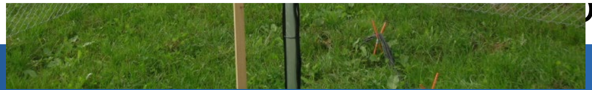
Grassland renewal: N_2O fluxes overcompensate CO_2 fluxes



Very large N_2O fluxes during renewal year, not only right after event

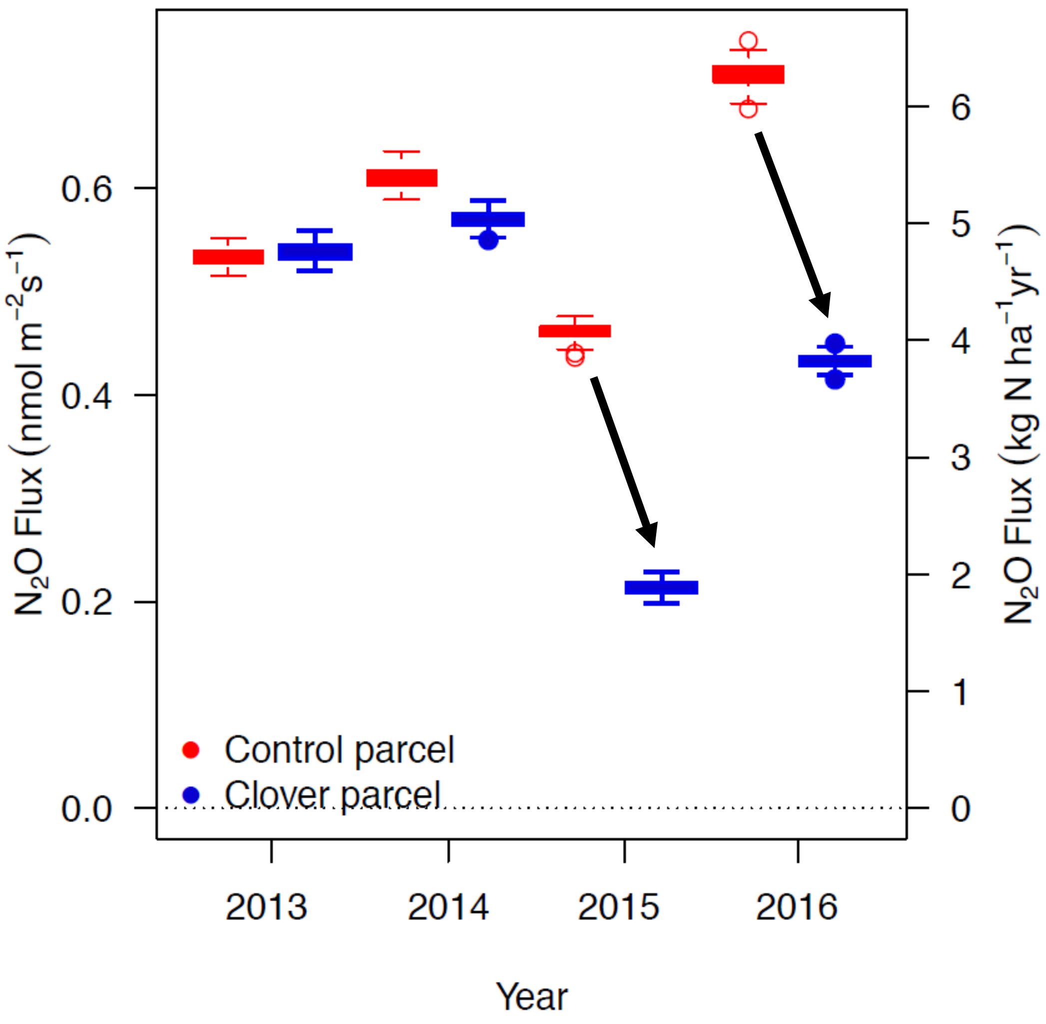
- ➢ **One sward renewal event in 6 to 7 years sets off a 5-yr CO_2eq sink**
- ➢ **Also in agriculture, no permanency of previous C sequestration in soils**

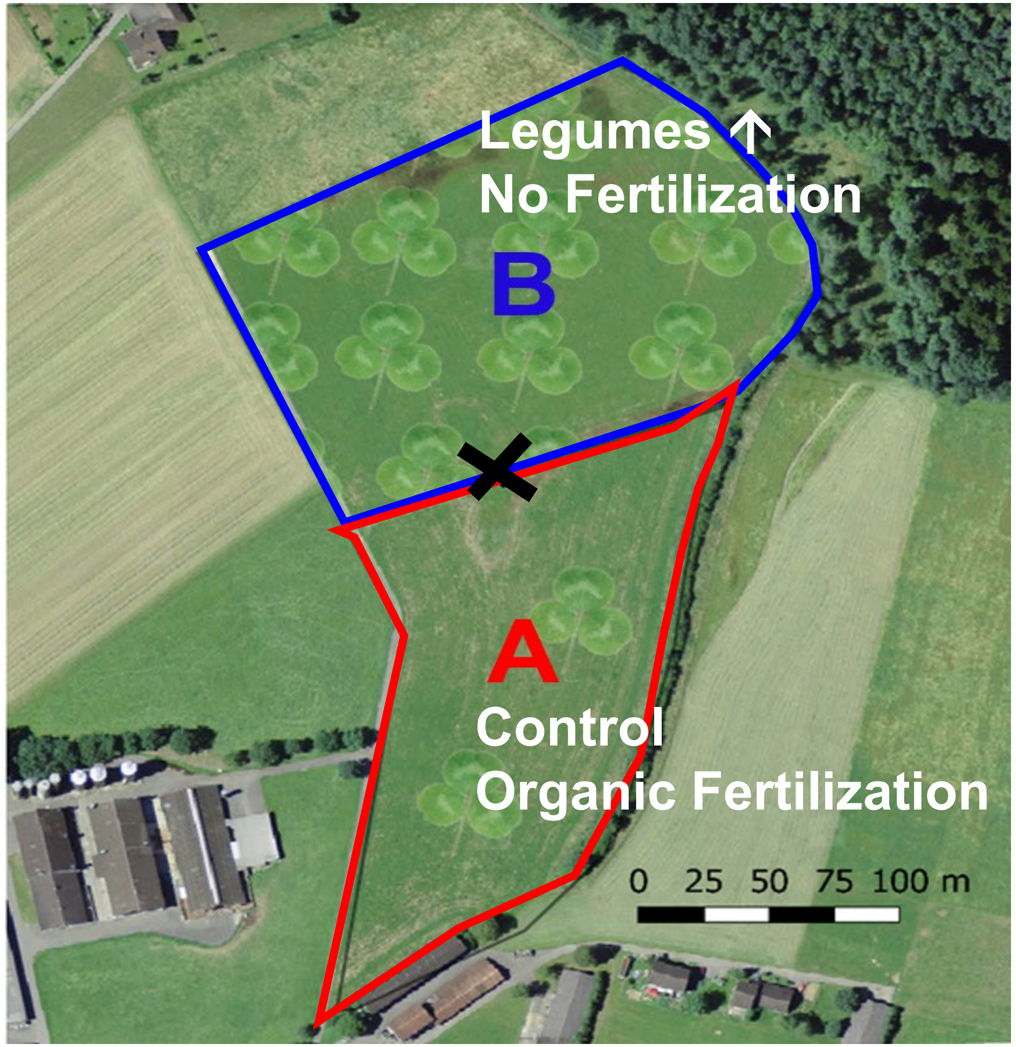




et al. (2020)

Legumes for N_2O Mitigation? Yes!





(Fuchs et al. 2018; Feigenwinter et al., subm.)

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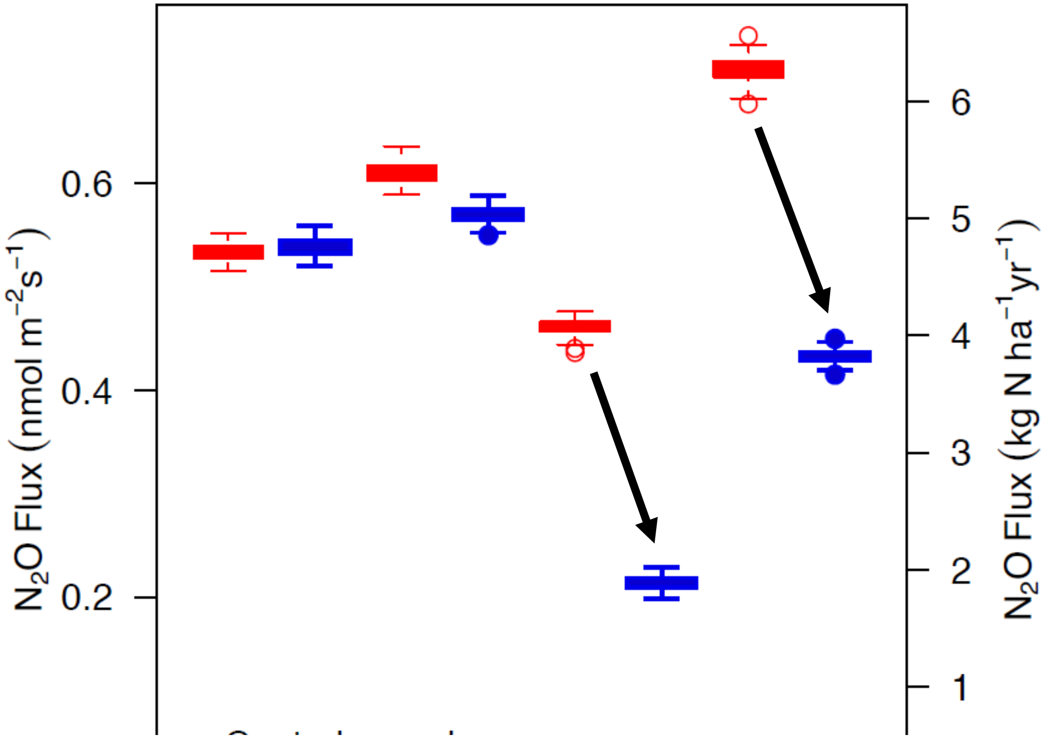
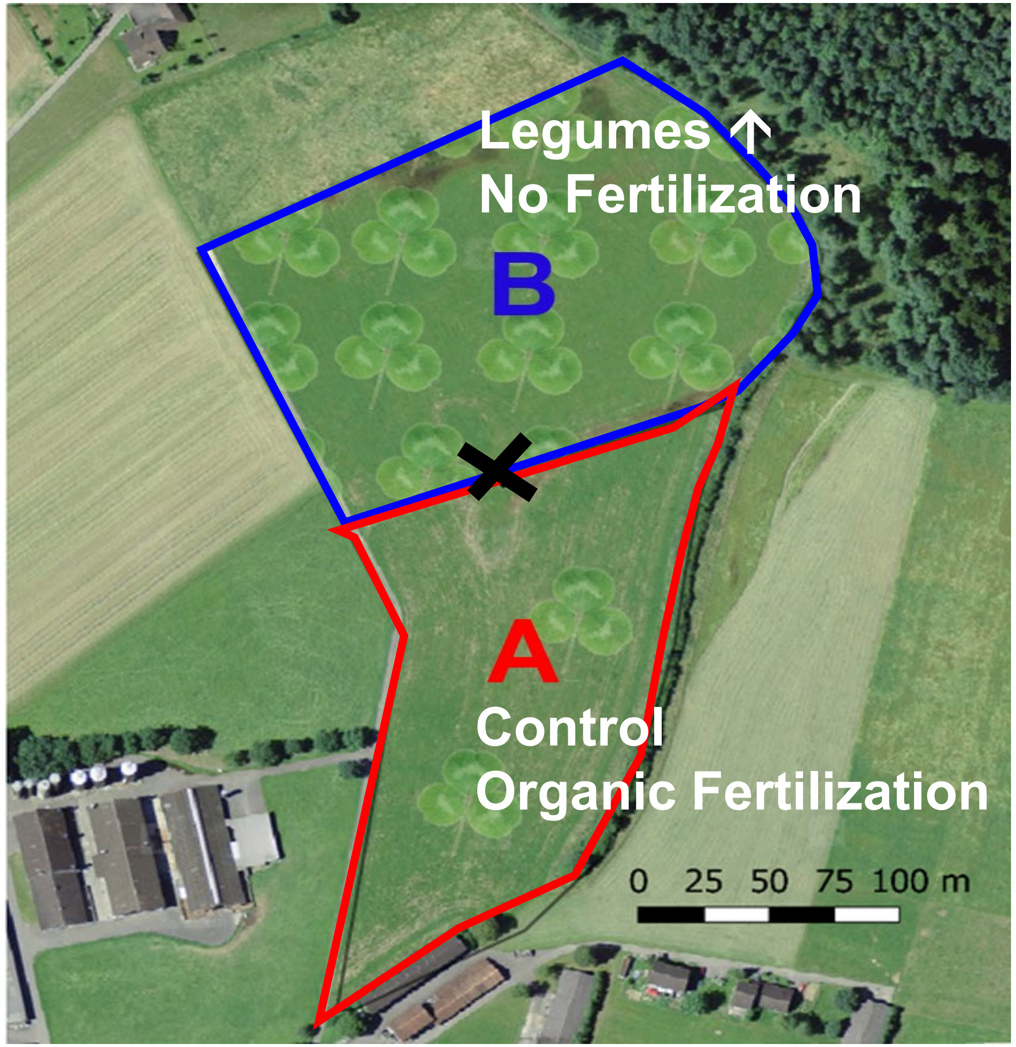


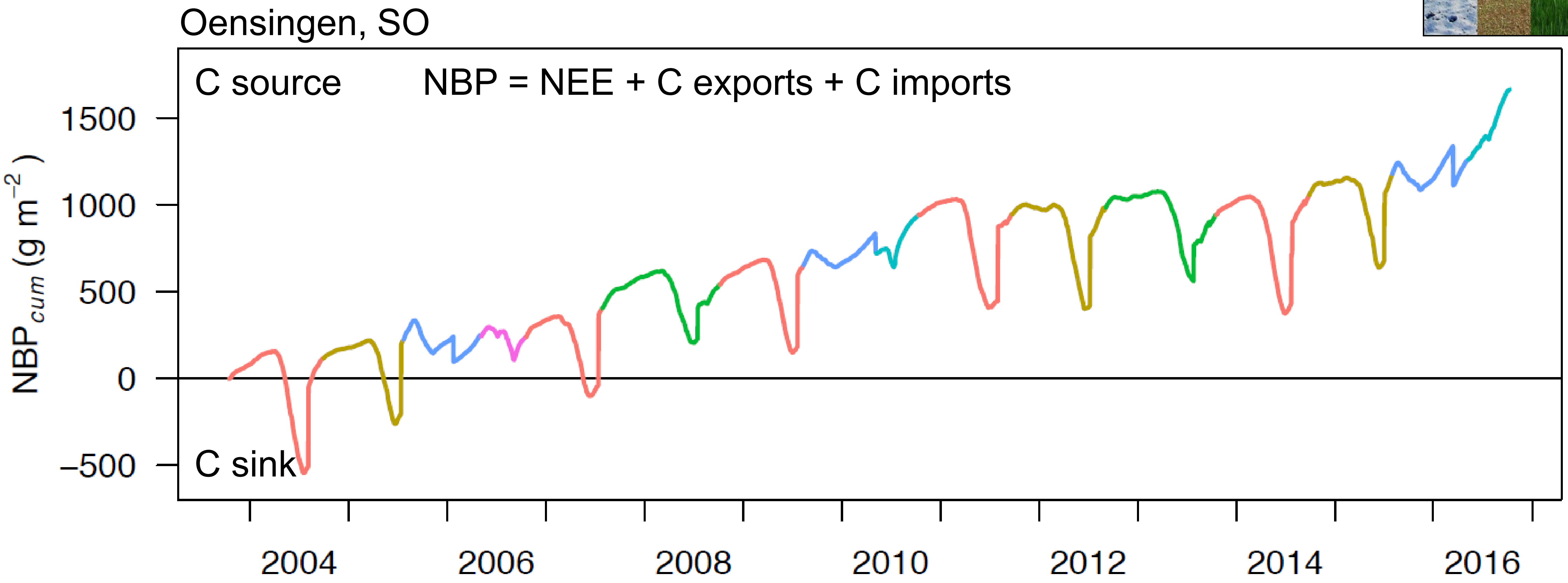


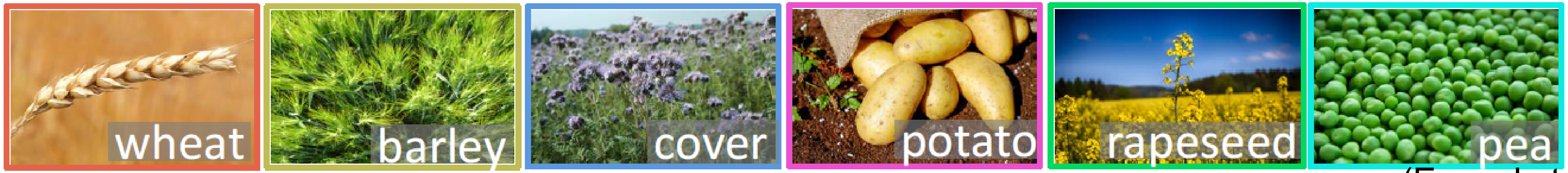
Higher fraction of legumes in sward:

- **40 to 53% lower N_2O emissions**
- **10% (to 30%) lower yields, but higher quality**
- **supporting biodiversity**

(Fuchs et al. 2018; Feigenwinter et al., subm.)

Cropland = CO_2-Source





(Emmel et al. 2018)

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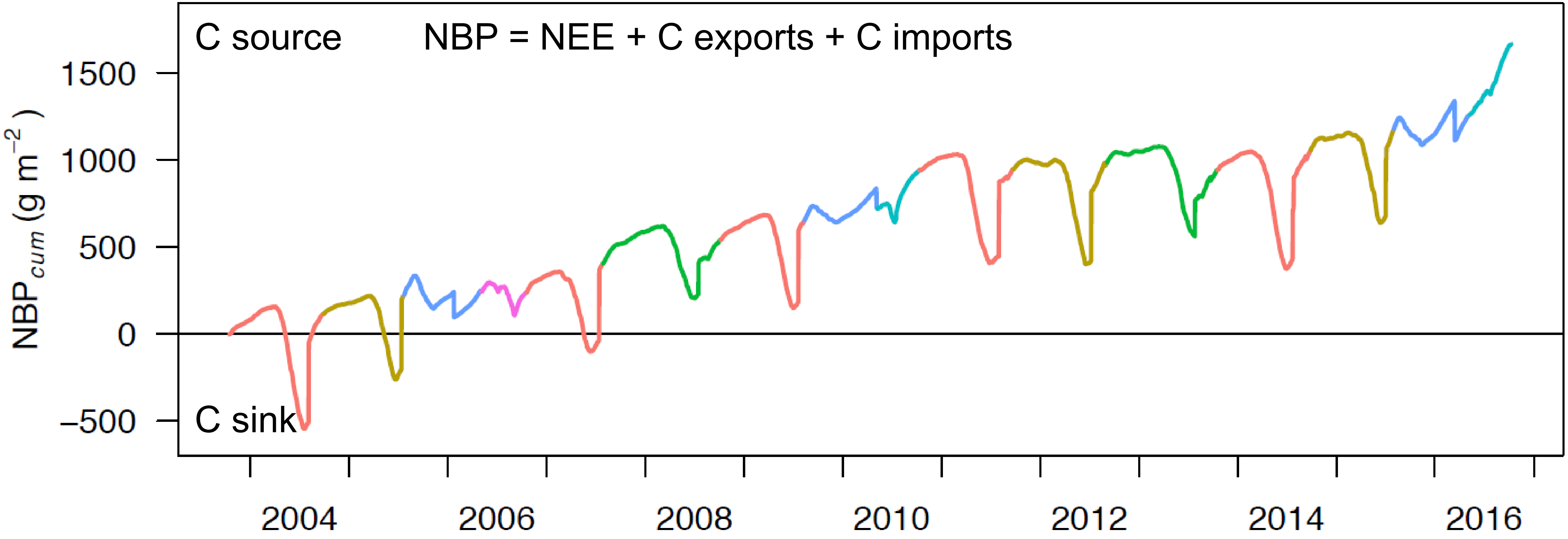
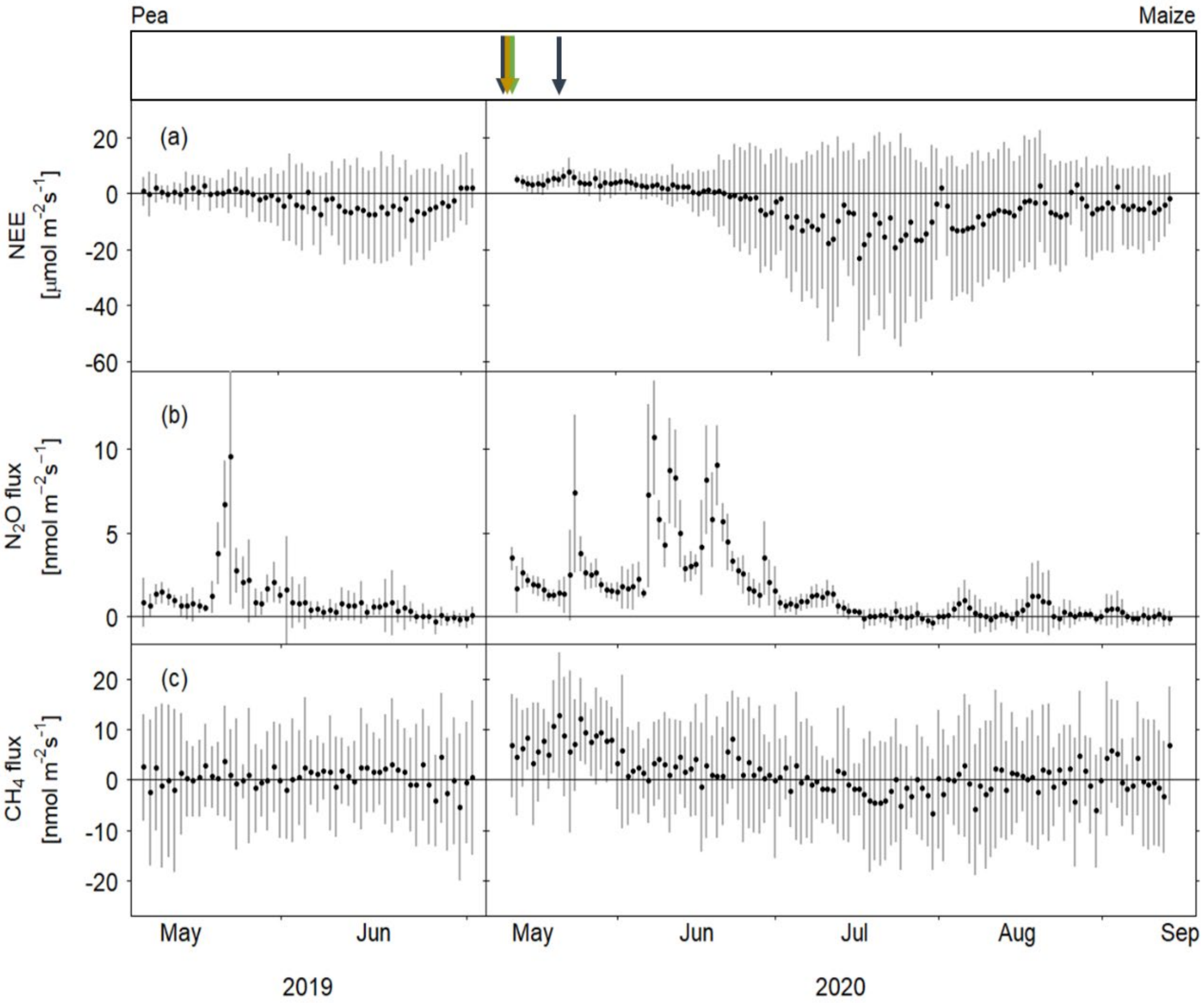


- **Cover crops & organic fertilizer reduce C losses**
- **Over 13 years, C source of about 1.3 t C per ha & yr, validated with soil C stocks**

➢ **Options to reduce C loss from Swiss croplands are limited**

(Emmel et al. 2018)

Cropland = N_2O-Source



Pea

- 1.4 kg N_2O-N ha^{-1}
- EF of 1.5%

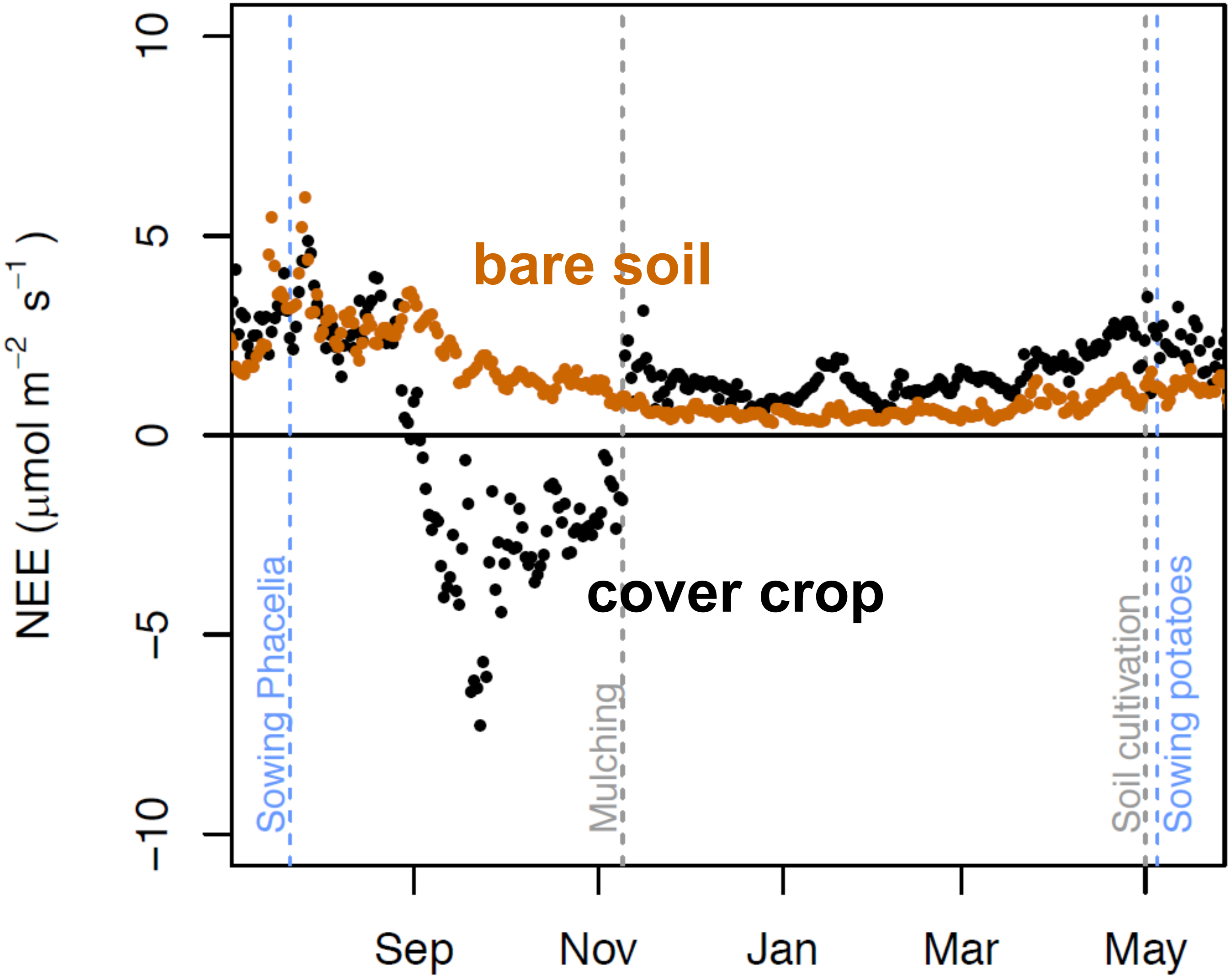
Maize

- 4.8 kg N_2O-N ha^{-1}
- EF of 4.4%

- **N_2O fluxes very dynamic**
- **N_2O peaks >10 nmol m^{-2} s^{-1}**
- ➢ **EF considerably higher than IPCC Tier 1**
- ➢ **Plant demand-adapted fertilization needed**

(Maier et al. 2022)

Cover crop is better than bare soil



C Loss ☹

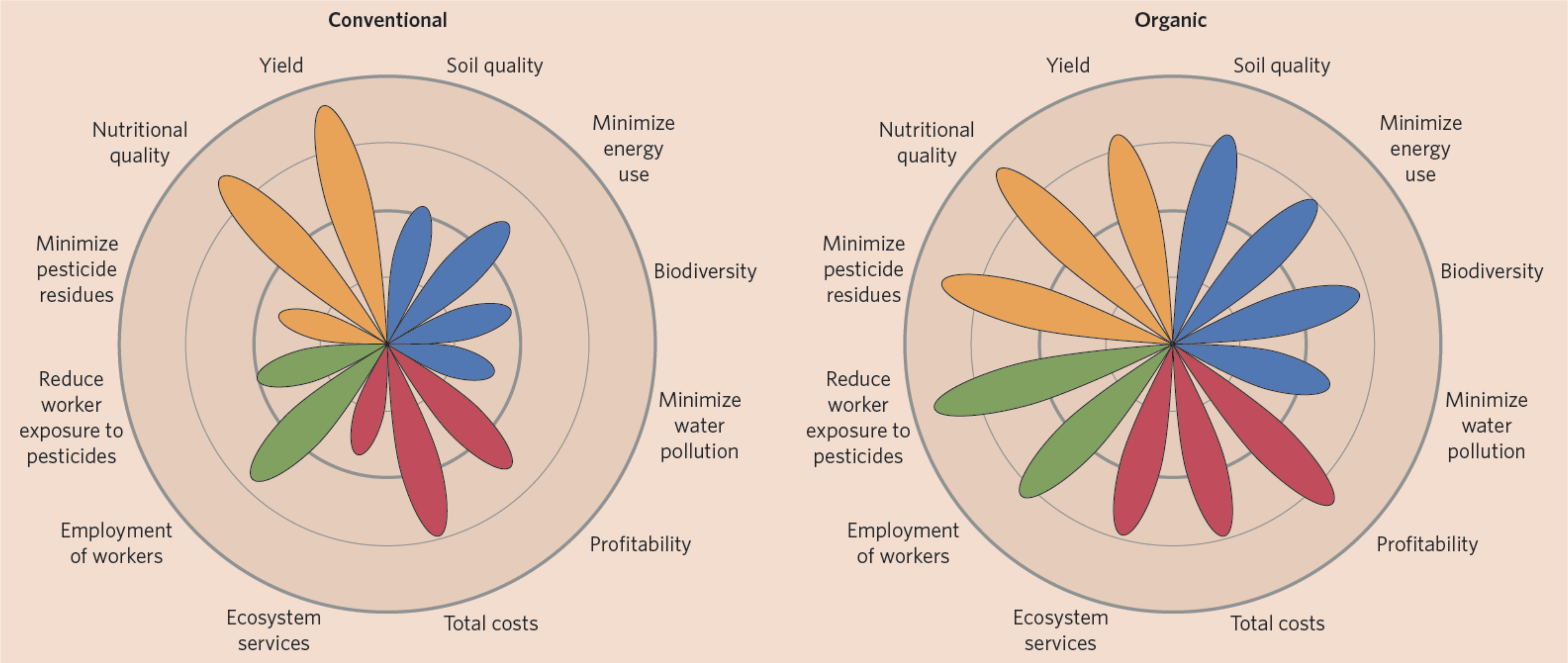
C Uptake ☺

- **During periods with bare soils, high CO_2 and N_2O losses as well as NO_3^- leaching**

➢ **Avoid bare soil periods**

(Emmel et al. 2018; Maier et al., subm.)

Organic agriculture: weigh trade-offs against each other



- **Organic agriculture has many benefits, e.g., lower GHG emissions, higher soil C stocks and C sequestration rates**
- **But: lower yields (–20%), depending on crop**

(Gattinger et al. 2012; Skinner et al. 2014; Reganold und Wachter 2016)

Towards a Sustainable agriculture

Croplands

- Options to reduce C loss from temperate croplands are limited → Paris Agreement, 4‰ Initiative ☹
- Cover crops stabilize C budget and reduce N_2O emissions → Crop rotations
- High N_2O emissions when plants are small/absent → Avoidance of bare soil periods, plant growth-adapted N fertilization, change in timing of management interventions, precision farming

Grasslands

- Sward renewal (glyphosate, plowing, reseeding) resulted in very large N_2O losses, and thus GHG source → Overseeding instead of renewals with herbicide and plowing
- Organic fertilization (with related C & N imports) needed for C sink → integrated production
- Less/Substitution of organic fertilization with increased fraction of legumes reduced N_2O fluxes and NO_3^- leaching, but also C sink

➢ **Need to address trade-off between N_2O loss and CO_2 sink**, e.g., by decreasing livestock numbers on farm to decrease amount of farmyard manure and slurry to be distributed

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Thanks for listening!

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