TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

SUSALPS
Sustainable use of alpine and pre-alpine grassland soils in a changing climate

Impact of climate change on grassland water, carbon and nitrogen cycling in the TERENO preAlpine Observatory

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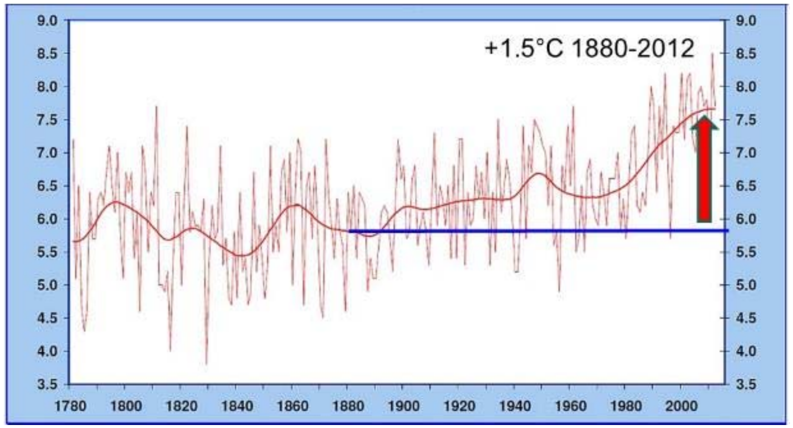
Motivation

Grassland soils …

- represent 30% of the total agricultural area of Germany
- are the dominating land-use in pre-alpine and alpine regions
- provide economic value via fodder used for milk and meat production
- support key soil functions such as C and N storage, nutrient and water retention, and biodiversity

Soil functions are jeopardized by rapid climate and land-use/ management changes



Main research questions

What are the impacts of climate and land management on

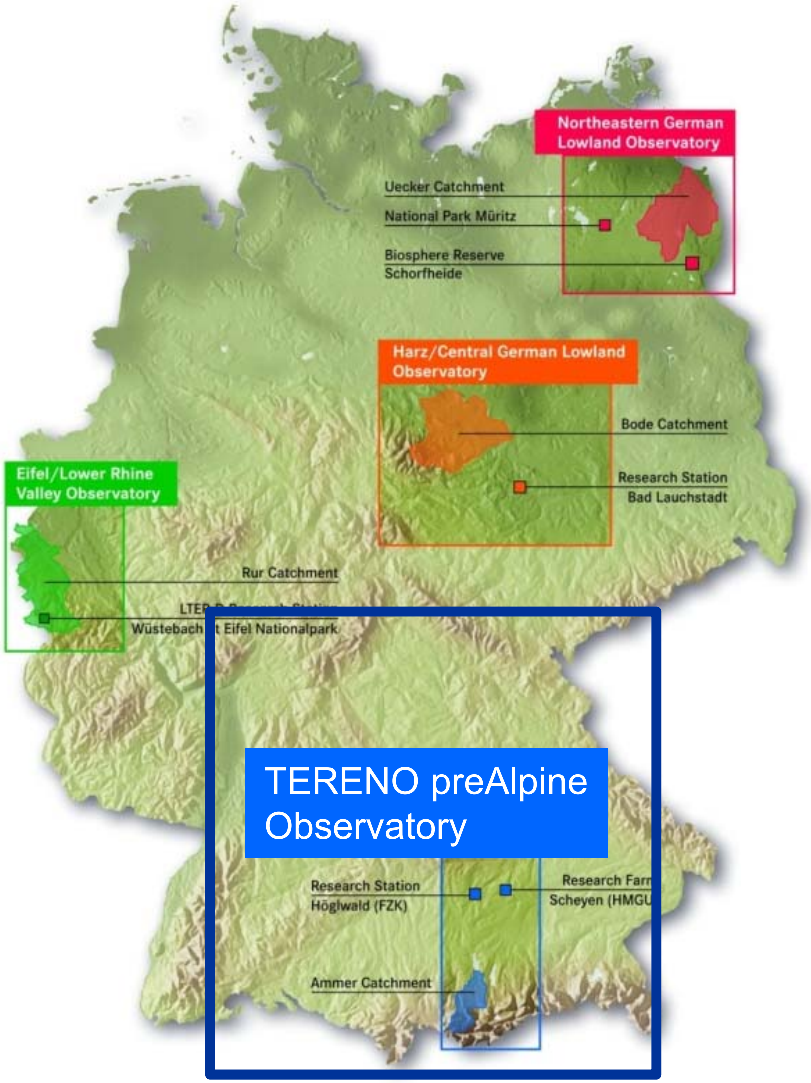
- soil and plant biodiversity, productivity and feed value
- the role of grassland soils as large C/N stores
- GHG (CO_2, N_2O, CH_4) exchange and nutrient retention regulated by plant and soil microbial processes

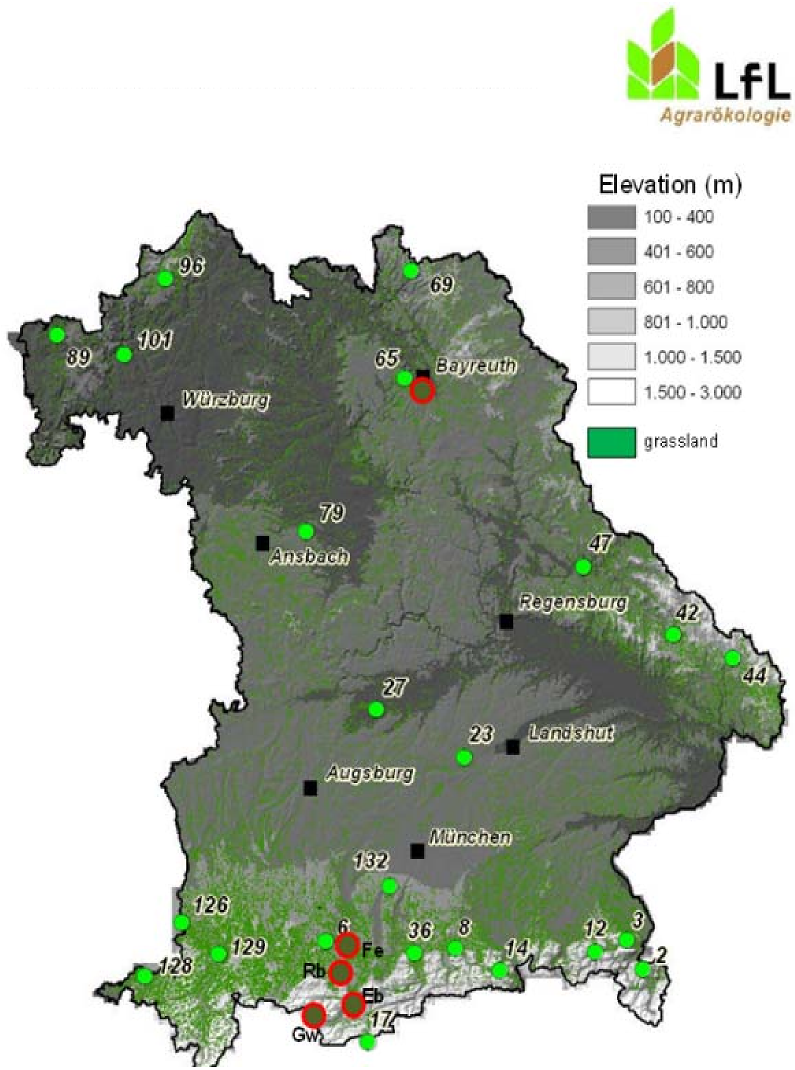
under given socio-economic conditions driving farmers decision making



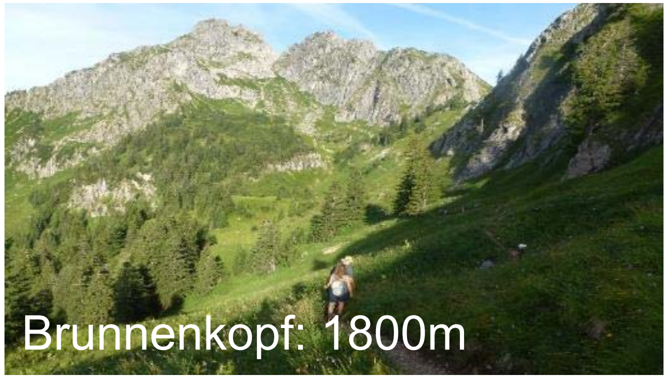


TERENO preAlpine Observatory



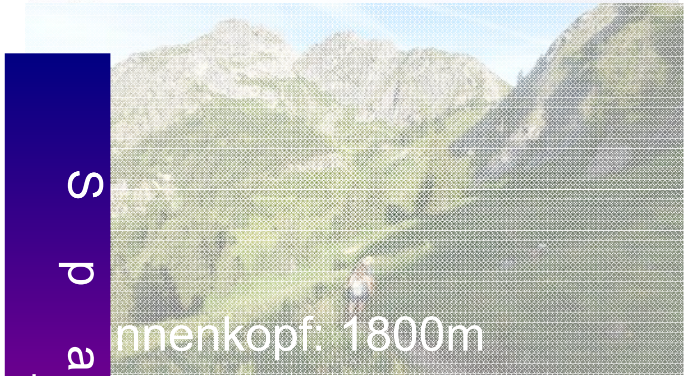


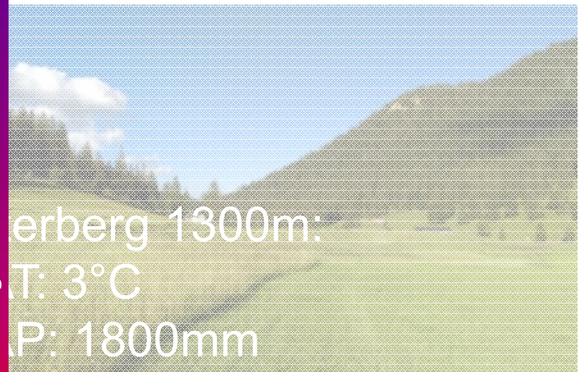
TERENO field sites



Kiese et al., 2018

TERENO field sites





Space for time approach

Lysimeter network along an elevation = climate gradient

Grassland management

<u>intensiv:</u>
4-6 cuts / 4-5 manure applications

1870 kg C / 210 kg N

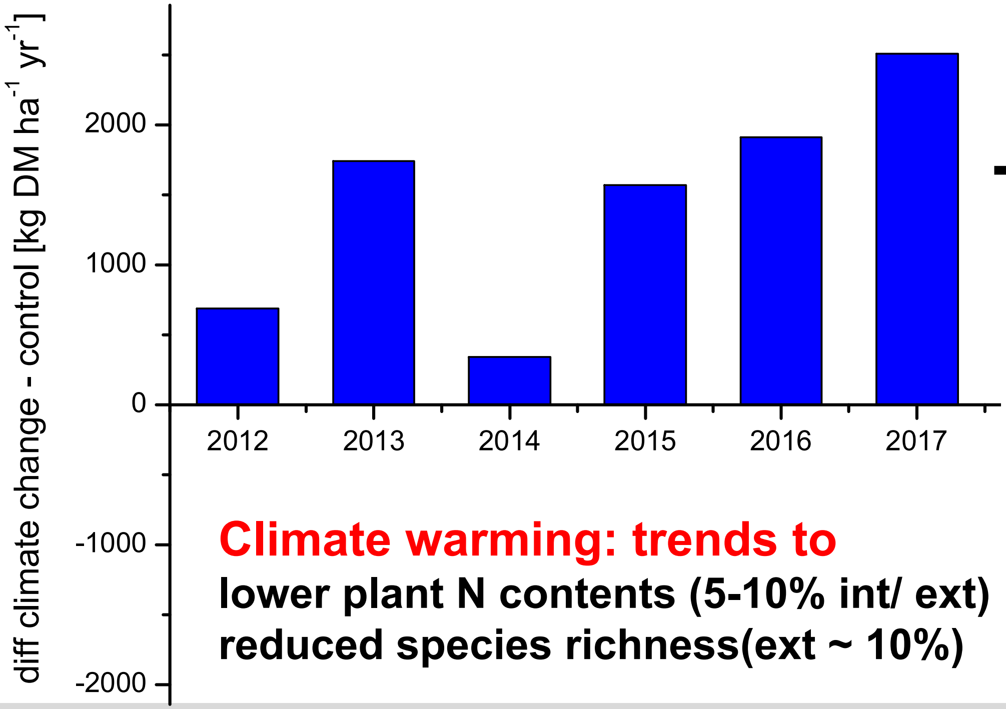
<u>extensiv:</u>
2-3 cuts / 1-2 manure applications

748 kg C / 84 kg N

mean C and N loads of one manure application
374 ± 50 kg C ha^{-1} und 42 ± 10 kg N ha^{-1} (range 28-72)

○ = intensive management **● = extensive management**

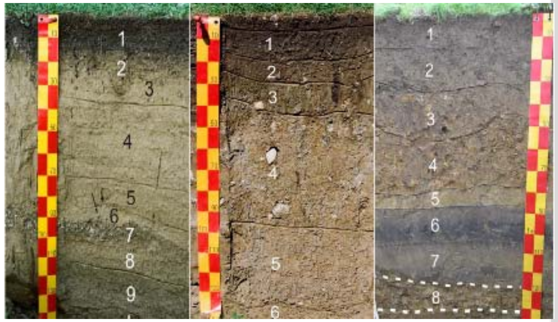
Grassland yields: climate change vs. control



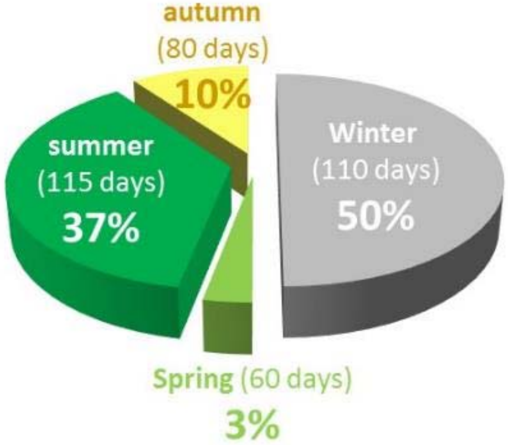
+ 1458 ± 465 kg C ha^{-1} yr^{-1} (+15%)

Climate warming: trends to
lower plant N contents (5-10% int/ ext)
reduced species richness(ext ~ 10%)

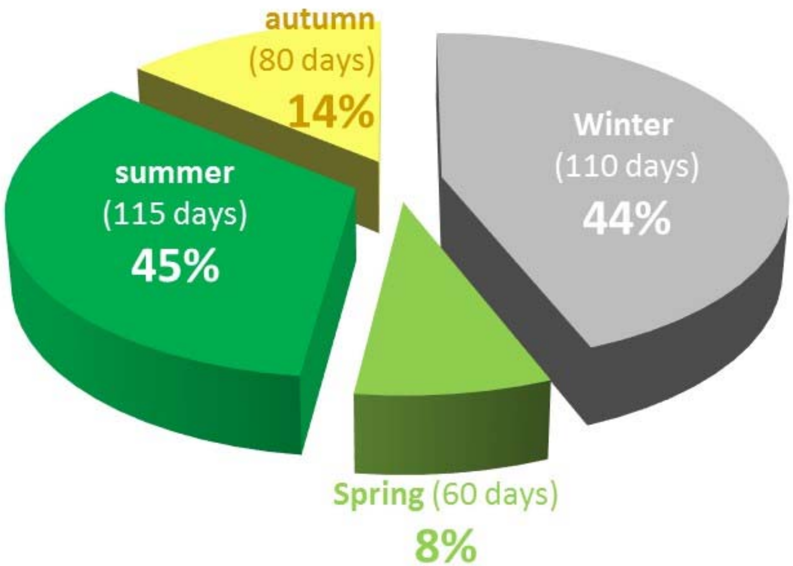
N mineralisation: control vs. climate change



Graswang (860m):
200 kg N ha^{-1} yr^{-1}

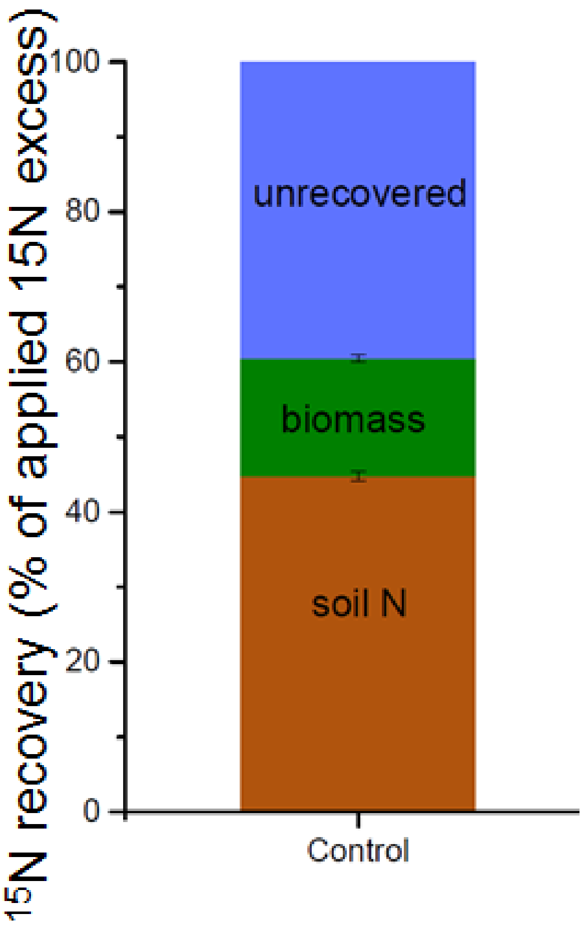


Graswang translocated (+ 2°C, 600m):
500 kg N ha^{-1} yr^{-1}

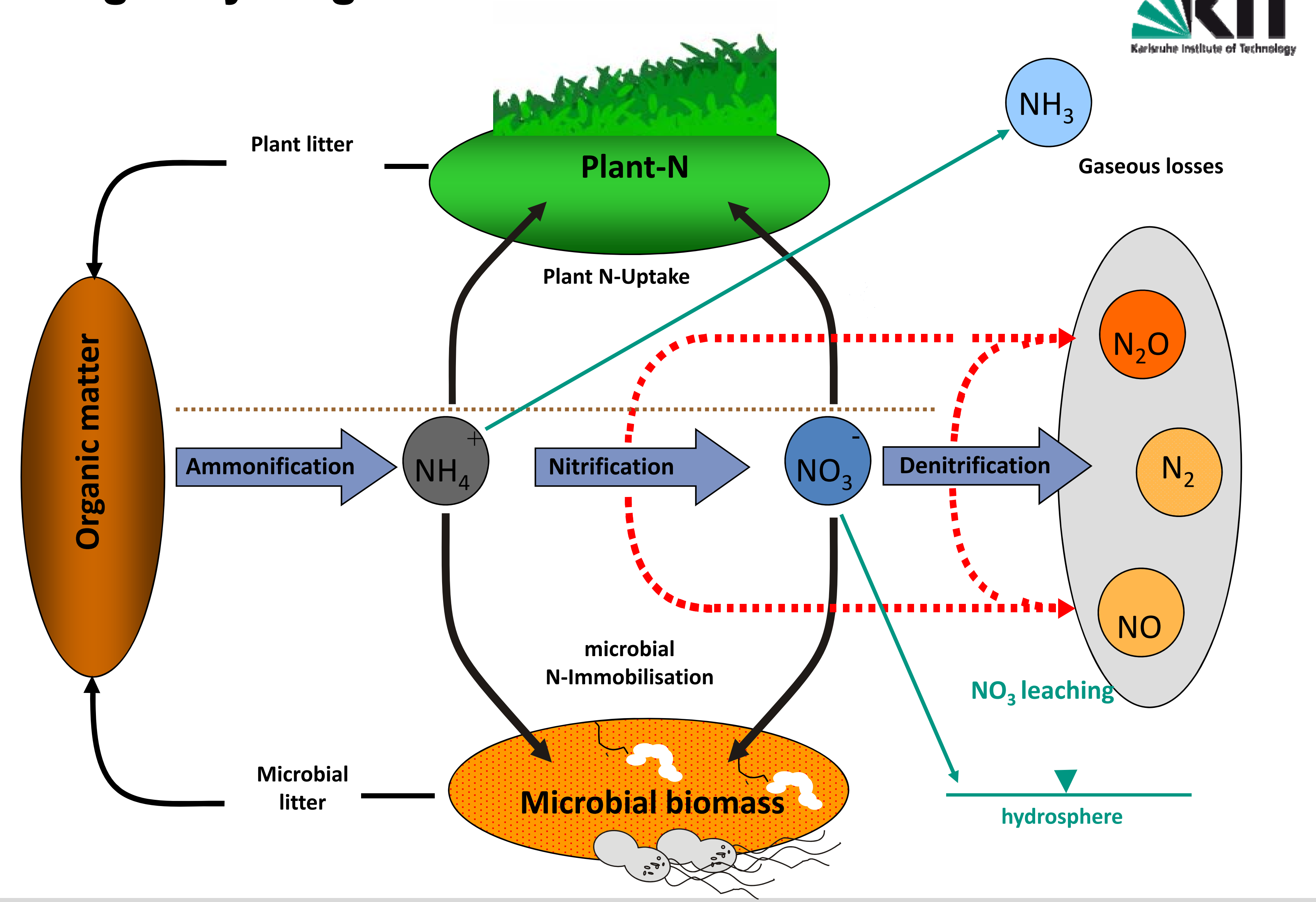


Wang et al., 2016

Manure ^{15}N tracing/ recovery experiment



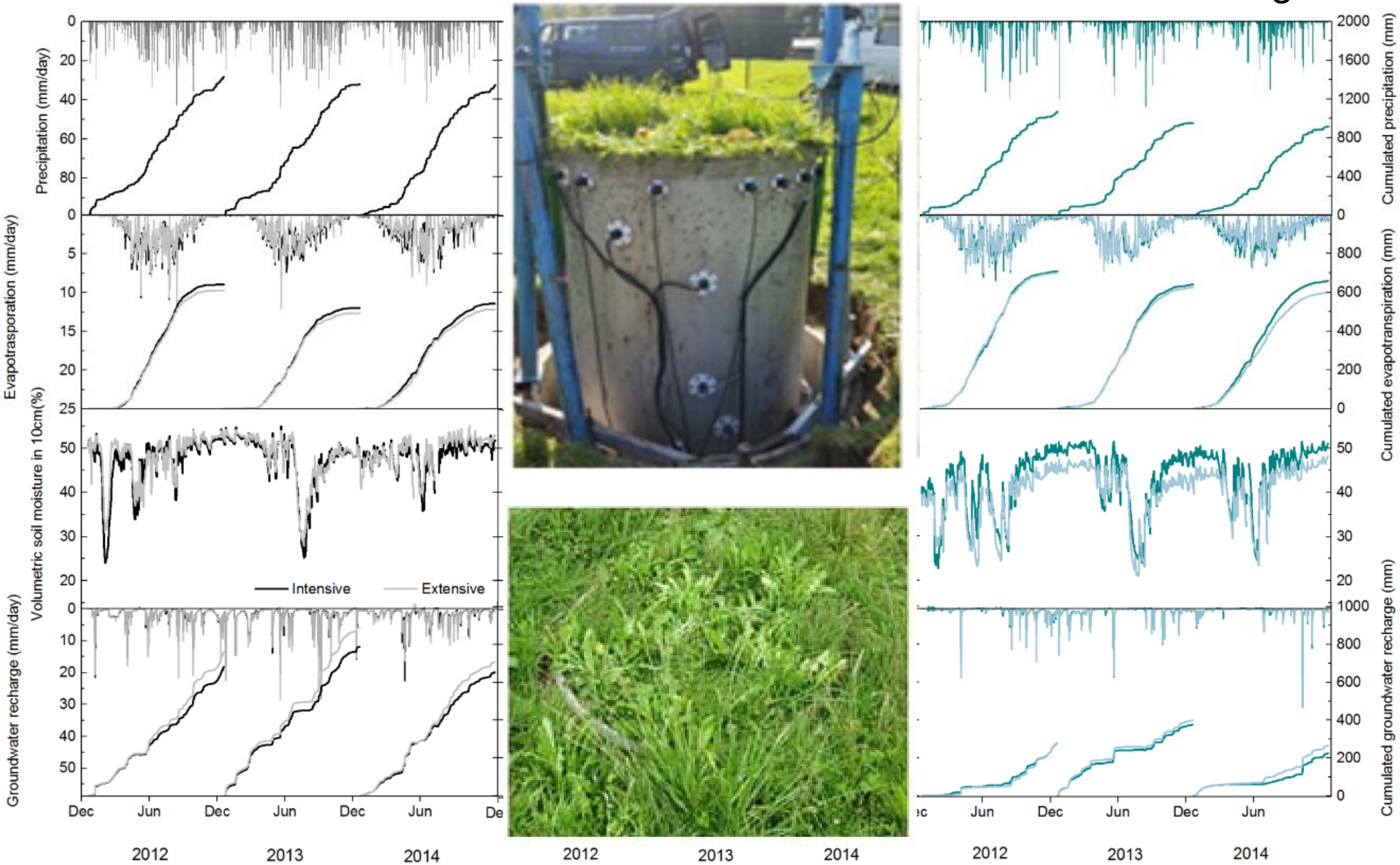
Nitrogen cycling and N losses



Daily cumulative water balance

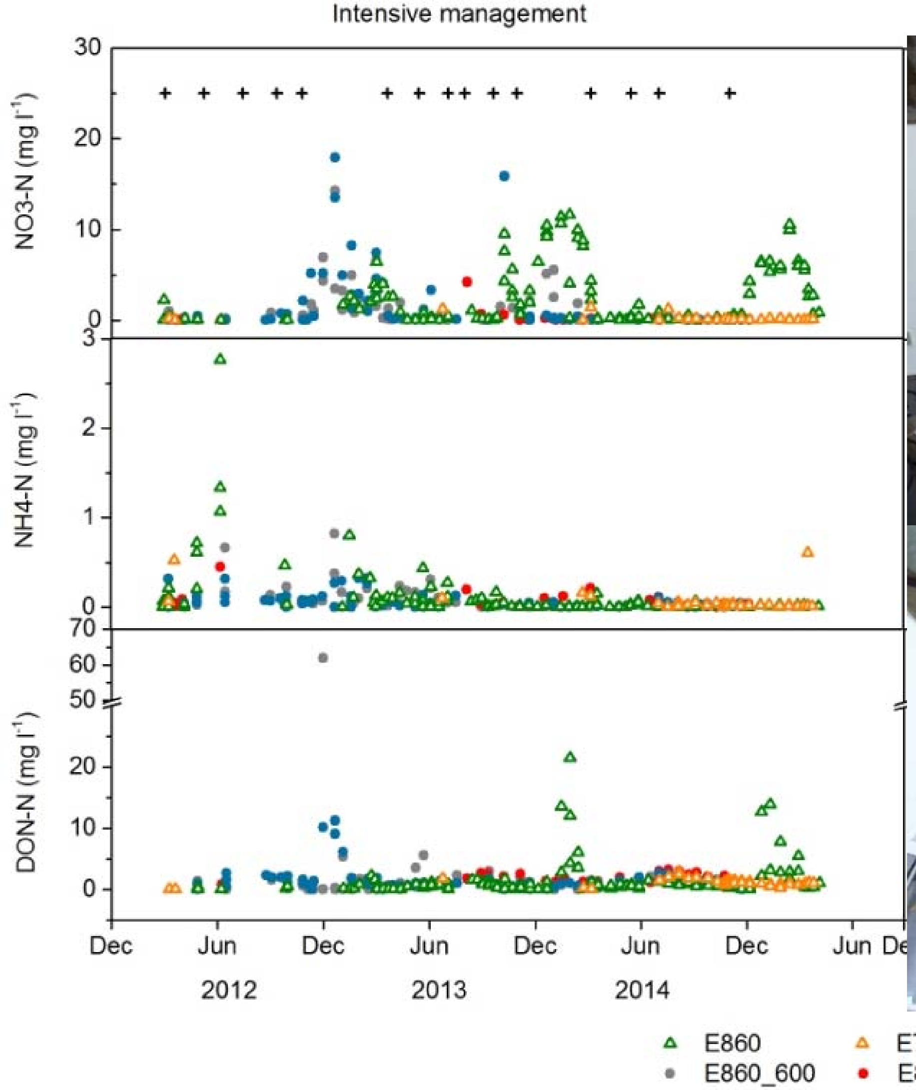
control

climate warming

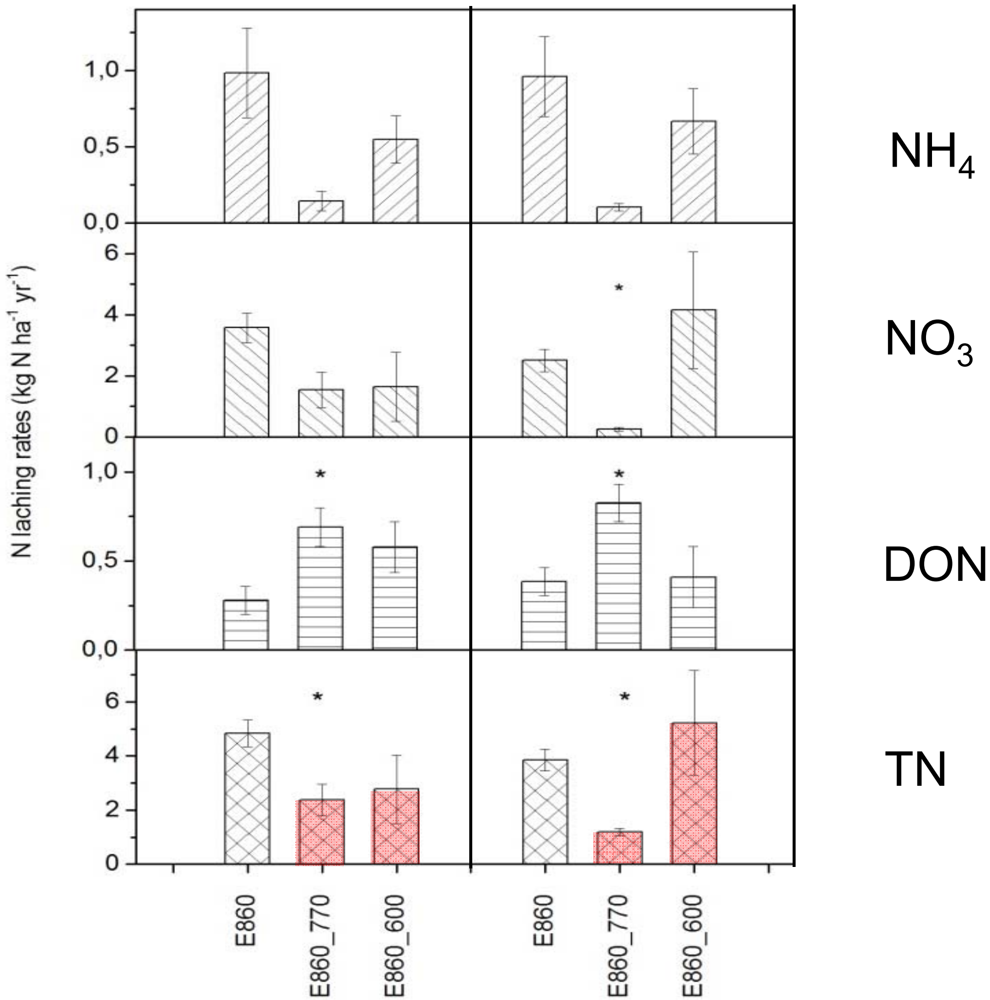


Fu et al., 2017 Env. Poll.

Bi-weekly N concentration in soil water (10cm)



Nitrogen and carbon leaching from grassland soils

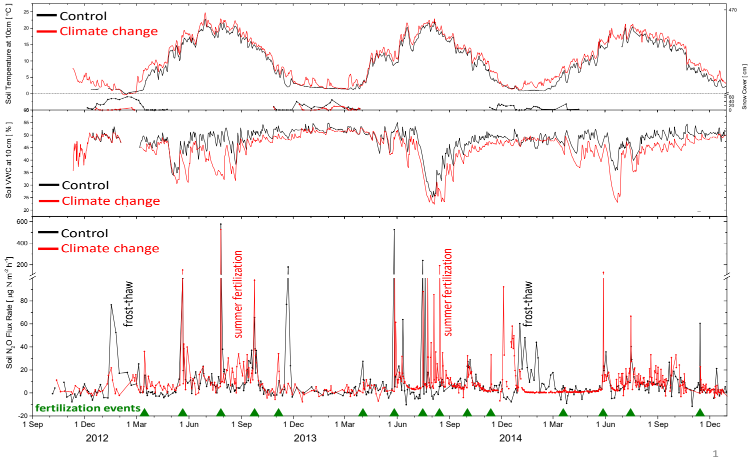


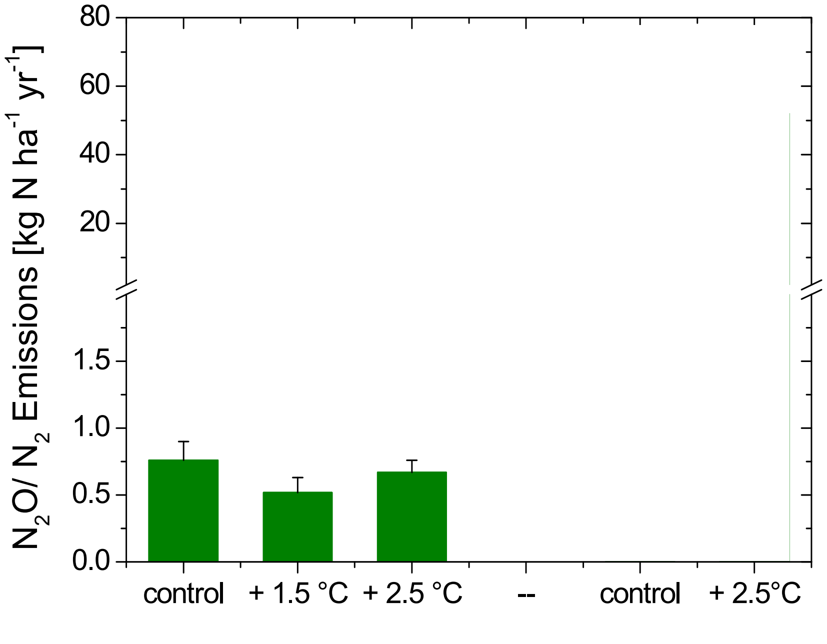
DOC losses
are not affected by management and are overall a minor component in grassland C budgets (<30 kg C ha^{-1})

Increases (40-50%) under climate change are still not relevant

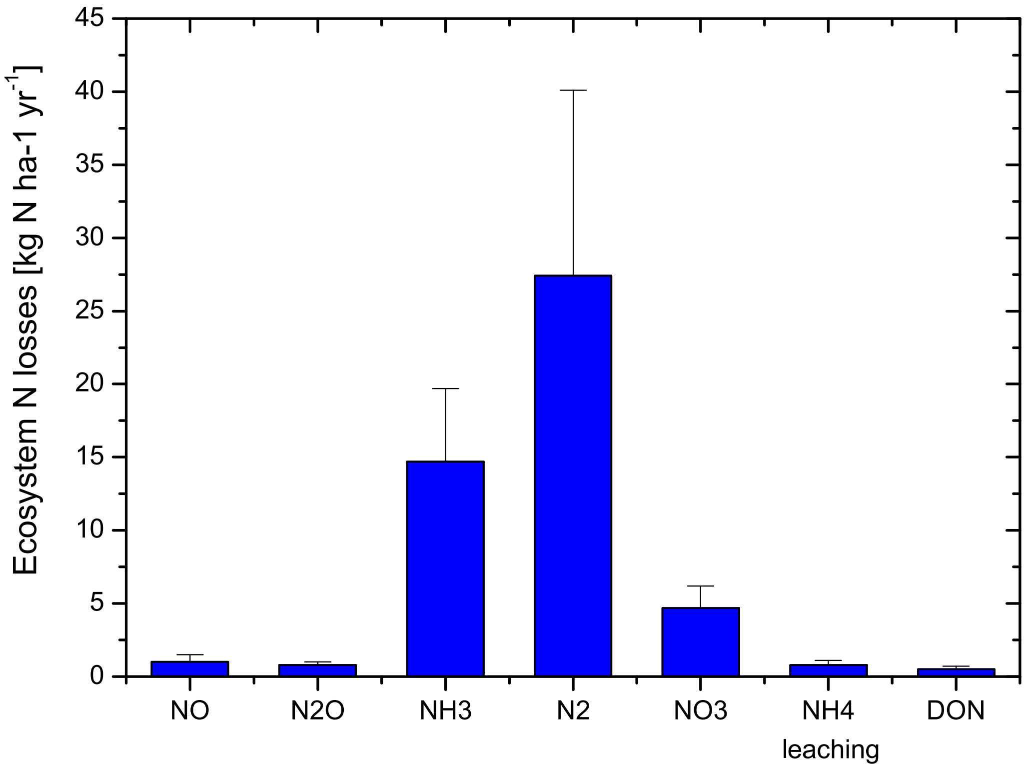
Fu et al., 2017, 2019

N_2O and N_2 emission from grassland sites





Grassland N losses from field and lab studies
(intensive management)

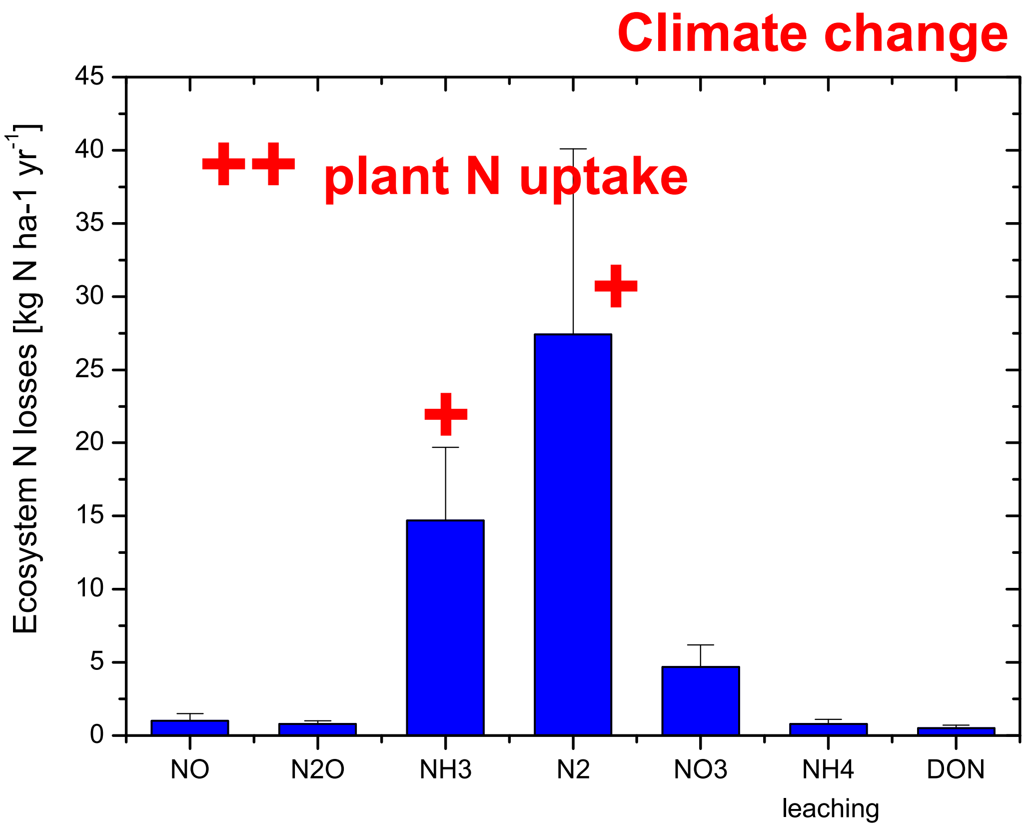


N_2 and NH_3 are dominating N losses, N_2O and NO_3 leaching much lower than in arable systems

N_2 emissions likely an overseen N loss in grasslands

Fu et al., 2017, Zistl-Schlingmann et al. 2019

Grassland N losses from field and lab studies
(intensive management)

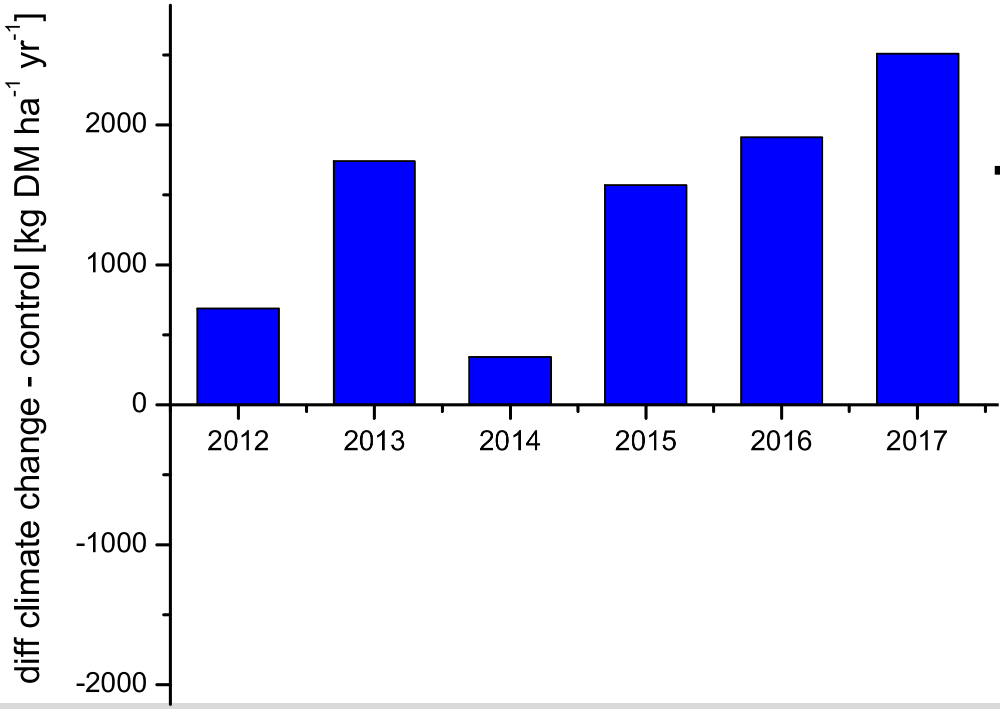


N balance calculations: N manure + deposition < N uptake + N losses indicating soil N mining

Increased losses and N uptake under climate change further enhance this imbalance

Fu et al., 2017, Zistl-Schlingmann et al. 2019

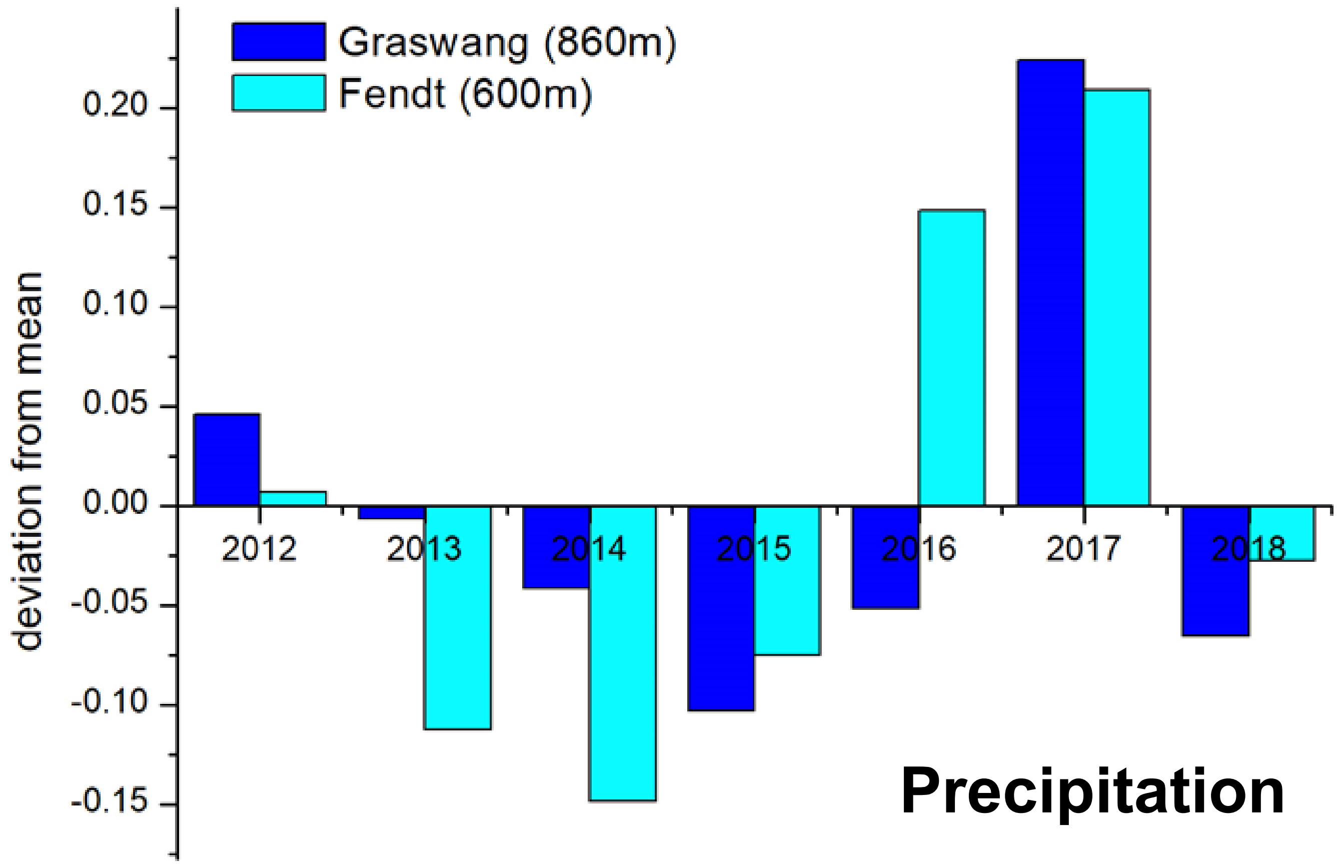
The year 2018



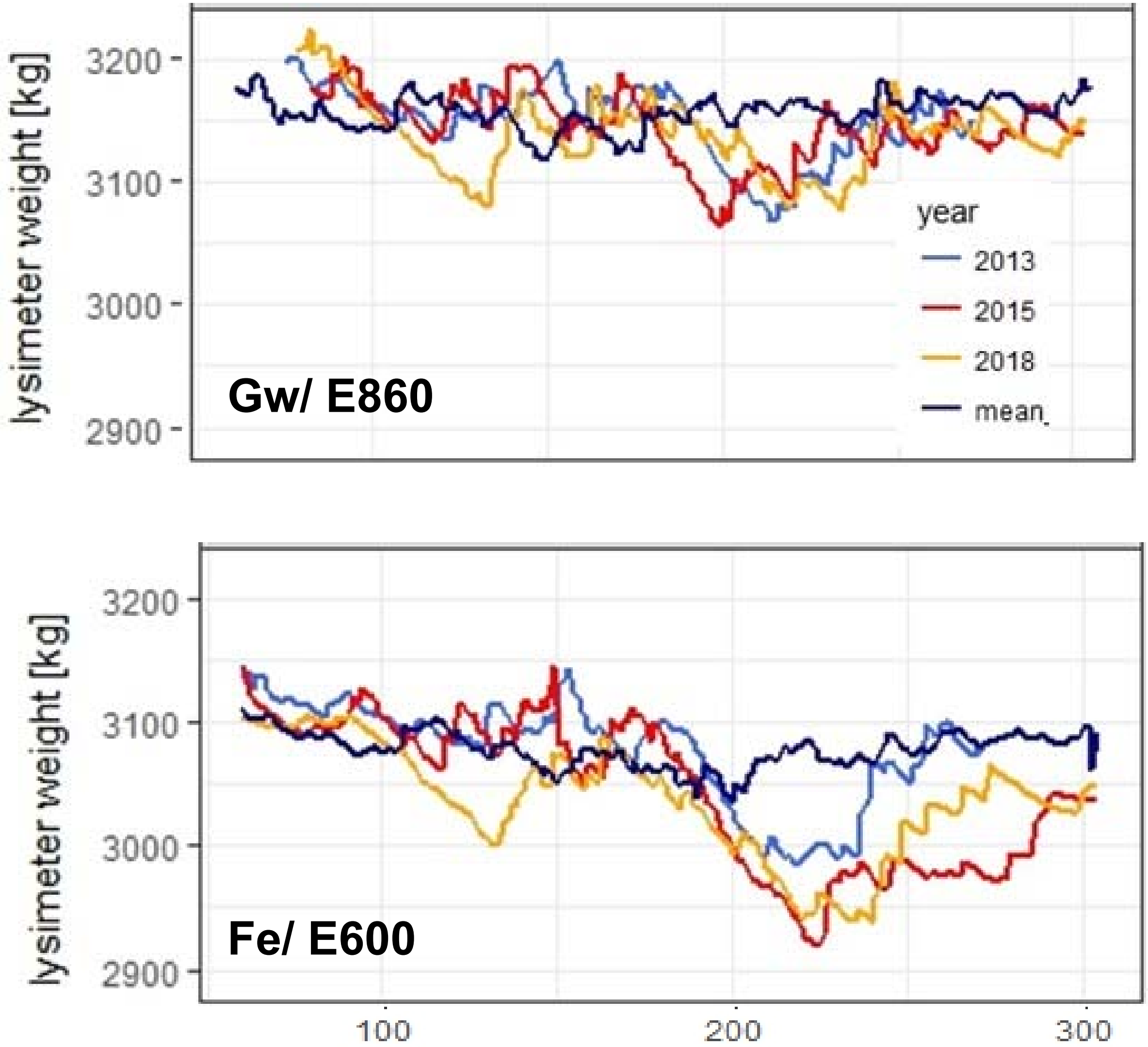
+ 1458 ± 465 kg C ha^{-1} yr^{-1} (+15%)

The year 2018

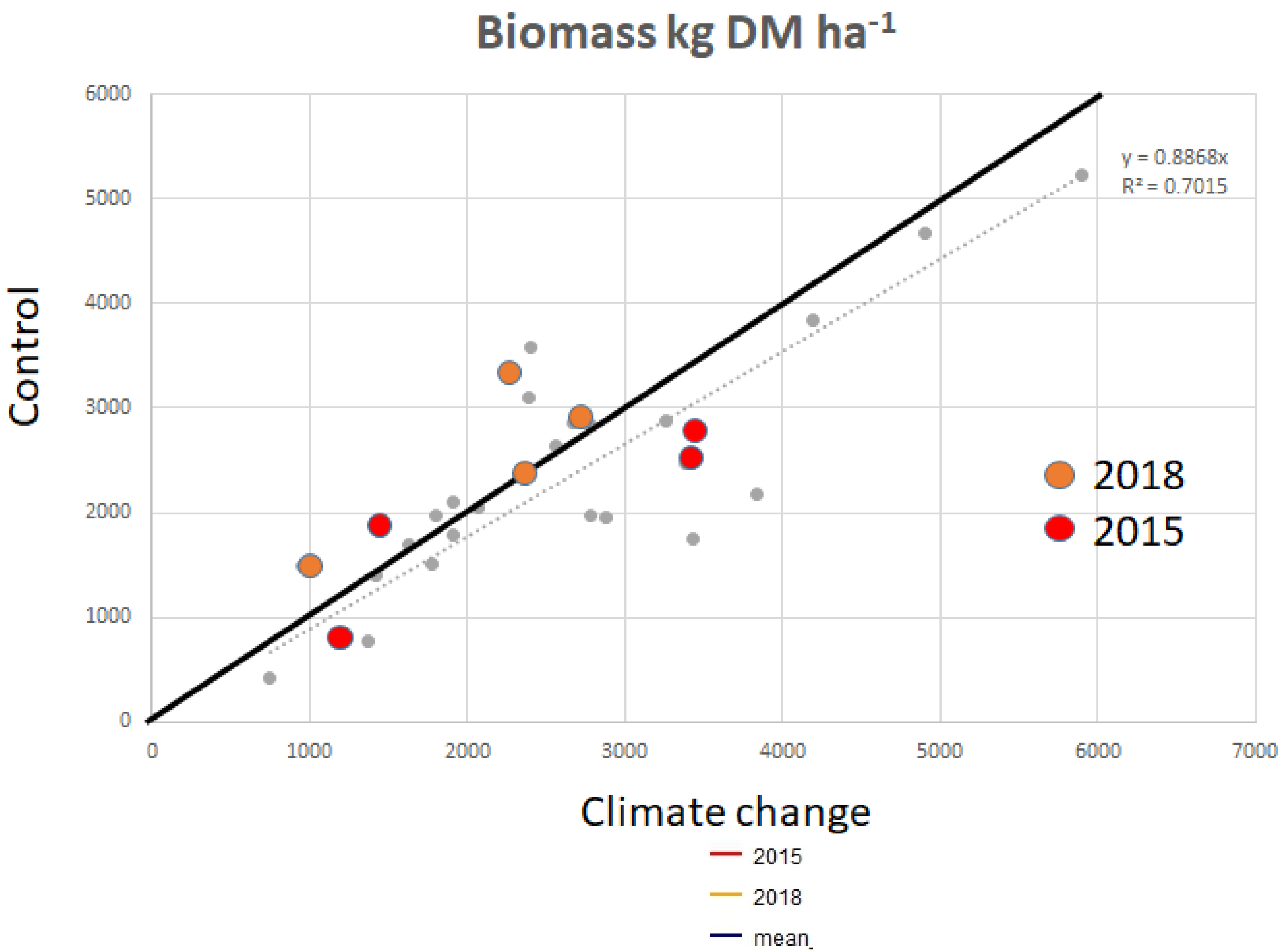
Temperature: Graswang + 0.7°C; Fendt +1.1°C



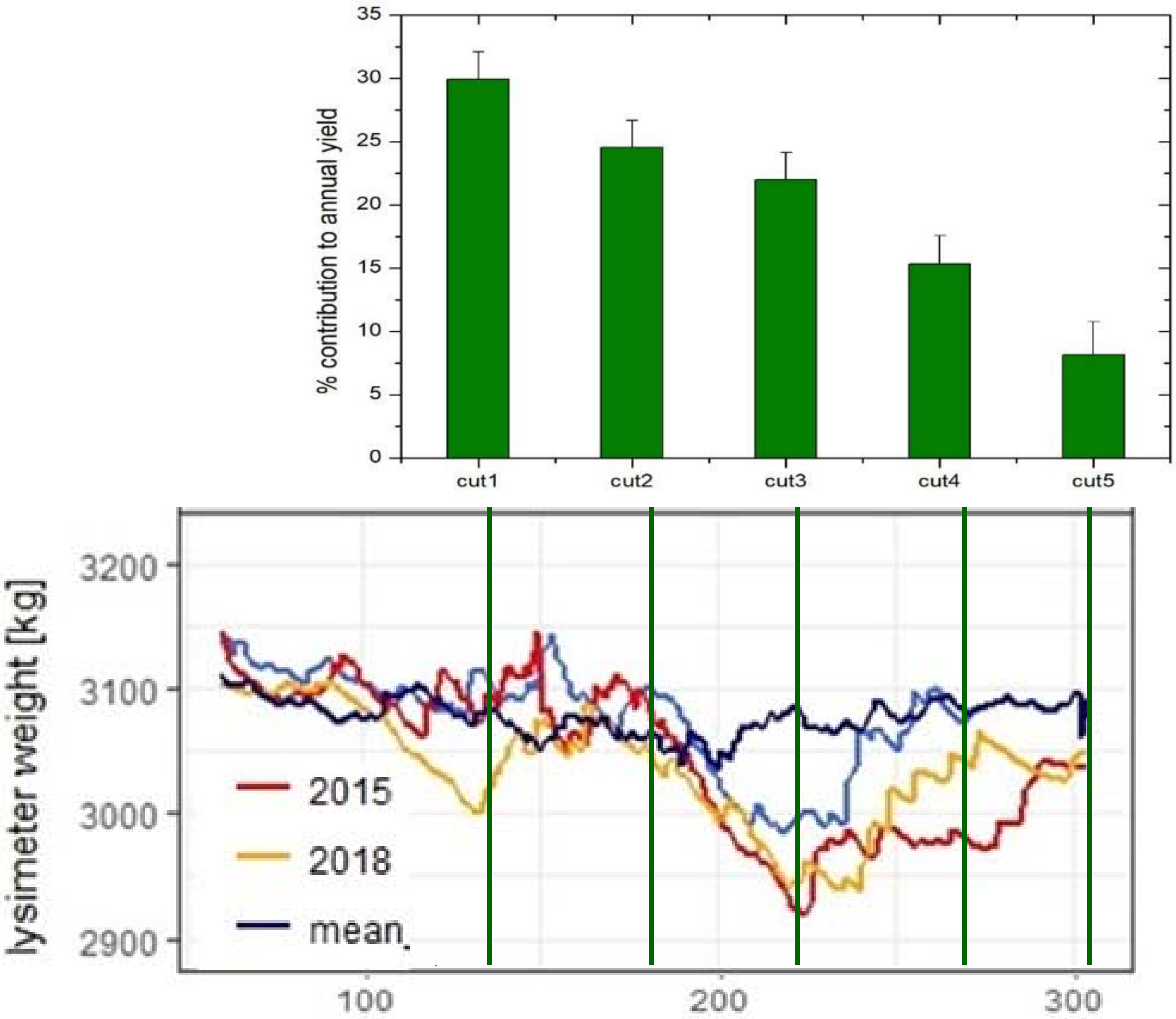
Lysimeter weight = soil moisture in the growing season



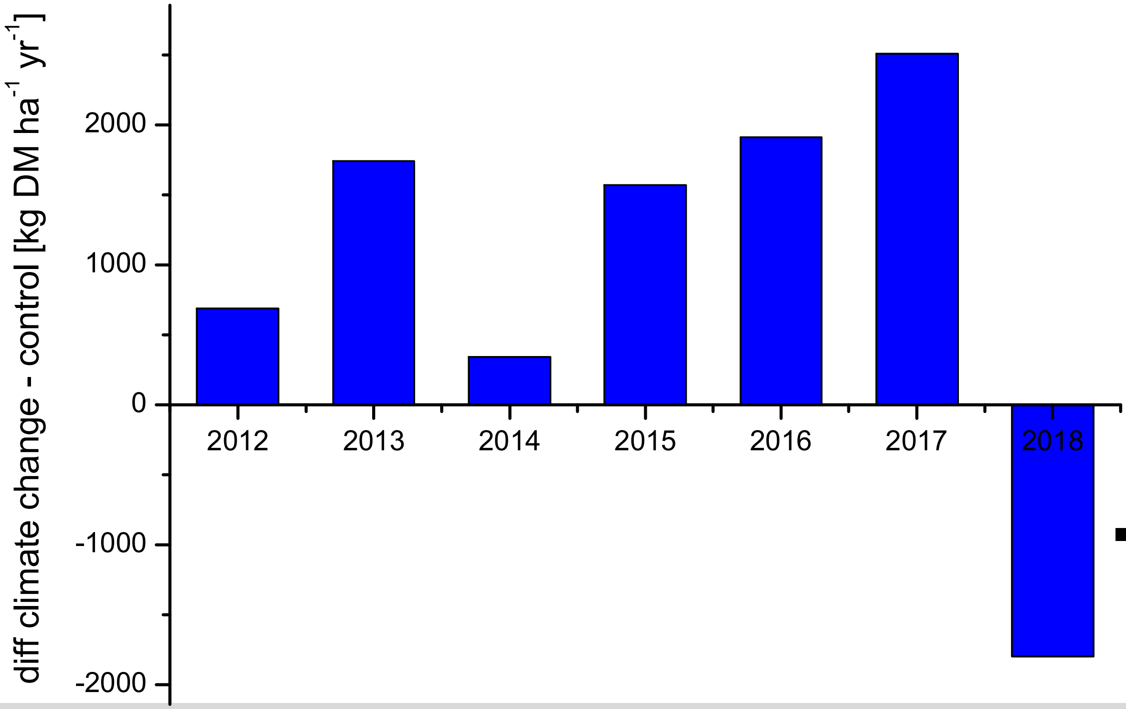
Grassland yields: climate change vs. control



Grassland yields: contribution of diff cuts



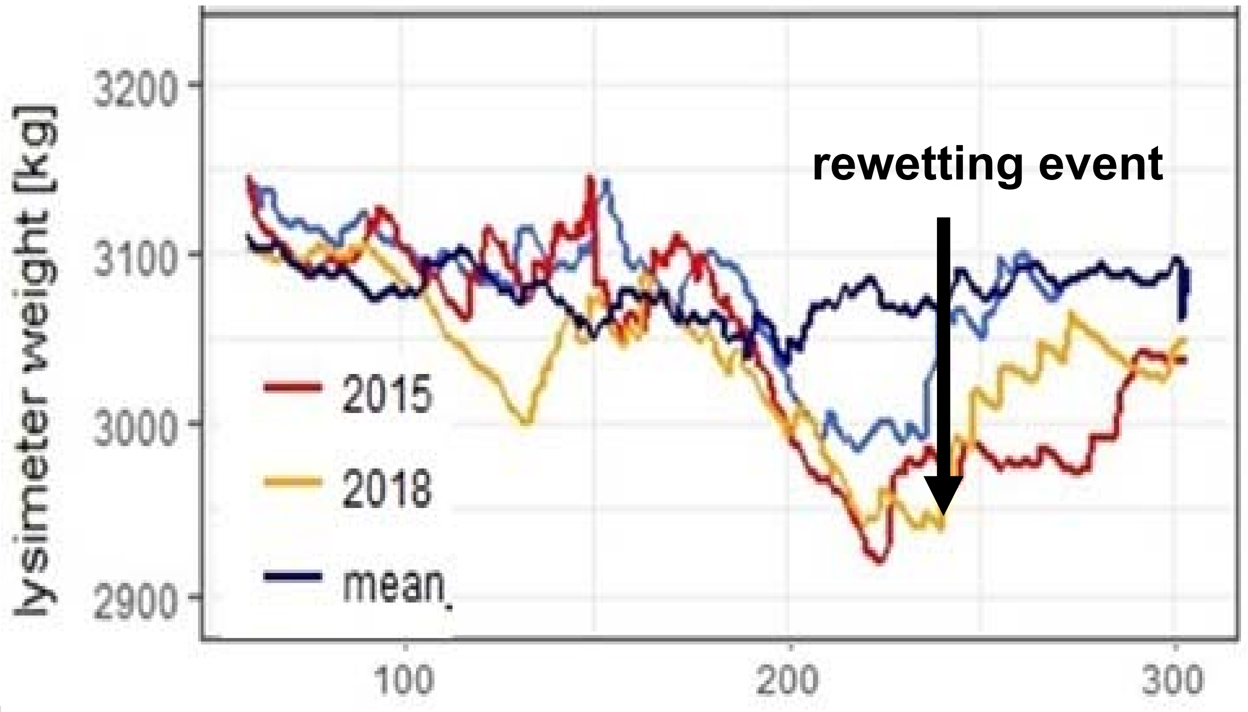
Grassland yields: climate change vs. control



diff in plant N uptake 2018
control vs climate change
ca. 50 kg N ± excess N

– 1798 kg DM ha^{-1} yr^{-1} (-18%)

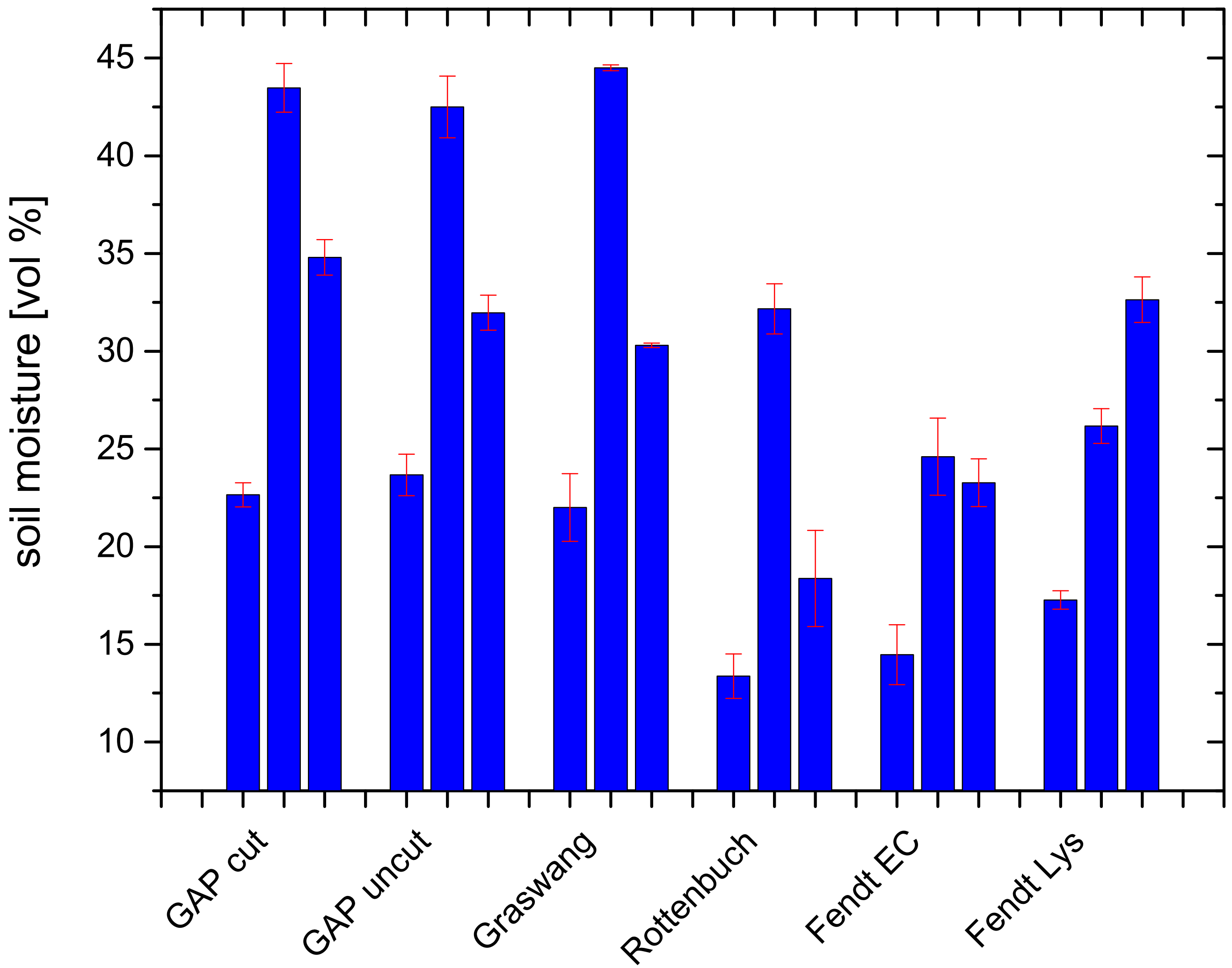
Grassland yields: climate change vs. control



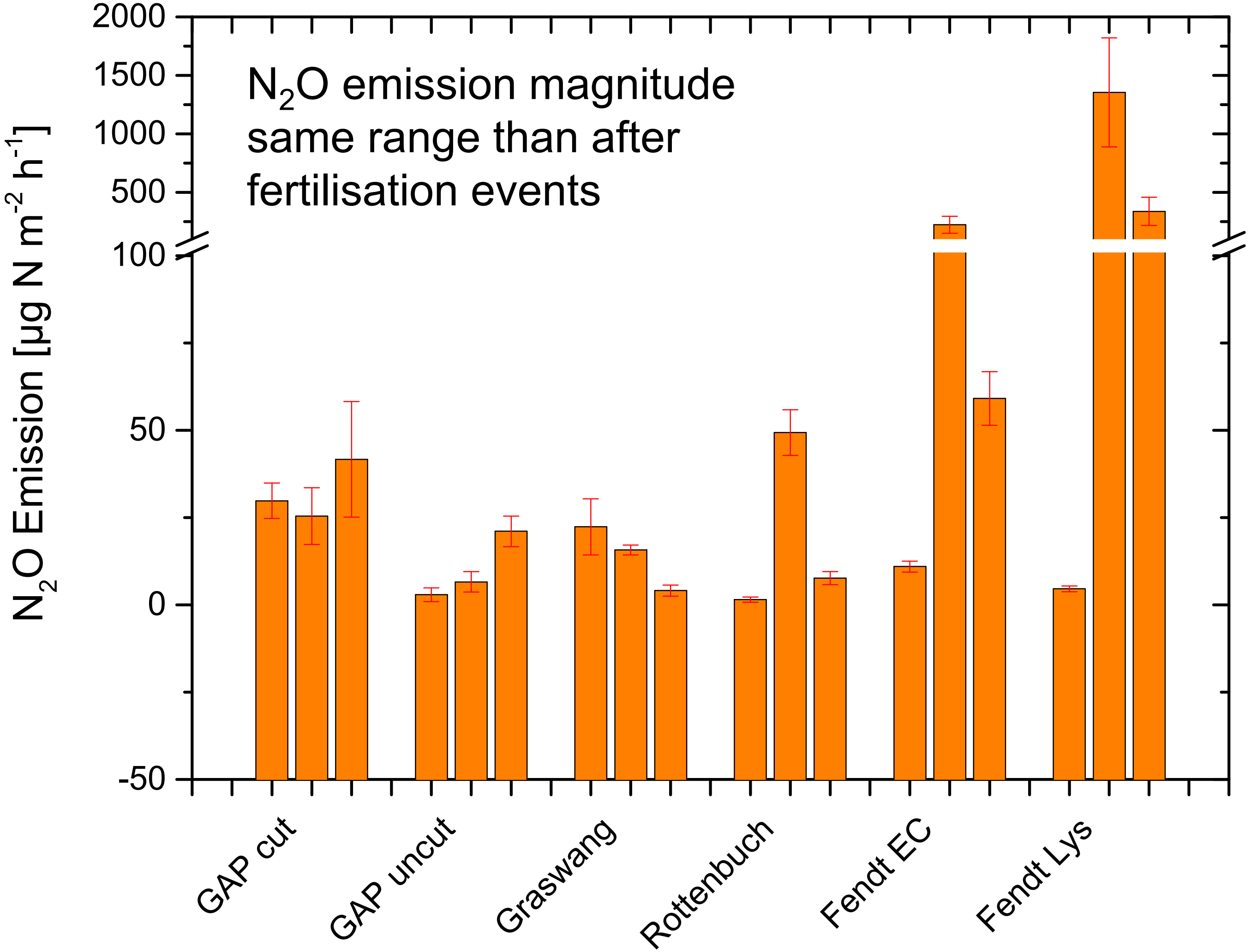
in plant N uptake 2018
trol vs climate change
50 kg N ± excess N

2018 rewetting event

2018 rewetting event: soil moisture



2018 rewetting event: N_2O emissions



Summary

Grassland productivity is highly supported by mineralization of soil organic nitrogen

Soil N mineralization increases under climate change

Climate change (+2°C) is still beneficial for grassland productivity if there is no constrains by drought

Under drought yields decrease with the risk of environmental N losses (e.g. N_2O) to increase

Increased mineralization likely leads to decreasing soil organic N and C stocks with risks on important soil functions e.g. fertility, C sequestration on the long term

Adaptation of organic fertilizer management can compensate for soil N and C losses

Legislation driven lowering of fertilization rates may cause a conflict for grassland productivity and maintenance of soil C and N stocks

Farmers´decision making under climate and socio-economic changes is getting more and more complex


Thank you for your attention