



# Using reported water use data to map future water scarcity in Scotland

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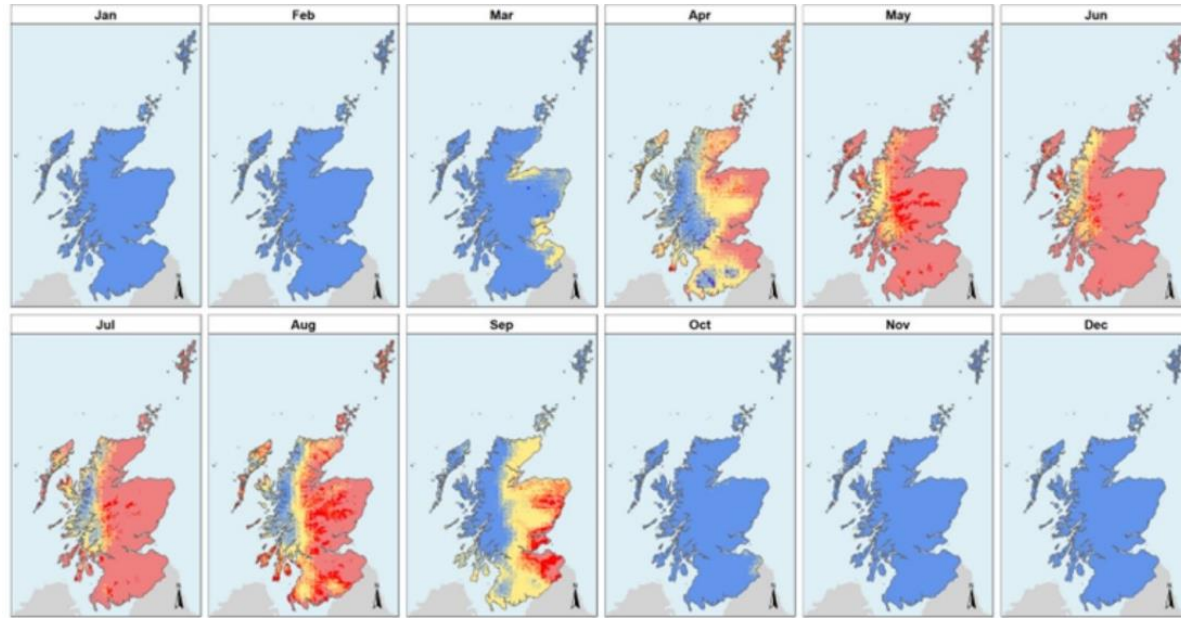
Scottish Freshwater Group Meeting, 2025  
24<sup>th</sup> April 2025



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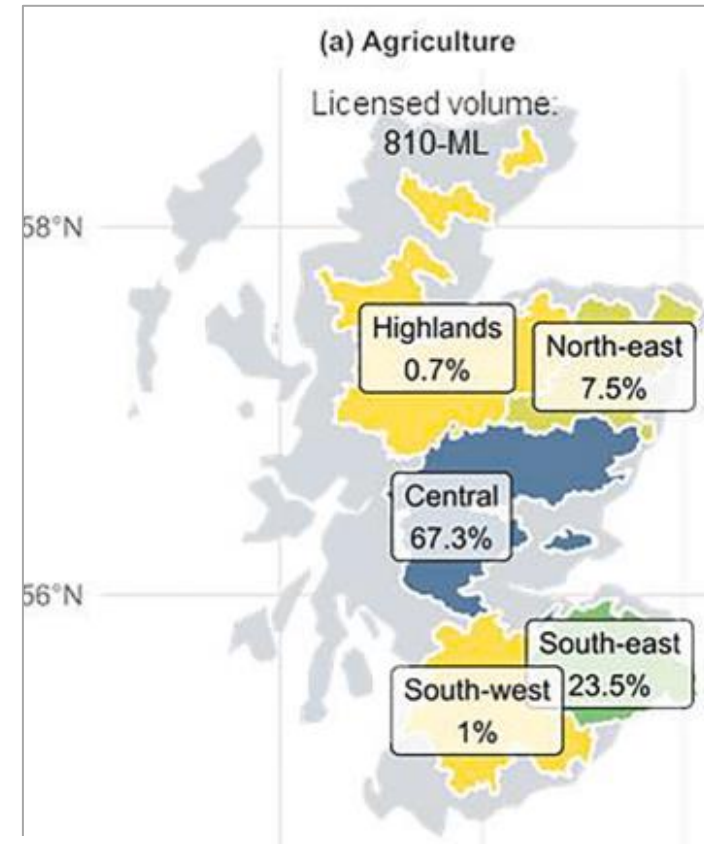
# Scotland's land and water resources are increasingly vulnerable to periods of droughts

- Increasing risk of reduced climatic water balance in future 2020-2049



Rivington and Jabloun, 2023 [D2\\_1a-Climate-trends-summary-report-FINAL-6-12-22.pdf](https://hutton.ac.uk/d2_1a-Climate-trends-summary-report-FINAL-6-12-22.pdf) (hutton.ac.uk)

- Abstractions are forecasted to exacerbate these impacts



Daily and annual abstraction licence limit (Visser Quinn et al., 2021, *Climate Risk Management*)

- Previous analyses limited by lack of data on reported abstraction volumes

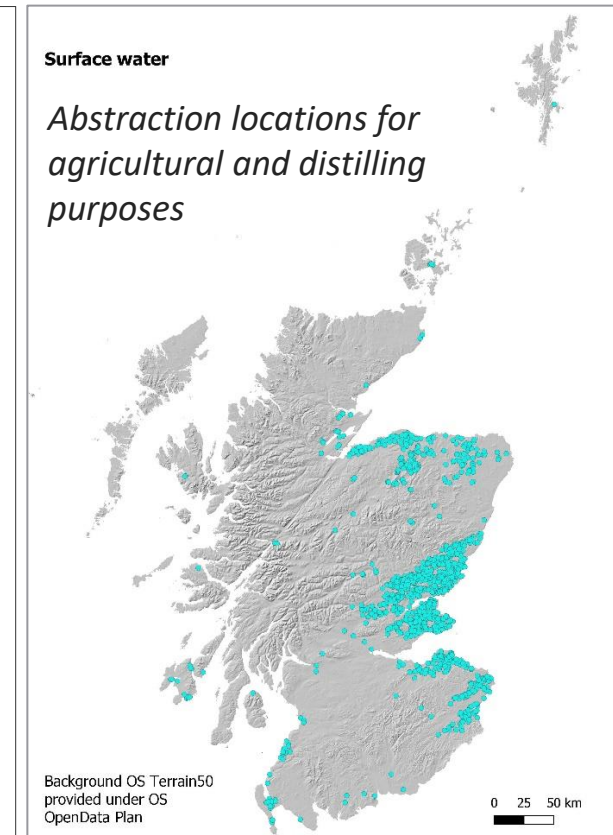
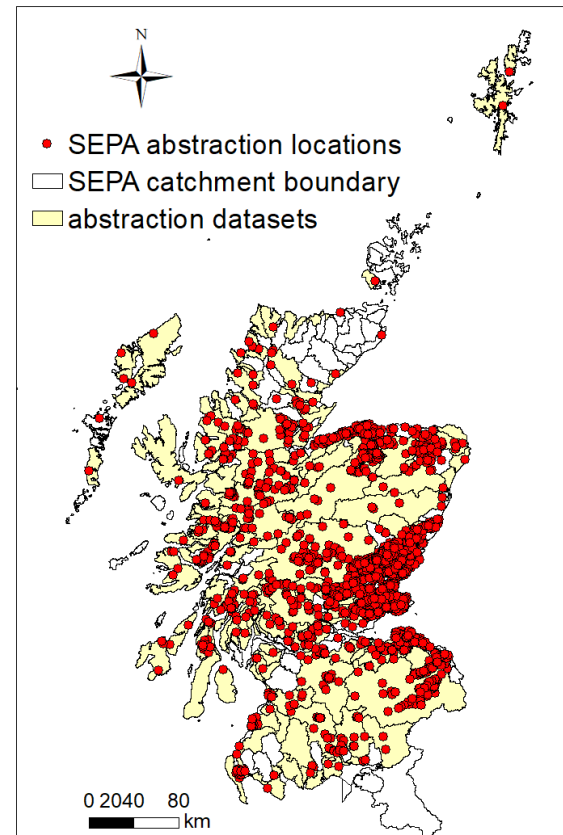
**Need for detailed abstraction return values for all sectors**

# How abstractions by different water sectors may exacerbate the future impacts of droughts in Scotland?

## *Objective 1 Forming a detailed licensed reported abstraction database*

- Daily licensed Sectoral abstractions  
**SEPA 2015-2023**

- Daily licensed Public water supply abstractions  
**Scottish Water 2017-2022** catchment scale



## **Objective 2** *Develop future water abstraction scenarios for the period 2015 to 2050.*



### **Step 1: Forming a representative Abstraction Dataset**

- Aggregated SEPA sectoral **consumptive** abstractions annually.
- Calculated average daily time series over **8 years** for **SEPA** data.
- Calculated average daily time series over **5 years** for **Scottish Water** data.
- **Combined both datasets - generate a total aggregated daily abstraction time series representing an average year**

### **Step 2: Developing Future Scenarios**

- Applied **percentage increases** to the Representative Abstraction Dataset
- No change, +5%, +10%, +15%, ..., up to +100% (worst-case)

# Objective 3 Designing a drought profiling framework



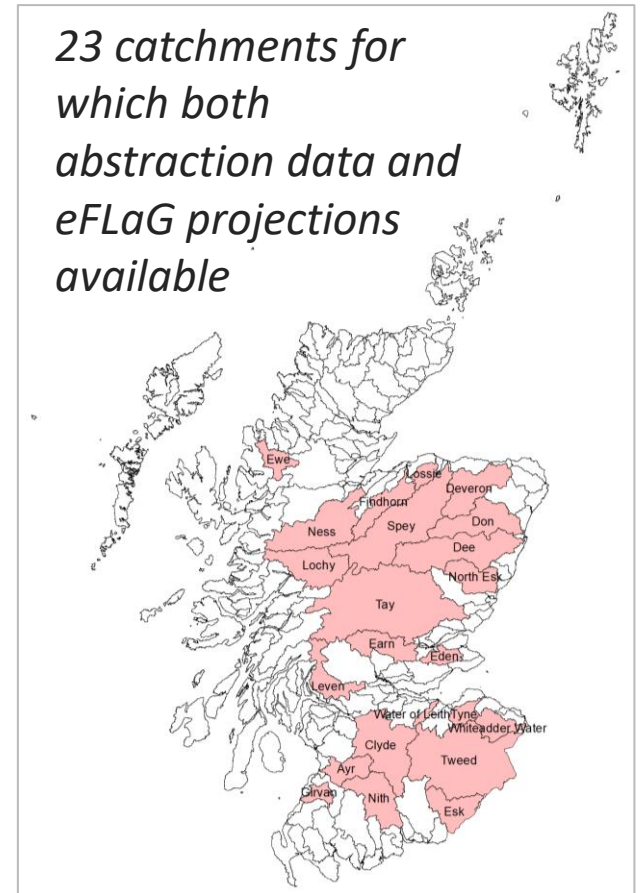
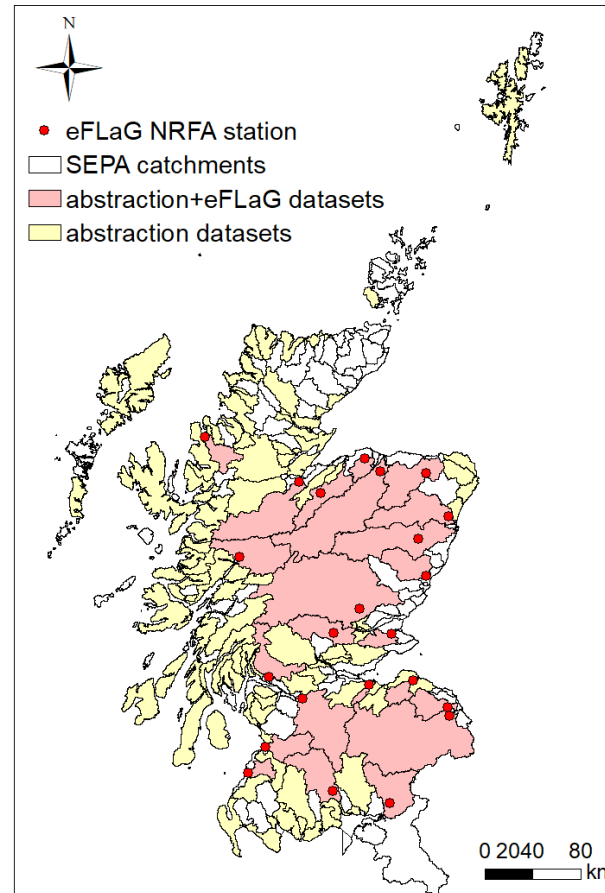
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- Using a compiled daily water abstractions database 2015-2023

- eFLaG historical and future flow projections upto 2050

[eFLaG: Enhanced Future Flows and Groundwater | UK Centre for Ecology & Hydrology \(ceh.ac.uk\)](https://www.ceh.ac.uk) (Hannaford et al., 2022, ESSD)

Date	Catchment.Id	SW_drinking_water	SEPA_abs	Total_abs	percent_SW	percent_SEPA
2018-06-30	26	9299.0	1958.3	11257.3	82.6	17.4
2018-06-30	90	9292.0	0.0	9292.0	100.0	0.0
2018-06-30	96	9064.0	0.0	9064.0	100.0	0.0
2018-06-30	102	8919.0	0.0	8919.0	100.0	0.0
2018-06-30	1596	7895.0	0.0	7895.0	100.0	0.0
2018-06-30	79	7585.0	657416.8	665001.8	1.1	98.9
2018-06-30	536	7429.9	1712.0	9141.9	81.3	18.7
2018-06-30	113	7355.0	4440612.1	4447967.1	0.2	99.8
2018-06-30	118	6184.0	57654.3	63838.3	9.7	90.3
2018-06-30	3659	5982.0	0.0	5982.0	100.0	0.0
2018-06-30	74	5686.0	115.0	5801.0	98.0	2.0
2018-06-30	77	5565.0	0.0	5565.0	100.0	0.0
2018-06-30	104	4254.0	23395.0	27649.0	15.4	84.6
2018-06-30	1954	4187.0	0.0	4187.0	100.0	0.0
2018-06-30	80	4153.0	2719.4	6872.4	60.4	39.6



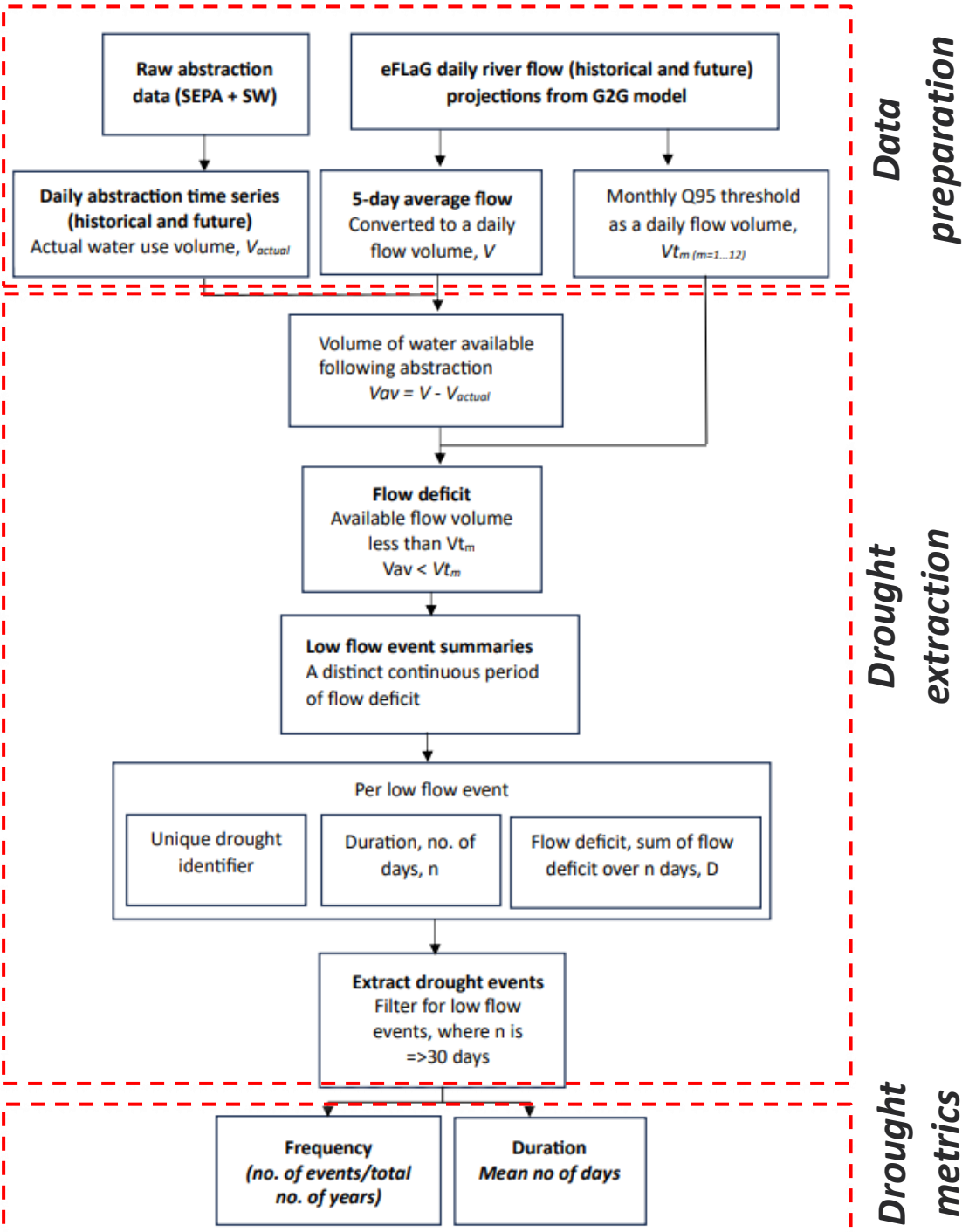
23 catchments for which both abstraction data and eFLaG projections available

# Drought profiling framework

Adapted from Visser Quinn et al., 2021, *Climate Risk Management*



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## Scenarios analysed

**Scenario 1: Baseline (2015-2018):** G2G model runs driven by **observations** and total aggregated abstractions

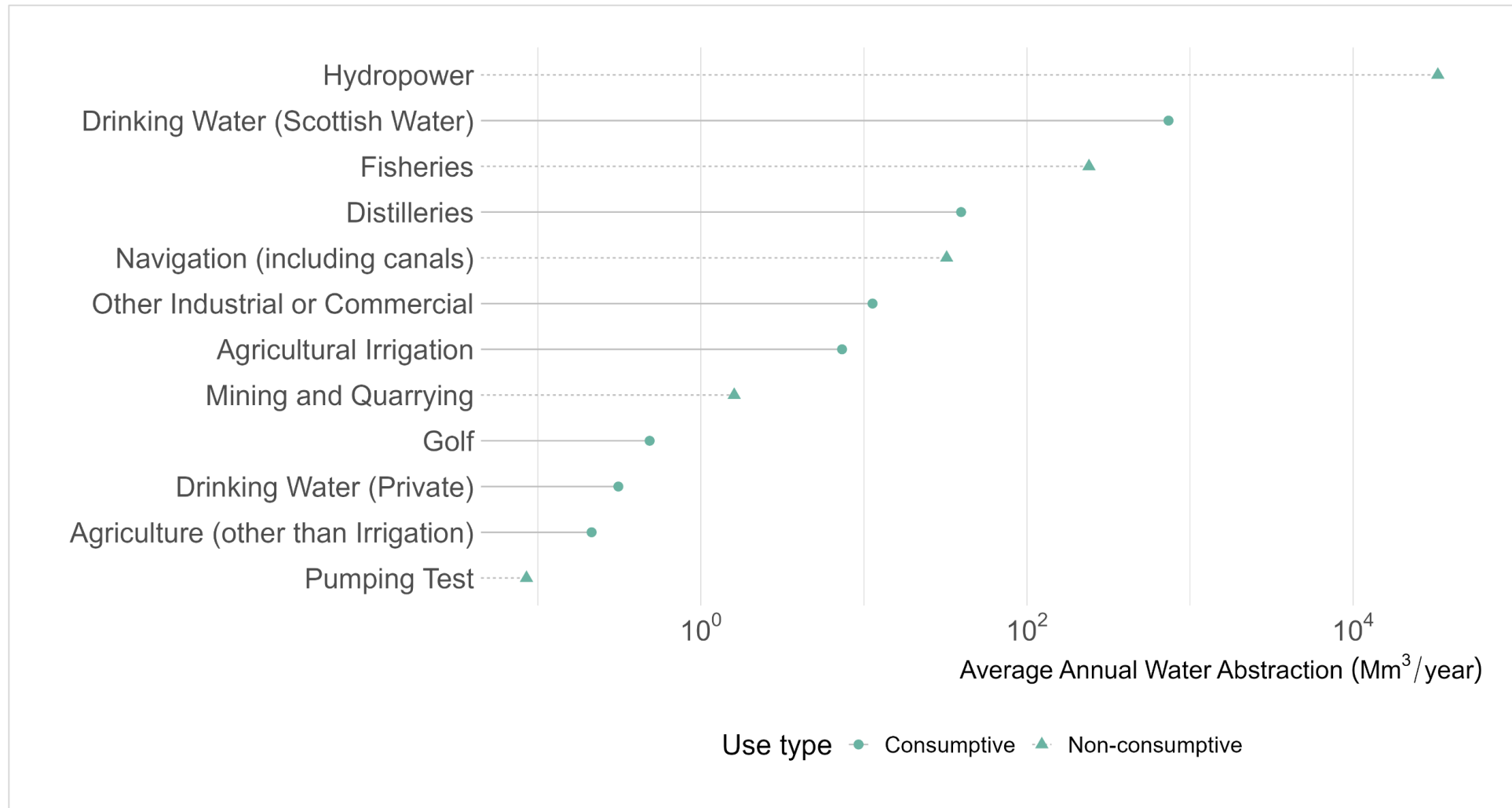
**Scenario 2: Baseline (2015-2023):** G2G model runs driven by **RCM**, and total aggregated abstractions

**Scenario 3: Future (2024-2050):** G2G model runs driven by RCM with 0, 5, 10, 15, 20, ... 100 % **increase** on total aggregated abstractions

# Sectoral average abstraction volumes for the years with complete data (2017, 2018, 2020, 2021 and 2022)



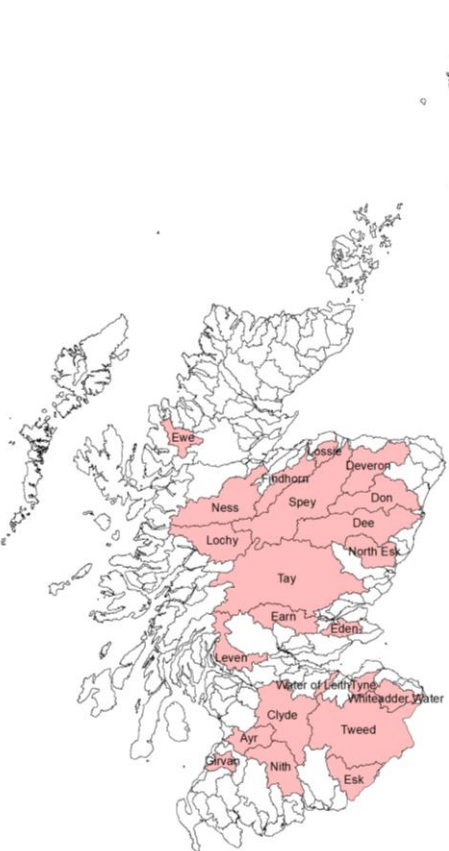
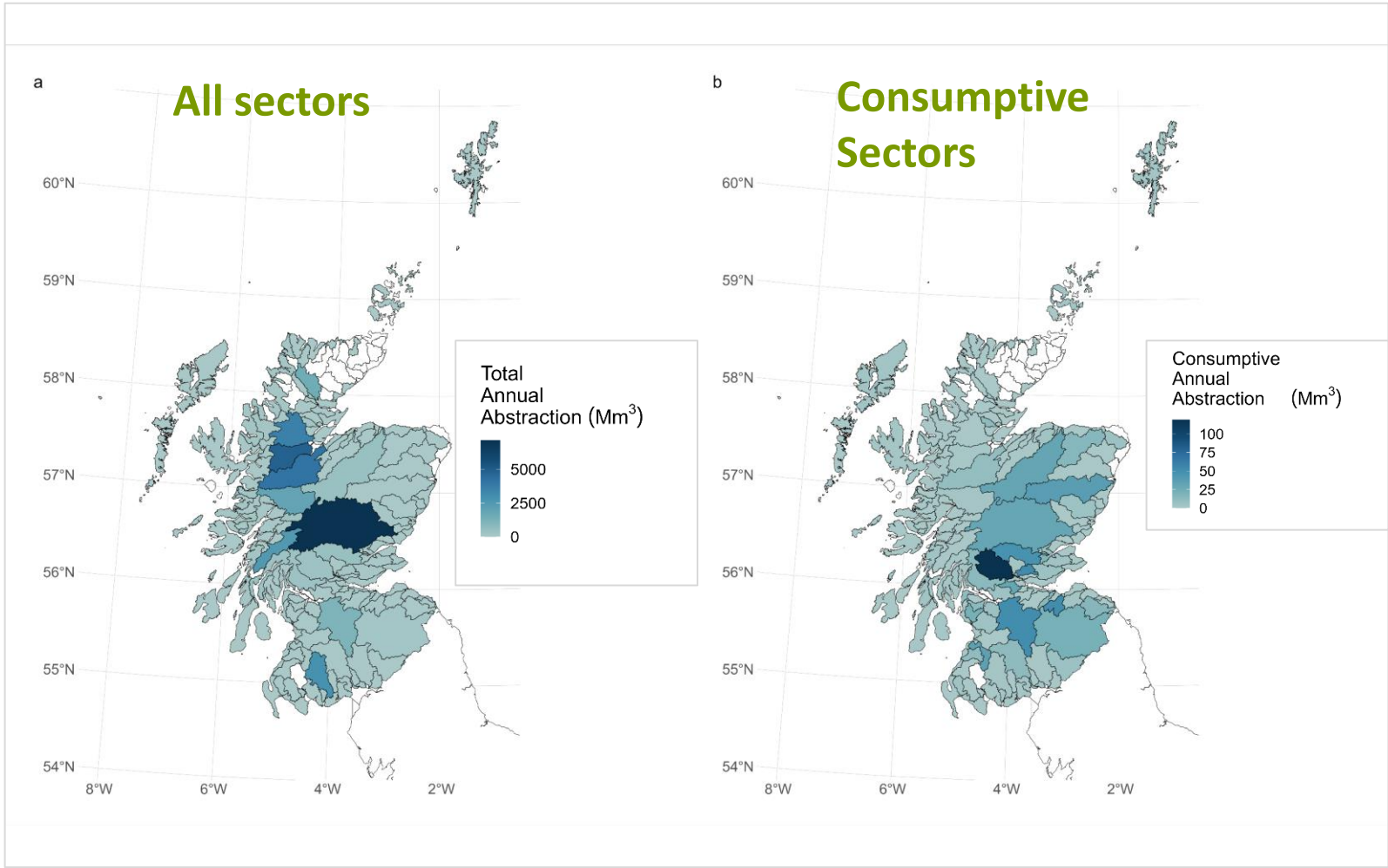
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# Regional distributions of reported abstraction in volume

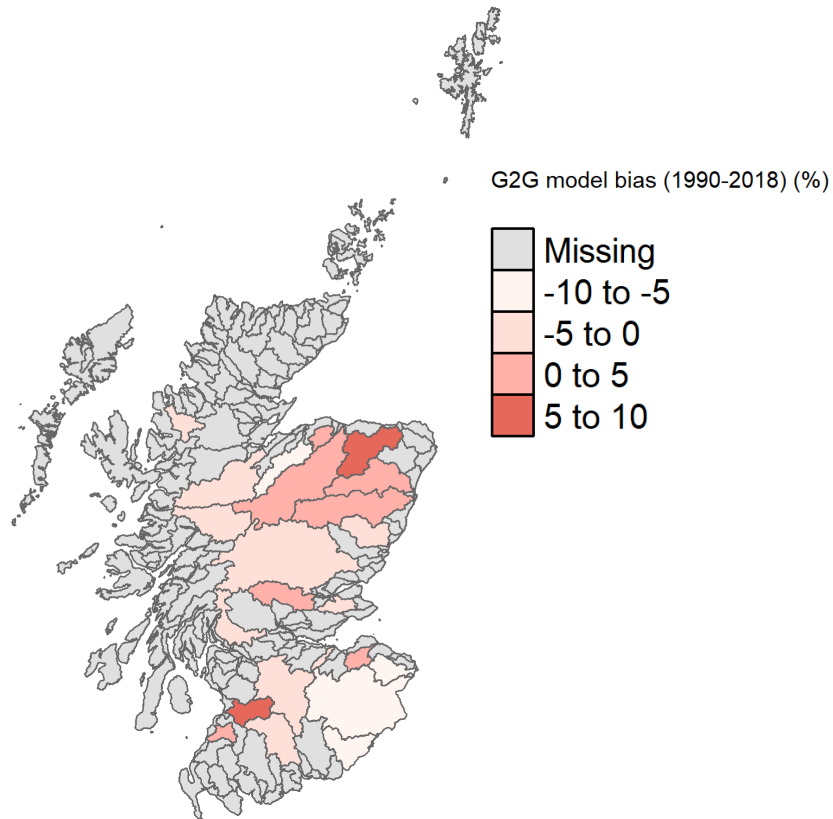


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# Evaluation of drought frequency and duration – Baseline period using RCM and observations

*Pbias* - RCM driven simulations against observations driven

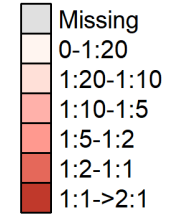


**Drought frequency**

G2G model driven by **observed climate**

G2G model driven by **RCM**

Baseline Frequency (2015-2023)  
Return period (years)



0–1 events/year

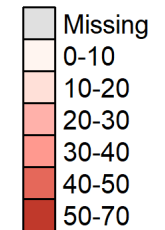
Upto 0.05–1 events/year

**Average drought durations**

G2G model driven by **observed climate**

G2G model driven by **RCM**

Baseline Duration (2015-2023)  
average drought event duration (days)

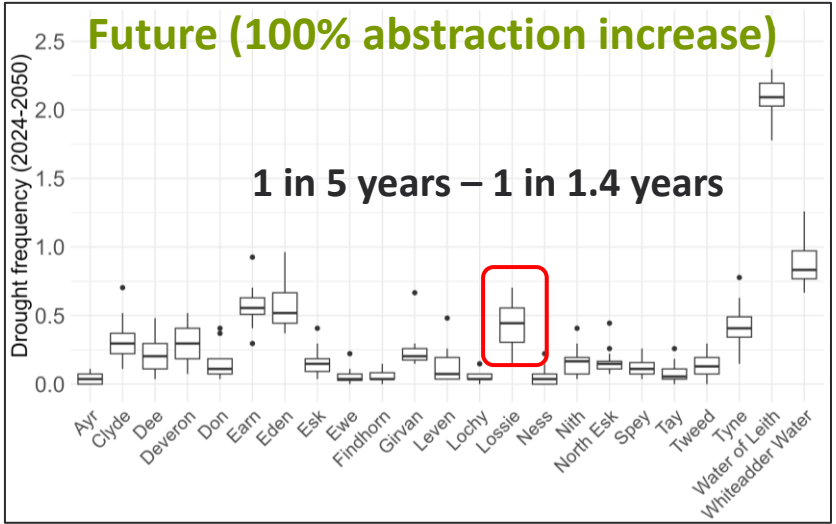
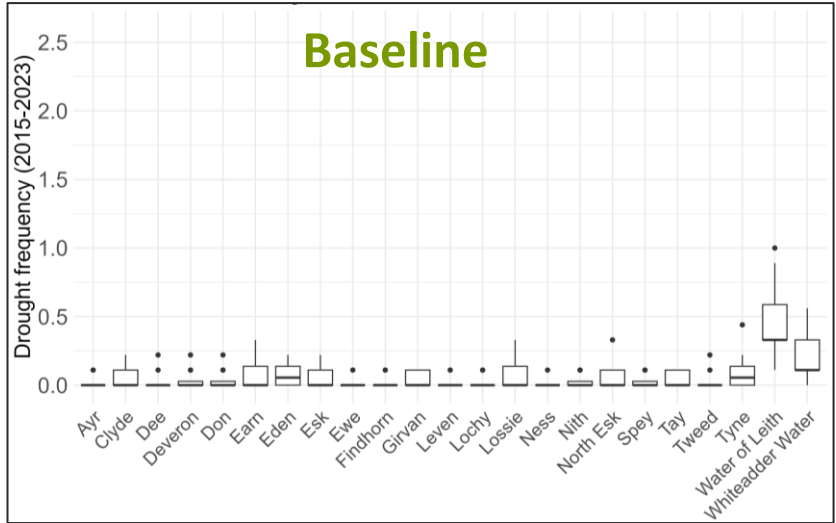


0–10 days

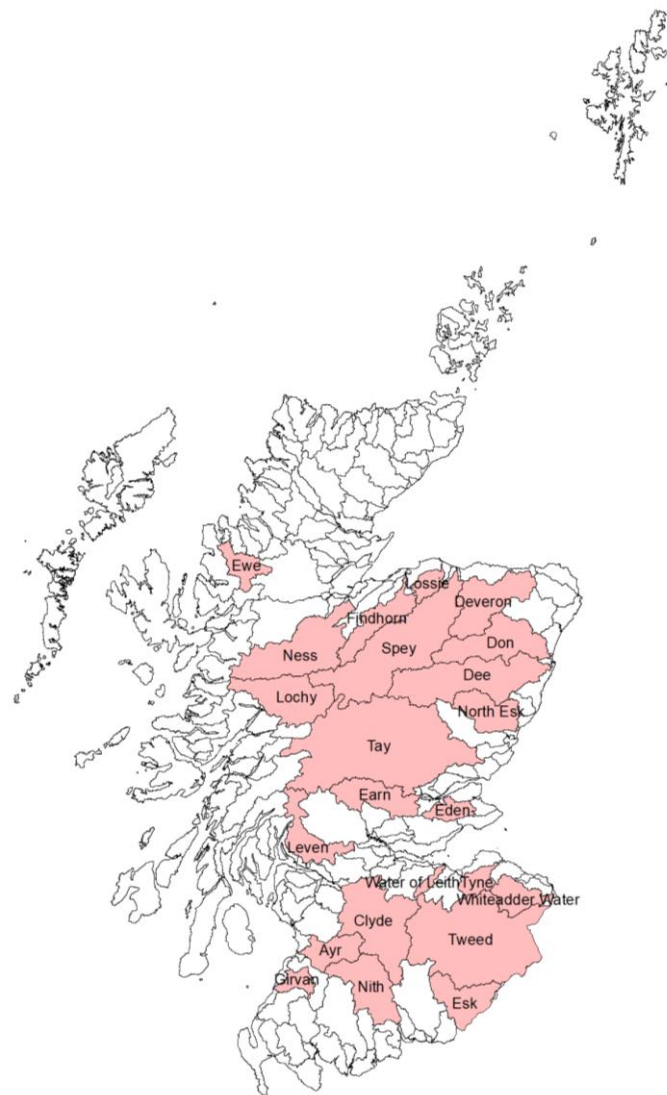
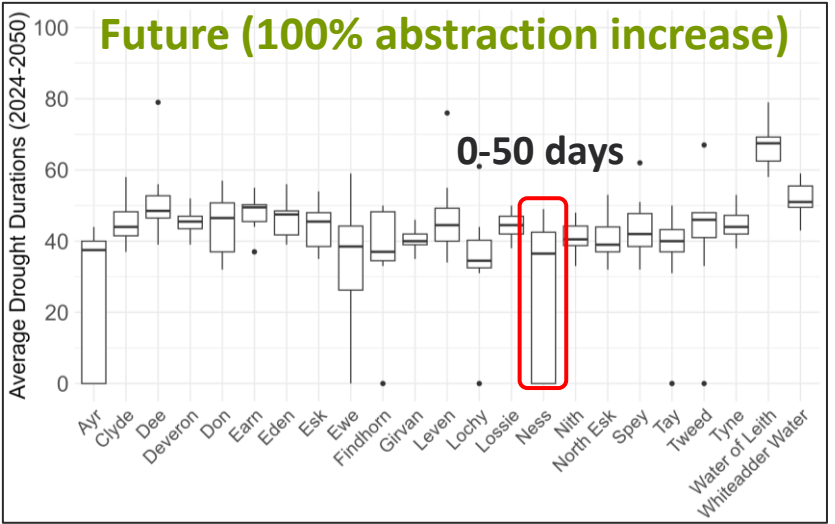
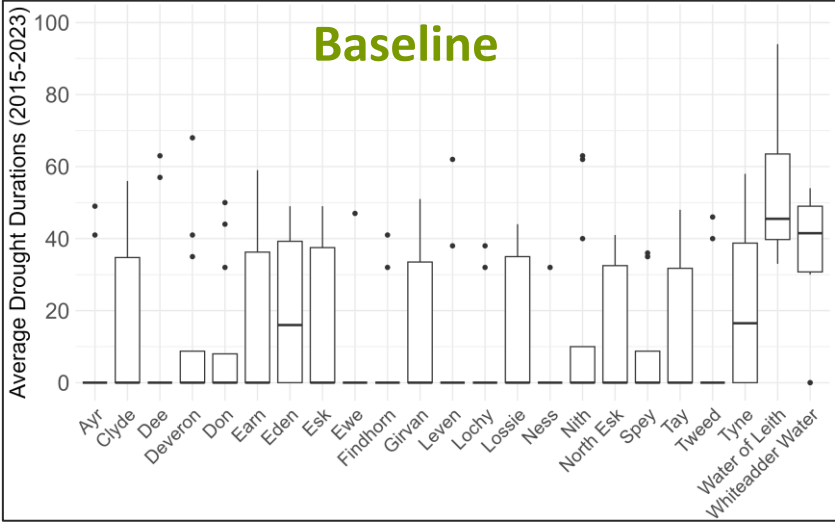
Upto 40 days

# Future drought prediction across 12 RCM (RCP 8.5) scenarios

## Drought frequency



## Drought duration



# Drought frequency – Baseline and future

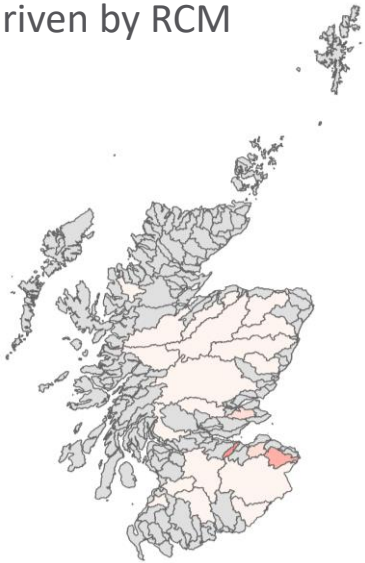
*Increase* in mean, min. and max. drought frequency in future scenarios



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## Baseline (2015-2023)

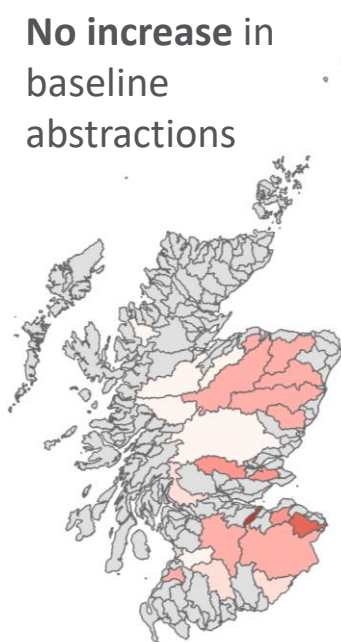
G2G model  
driven by RCM



No droughts - 1 in 10 years

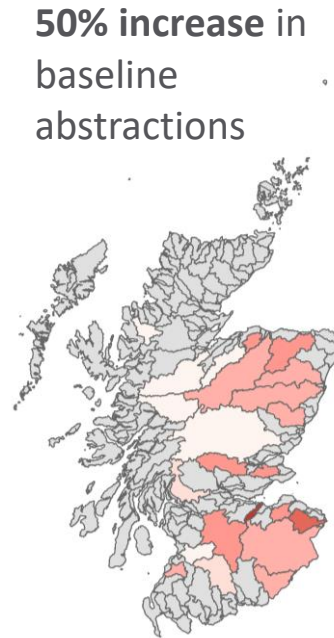
## Future (2024-2050)

No increase in  
baseline  
abstractions

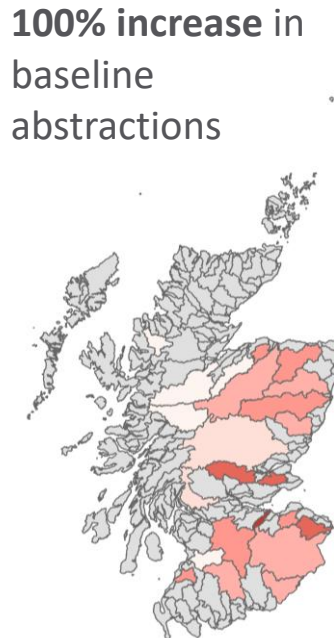


1 in 20 years - 1 in 5 years

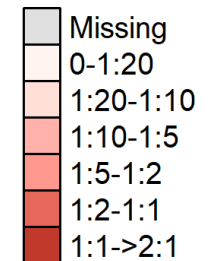
50% increase in  
baseline  
abstractions



100% increase in  
baseline  
abstractions



Future Frequency (2024-2050)  
Return period (years)



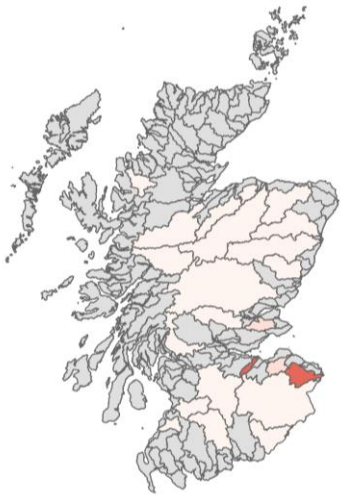
*No change to slight increase* with increasing abstractions

# Drought durations – Baseline and future

*Increase* in mean, min. and max. drought duration in future scenarios

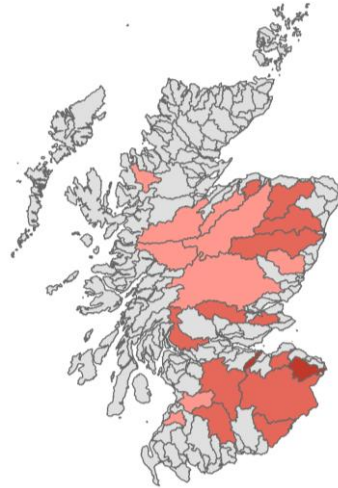
## Baseline (2015-2023) Future (2024-2050)

G2G model  
driven by RCM



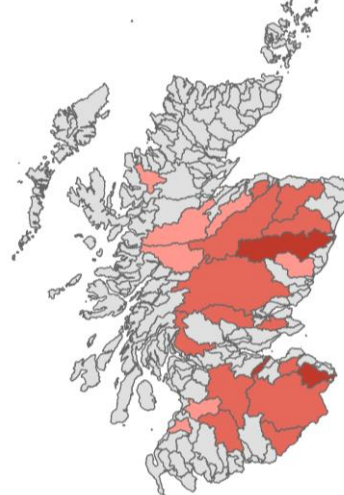
Median drought durations  
0 to 10 days

No increase in  
baseline  
abstractions



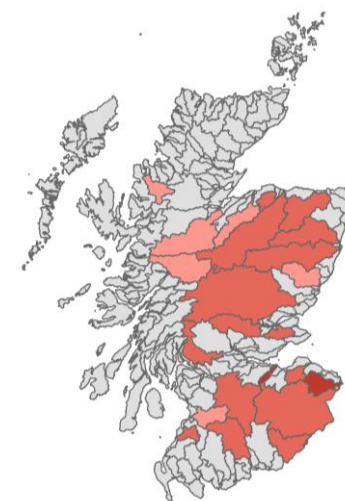
35 – 54 days

50% increase in  
baseline  
abstractions



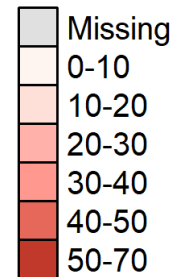
35 – 60 days

100% increase in  
baseline  
abstractions



35 – 68 days

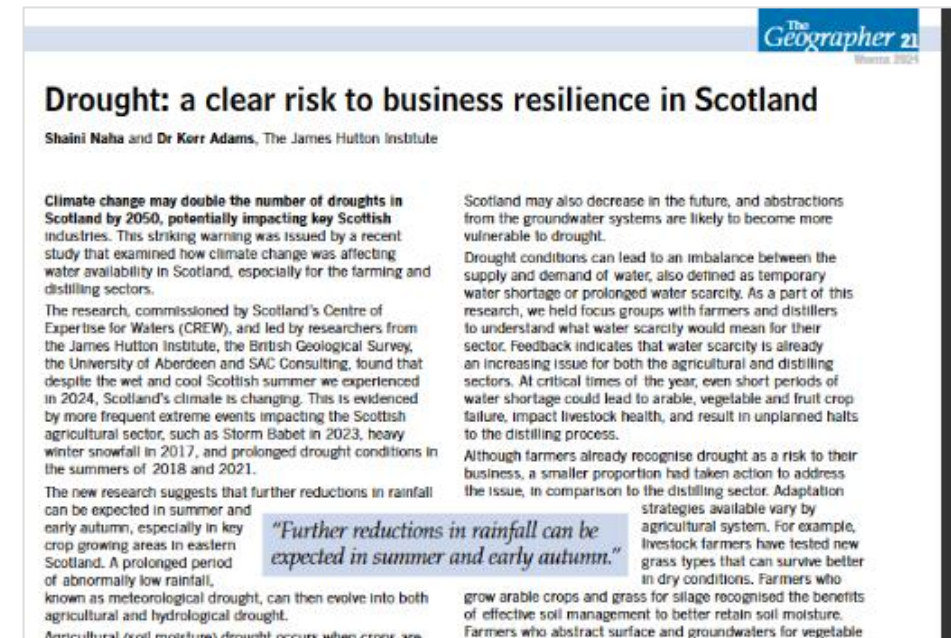
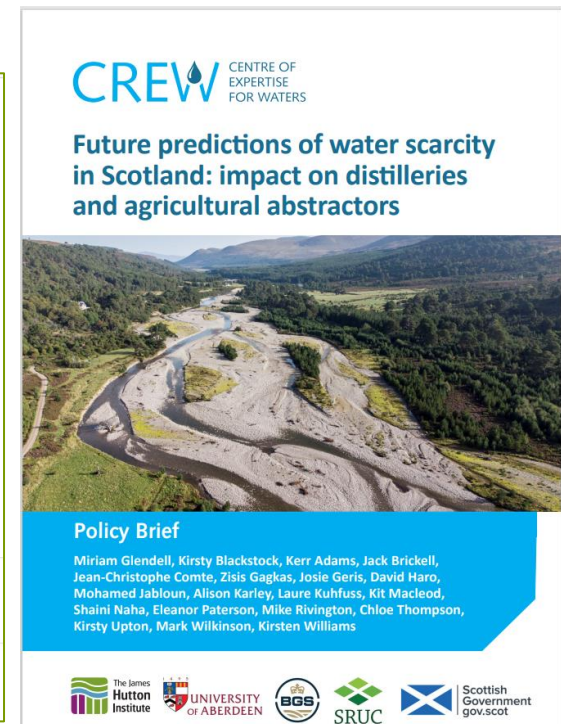
Future Duration (2024-2050)  
average drought event duration (days)



*Increase* in median drought durations with increasing abstractions

# Conclusions and Implications

- Identifying drought hotspots using water usage data returns and looking at future demand.
- Drought metrics are projected to increase between 2024–2050.
- More frequent (up to 1/5 years) and of longer duration (up to 50 days) in eastern catchments.
- Spey, Dee, Don, Deveron, and Tweed, as well as in the southwestern Clyde catchment are the drought hotspots.
- Likely future change in abstraction volumes, lead to noticeable changes in drought metrics
- Impact of increasing future abstractions is more evident in drought durations.
- Projected increase in droughts is primarily due to the hydrological model's predictions of reduced future flows.

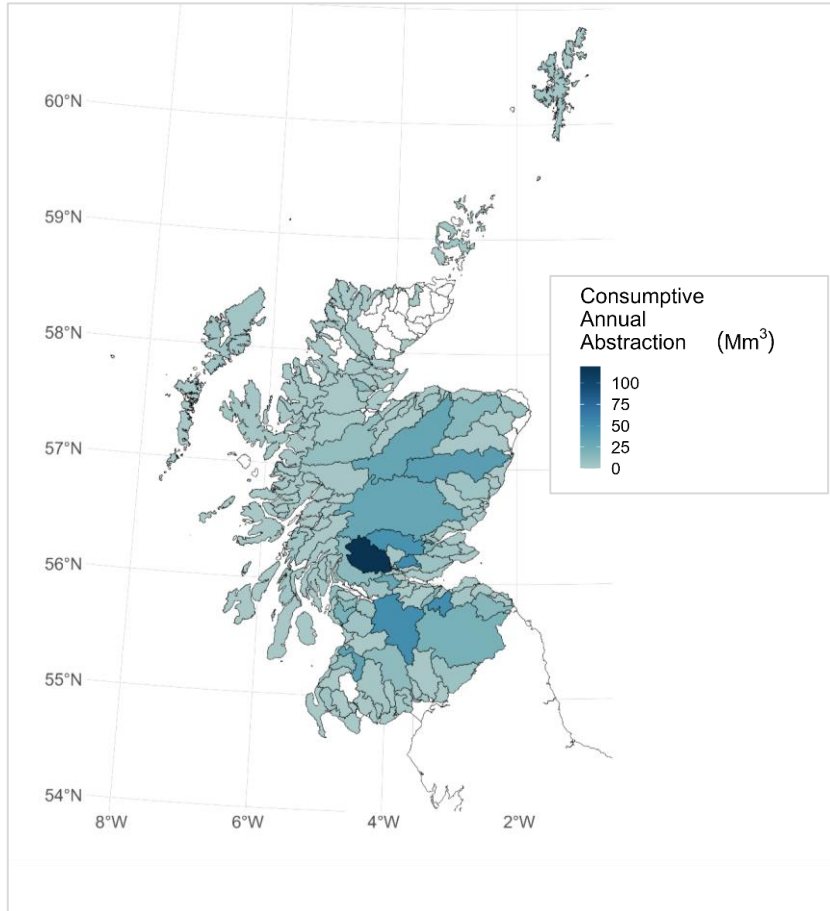


# Sectors Most Vulnerable to Future Droughts

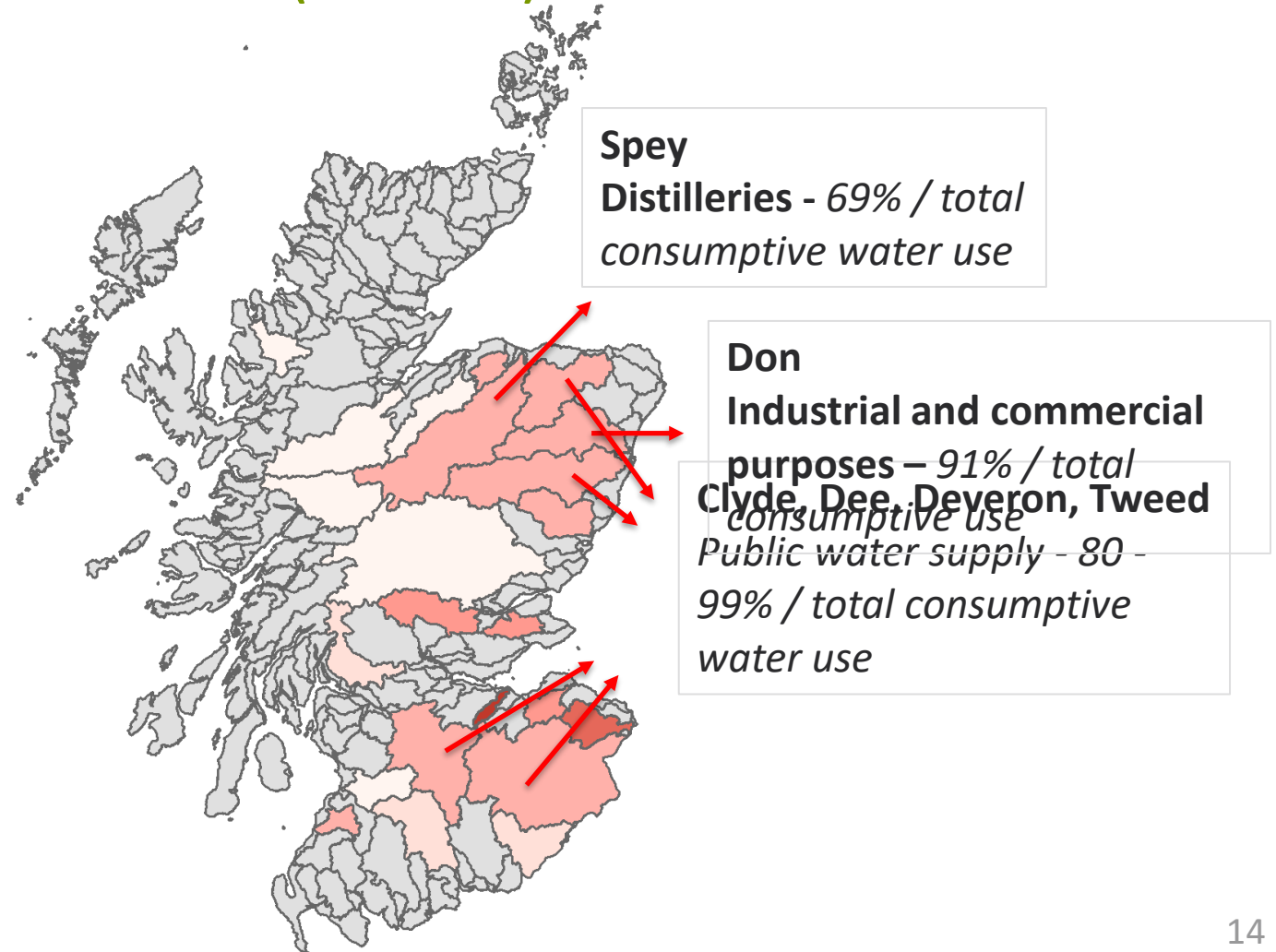


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## Reported abstraction for Consumptive Sectors



## Drought Frequency Future (2024-2050)





- Helps improving understanding of water abstraction pressures in Scotland.
- Detailed assessment on water resources availability in smaller river catchments need to be developed.
- Holistic adaptation options for water resources management in future.
- Accurate metering (especially for agriculture).
- Development of farm- and catchment-scale adaptation tools.

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### Using Reported Water Use Data to Map Future Water Scarcity in Scotland

24 Pages • Posted: 11 Apr 2025

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**Naha, Shaini** and Monteagudo, David Haro and Lau, Tiffany and MacCarthy, Brian and Glendell, M., Using Reported Water Use Data to Map Future Water Scarcity in Scotland. Submitted to Journal of Hydrology.

Available at

SSRN: <https://ssrn.com/abstract=5214283> or <http://dx.doi.org/10.2139/ssrn.5214283>

# Opportunities for further work

- Looking at individual water use sectors and specific regions, considering population growth forecast.
- Information on future demand in current and emerging sectors, for example hydrogen production, would be valuable.
- Looking at seasonality of drought occurrence and water scarcity in Scotland.
- Further work could link this analysis to an improved understanding of groundwater availability.





# Thank you!



Jennifer Leonard  
Louise Henderson  
Rosaria Cartisano  
Stephen McGuire  
Ellen Willmott  
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