The effect of dairy farm management on GHG emissions and soil carbon

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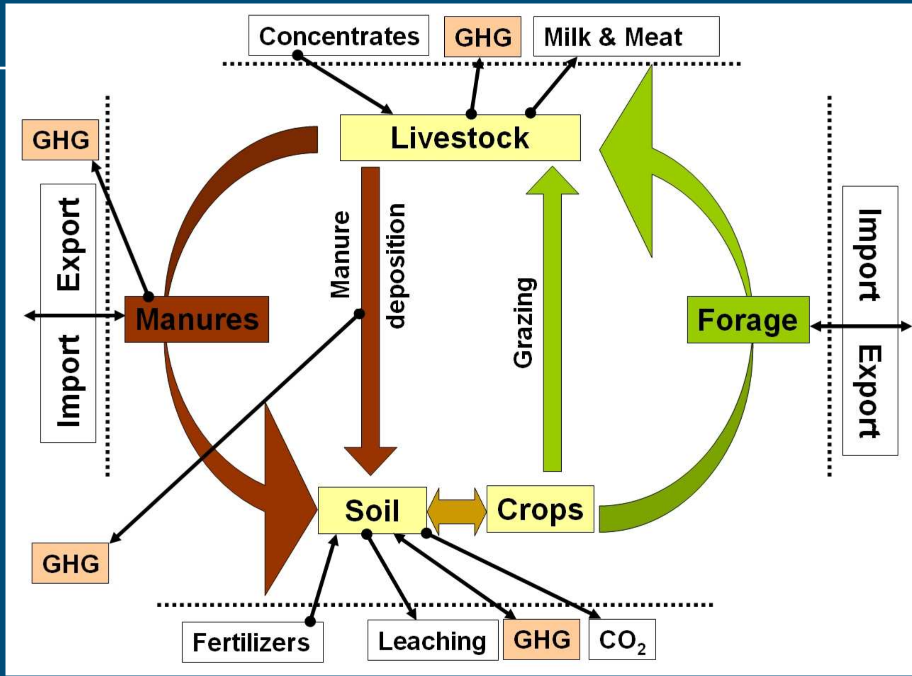
Introduction

- Climate change impacts agriculture;
  Agriculture contributes to climate change
- Agricultural management impacts:
  - Carbon sequestration
  - GHG emissions

Objective

- Identify effective strategies for reduction of GHG emissions and for carbon sequestration

FarmMin



- Dairy farm carbon and nutrient flows
- Static (non-dynamic)
- Simple but realistic relationships (e.g., emission factors)
- Suitable for exploring management alternatives

Soil organic carbon and nitrogen in FarmMin

- $C_t = C_0 \exp(-R_9\ t^{1-S})$

  where C_0 = soil org. C added at t=0

  C_t = soil org. C remaining at t=t

  R_9 = parameter for rate of decomposition at 9 °C

  S = rate of ageing

  Yang and Janssen (1997, 2000)

- $N_t = (N_0 - C_0/r_{cnmic})\ (C_t/C_0)^p + C_t/r_{cnmic}$

  where N_t = soil org. N at time t

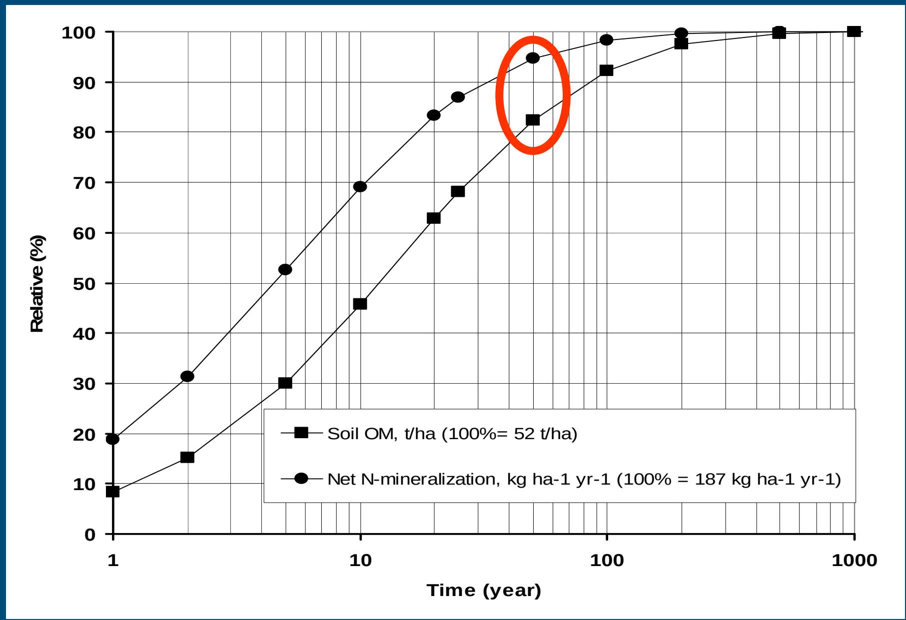
  r_{cnmic} = C:N of microbial biomass

  p = related to ratio of assimilation and disassimilation

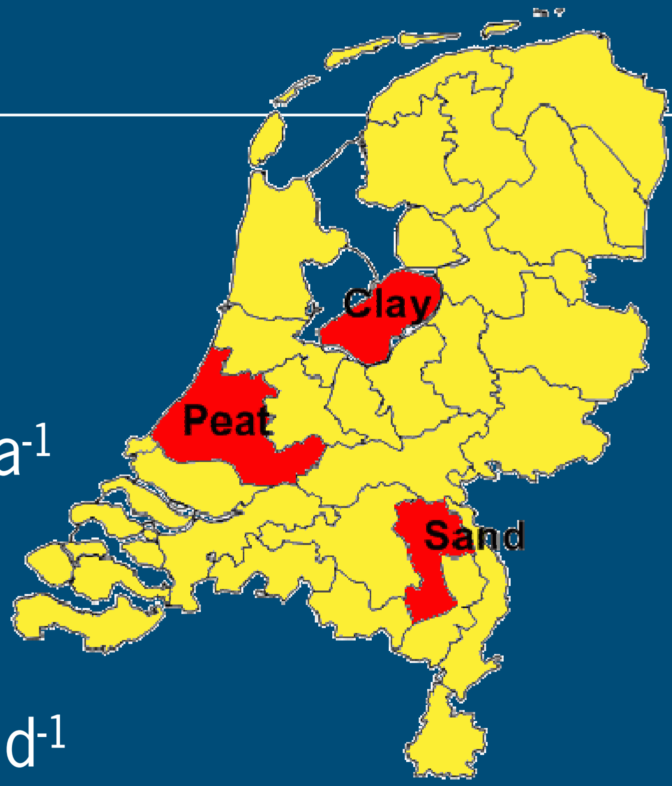
  Bos, Ten Berge en De Willigen (pers. comm.)

Dynamics of soil C after management change

- Hundreds of years needed to reach equilibrium
- Most of the change happens within 50 years



Scenario's



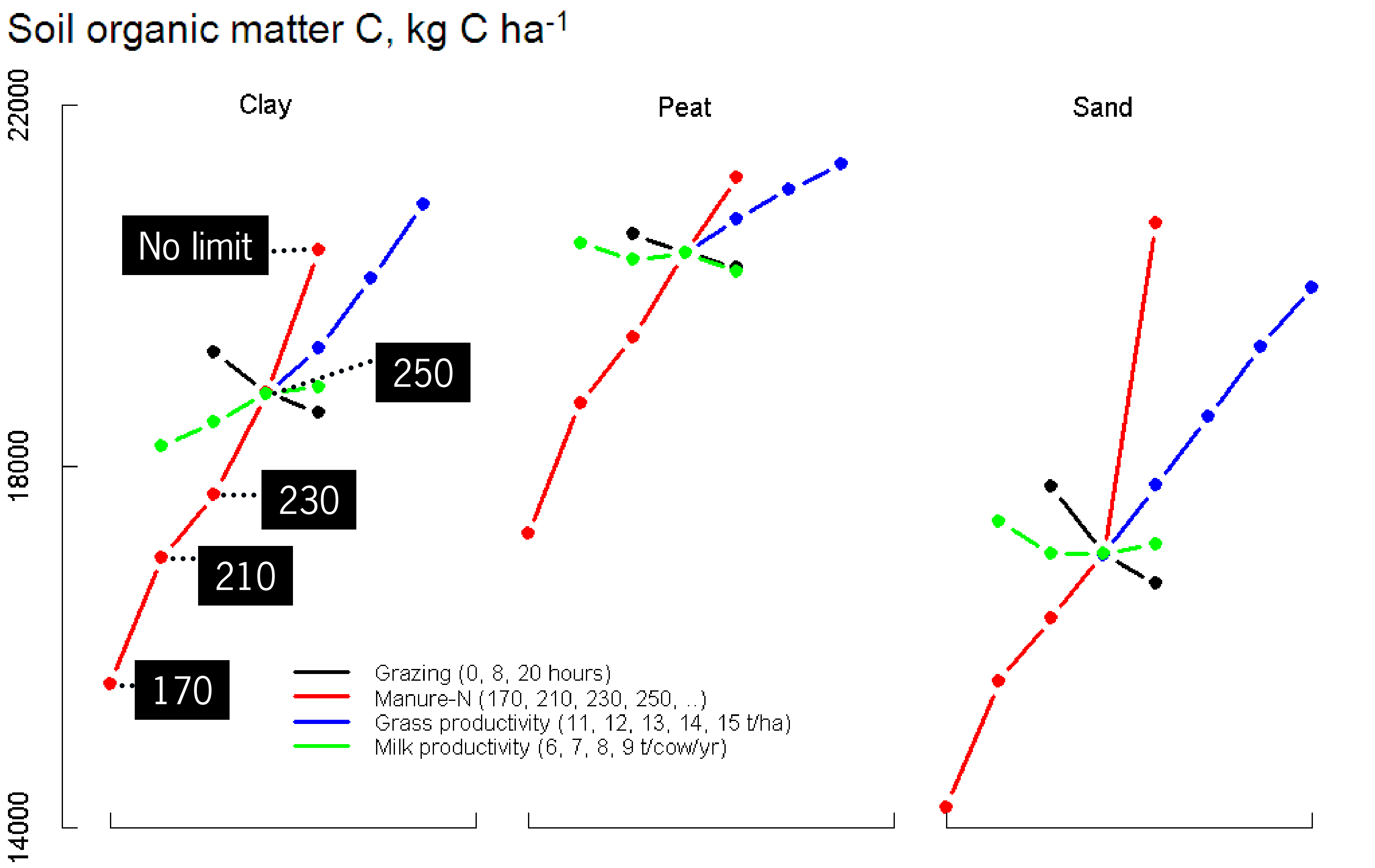
- Aggregated farms
  - Stocking rate ≈1.6 dairy cows ha^{-1}
  - Maize 30% (none on peat)
- Management
  - Hours of grazing: 0 → 20 hours d^{-1}
  - Application limit N from manure: 170 → 250 kg ha^{-1}
  - Dairy cow productivity: 6000 → 9000 kg yr^{-1}
  - Grassland productivity: 11 → 15 t ha^{-1}

Dry sand, 8000 kg milk, 8 hours grazing, 250 kg manure-N

Soil OM C, kg ha^{-1}	17025
Soil OM N, kg ha^{-1}	1316
N mineralization, kg ha^{-1} yr^{-1}	131
Emission CH_4, kg ha^{-1} yr^{-1}	413
Emission N_2O-N, kg ha^{-1} yr^{-1}	10.3
Emission NH_3-N, kg ha^{-1} yr^{-1}	53.8
Groundwater NO_3, ppm	50.2
"Cost", € ha^{-1}	1471

Dry sand, 8000 kg milk, 8 hours grazing

	Manure-N application limit		
	∞	**250**	**170**
Soil OM C, kg ha^{-1}	20701	17025	14223
Soil OM N, kg ha^{-1}	1628	1316	1082
N mineralization, kg ha^{-1} yr^{-1}	177	131	104
Emission CH_4, kg ha^{-1} yr^{-1}	413	413	413
Emission N_2O-N, kg ha^{-1} yr^{-1}	10.9	10.3	11.0
Emission NH_3-N, kg ha^{-1} yr^{-1}	63.0	53.8	51.7
Groundwater NO_3, ppm	70.8	50.2	48.2
"Cost", € ha^{-1}	1131	1471	1765



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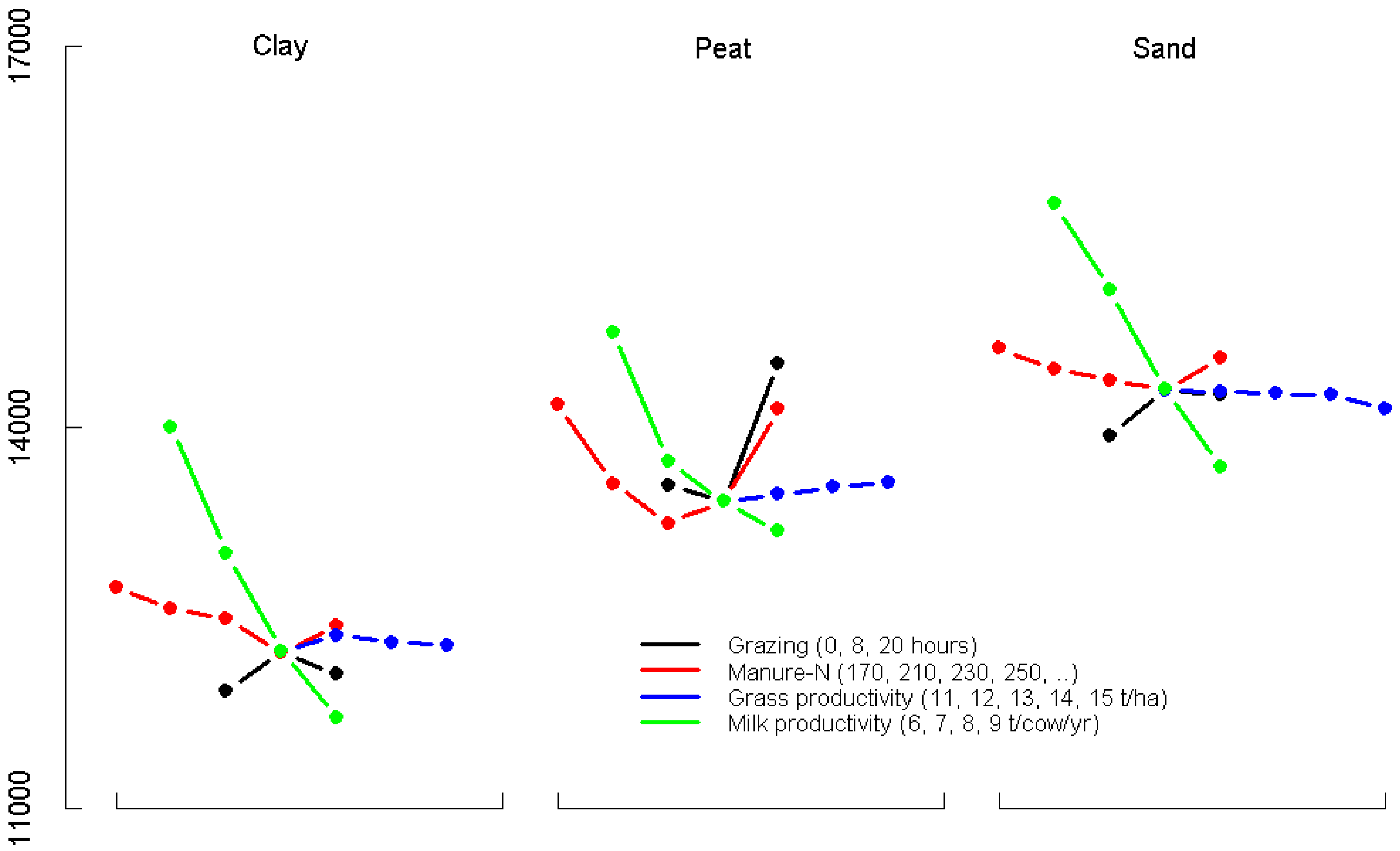
GHG emissions, kg CO_2-eq ha^{-1} yr^{-1}



Summary

- Limit application of manure-N → decrease soil C
- Increase grass productivity → increase soil C
- Increase productivity of cows → decrease GHG emissions
- Grazing has opposite effects → ≈GHG neutral
- Management effects on GHG emissions are more important than effects on soil carbon stocks

Conclusion

- Increasing the productivity of dairy cows is an effective strategy for reduction of GHG emissions
- Increasing the productivity of grass is an effective strategy for carbon sequestration
- Manure application limits reduce carbon sequestration