

Grazing by red deer counteracts atmospheric nutrient deposition in semi-natural open habitats

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Atmospheric nutrient deposition & habitat conservation

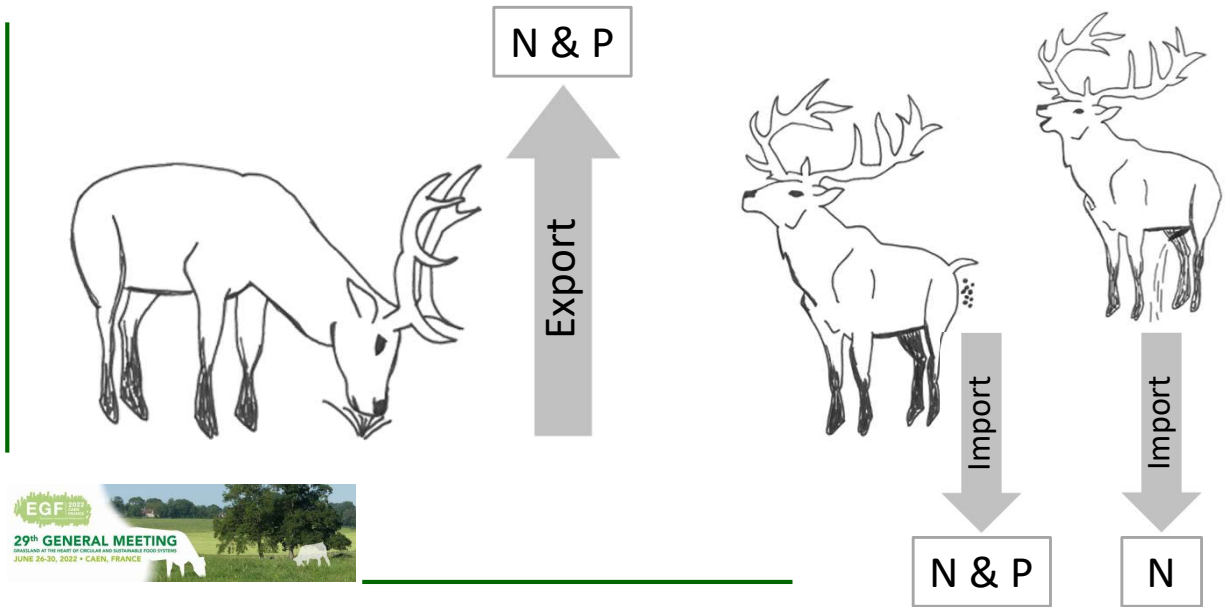
- Environmental impacts of atmospheric emissions underestimated (EEA 2020)
- Protected habitat types sensitive to nitrogen (N) and phosphorus (P)
- Atmospheric nutrient deposition multiplied since Industrial Revolution (KANAKIDOU et al. 2016)
- Critical N loads (BOBBINK et al. 2015)



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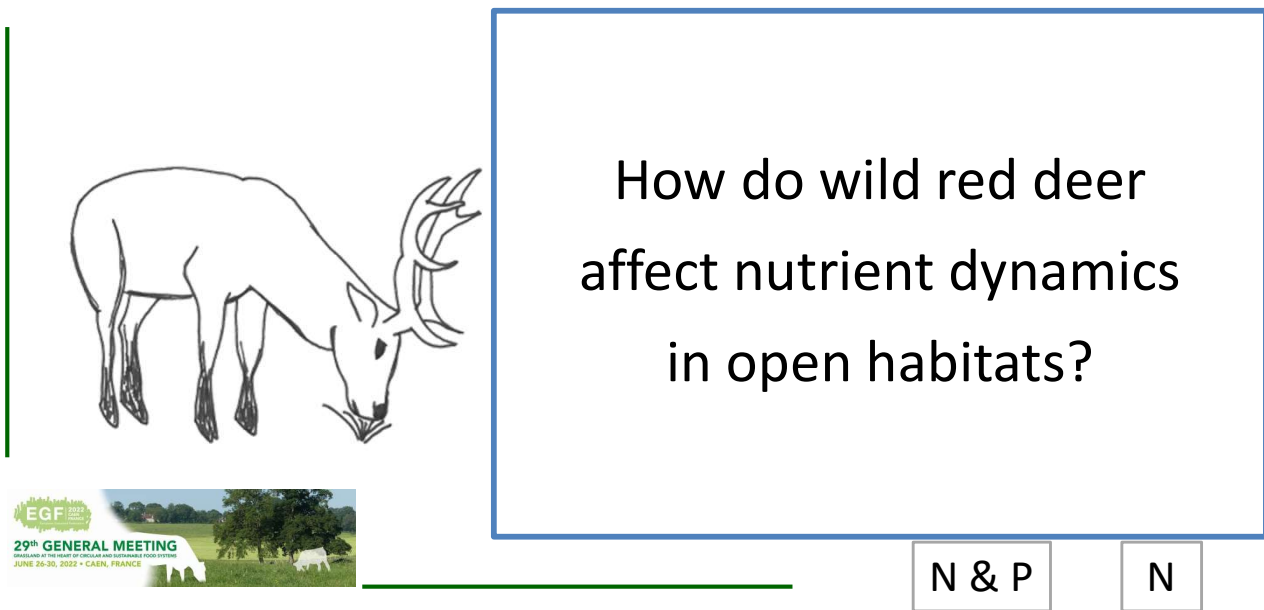
Nutrient fluxes through herbivores



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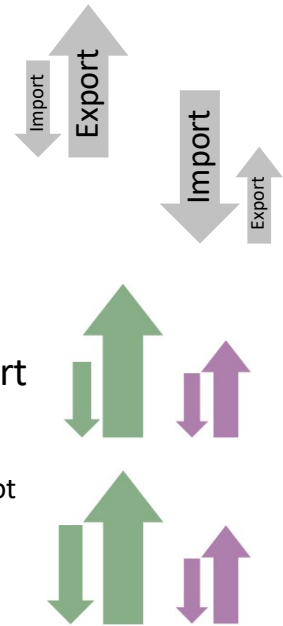


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Hypotheses

- H1: Red deer counteract atmospheric nutrient deposition in open habitats
 ≠ Red deer augment atmospheric nutrient deposition in open habitats
- H2: The difference between nutrient export and import by red deer is larger in grasslands than in heathlands
 ≠ The difference between nutrient export and import by red deer does not differ between habitat types



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Study area: Grafenwöhr military training area



- >100 years military land use
- Soils unaffected by agricultural intensification (RIESCH et al. 2018)
- ~23 000 ha, ~9 000 ha open habitats
- Abundant red deer
 - Benefits for open habitat conservation (RIESCH et al. 2019, 2020; WICHELHAUS 2020)



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Data collection

- Two habitat types (lowland hay meadows, European dry heaths)
- Eight plots (15×15 m) per habitat type
 - Vegetation productivity
 - Forage removal by red deer
 - Dung quantity
 - Plant and faecal nutrient concentrations
- Import and export of N and P
 - Five study periods from April 2015 to April 2016



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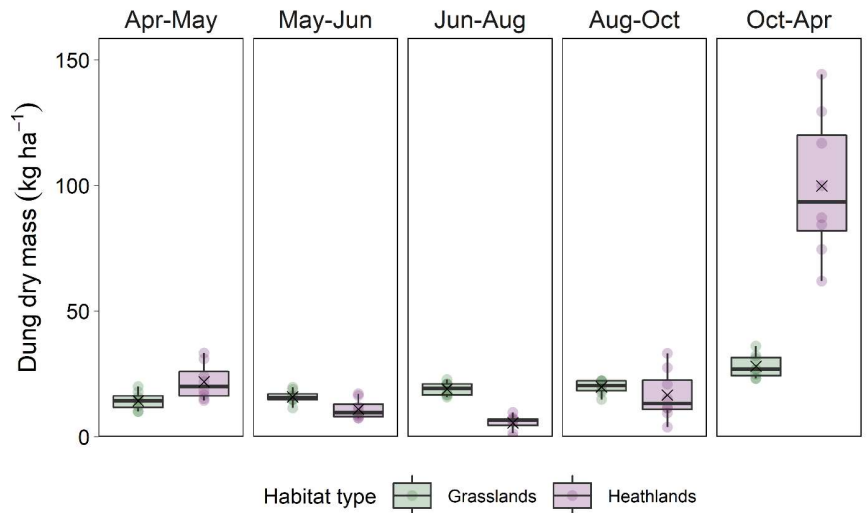


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Red deer dung deposition

- Dung pellet groups per sampling plot (225 m²) and period (mean ± se)
 - Grasslands: 15 ± 1
 - Heathlands: 22 ± 4



RIESCH et al. (2022)

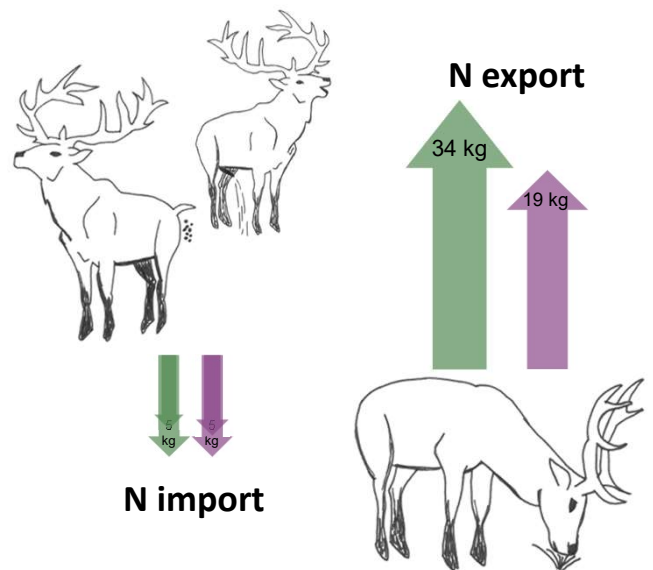
Annual N fluxes

Nitrogen (N) fluxes through wild red deer in kg ha⁻¹ yr⁻¹ (mean and 95% confidence interval)

	Faecal N import	Total N import [†]	N export	ΔN
Grasslands	2.6 [2.4, 2.8]	4.9 [4.5, 5.4]	34.4 [22.7, 46.1]	-29.5 [-41.2, -17.8]
Heathlands	3.0 [2.3, 3.7]	4.9 [3.8, 6.0]	18.8 [9.9, 27.7]	-13.9 [-22.9, -4.9]

[†]Calculated according to HOBBS (1996)

H1 ✓
H2 ✓

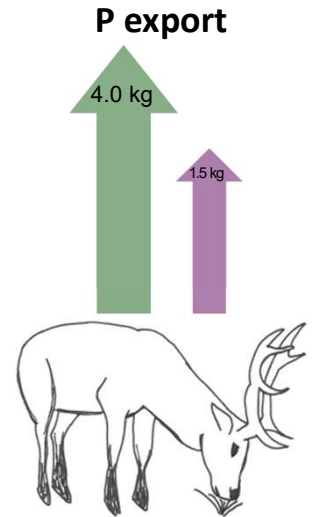
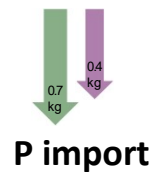


RIESCH et al. (2022)

Annual P fluxes

Phosphorus (P) fluxes through wild red deer in kg ha⁻¹ yr⁻¹ (mean and 95% confidence interval)

	P import	P export	ΔP
Grasslands	0.7 [0.7, 0.8]	4.0 [2.5, 5.5]	-3.3 [-4.8, -1.8]
Heathlands	0.4 [0.2, 0.6]	1.5 [0.8, 2.2]	-1.1 [-1.8, -0.3]



H1 ✓

H2 ✓



RIESCH et al. (2022)

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Relevance for habitat conservation

Modelled annual atmospheric deposition and net nutrient fluxes (mean and 95% confidence interval) through red deer in kg ha⁻¹ yr⁻¹

	N deposition Grafenwöhr [†]	ΔN	P deposition Europe [‡]	ΔP
Grasslands	9–11	-29.5 [-41.2, -17.8]	0.3	-3.3 [-4.8, -1.8]
Heathlands		-13.9 [-22.9, -4.9]		-1.1 [-1.8, -0.3]

[†]UMWELTBUNDESAMT (2021); [‡]TIPPING et al. (2014)

- Critical N loads

(BOBBINK et al. 2015)

- Lowland hay meadows: 20–30 kg ha⁻¹ yr⁻¹
- European dry heaths: 10–20 kg ha⁻¹ yr⁻¹



RIESCH et al. (2022)

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Conclusions

- Red deer have multiple beneficial ecosystem functions in open habitats
- Red deer grazing in open habitats can mitigate atmospheric nutrient deposition
- Opportunity for conservation management in large and inaccessible areas



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CONSERVATION ECOLOGY – ORIGINAL RESEARCH

Grazing by wild red deer can mitigate nutrient enrichment in protected semi-natural open habitats

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