Monitoring infiltration and retention to support assessment of Ecosystem Services

Kathi Bauer – South East Rivers Trust

PROWATER

Agenda

- Introduction
- Measuring natural capital
- Assets and services we are focusing on
- Monitoring set up for each context
  - Land cover conversion
  - Wetland restoration
  - Soil management
- Lessons learned

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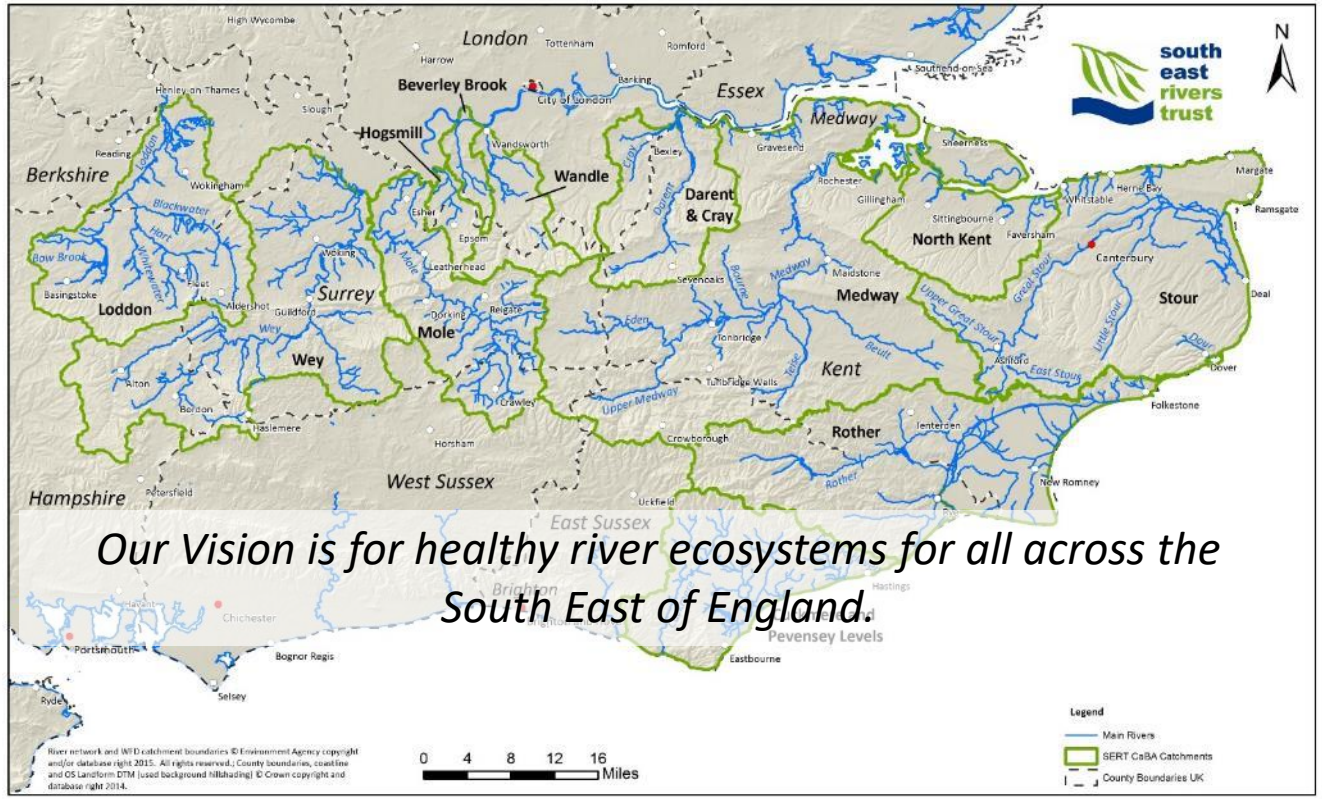
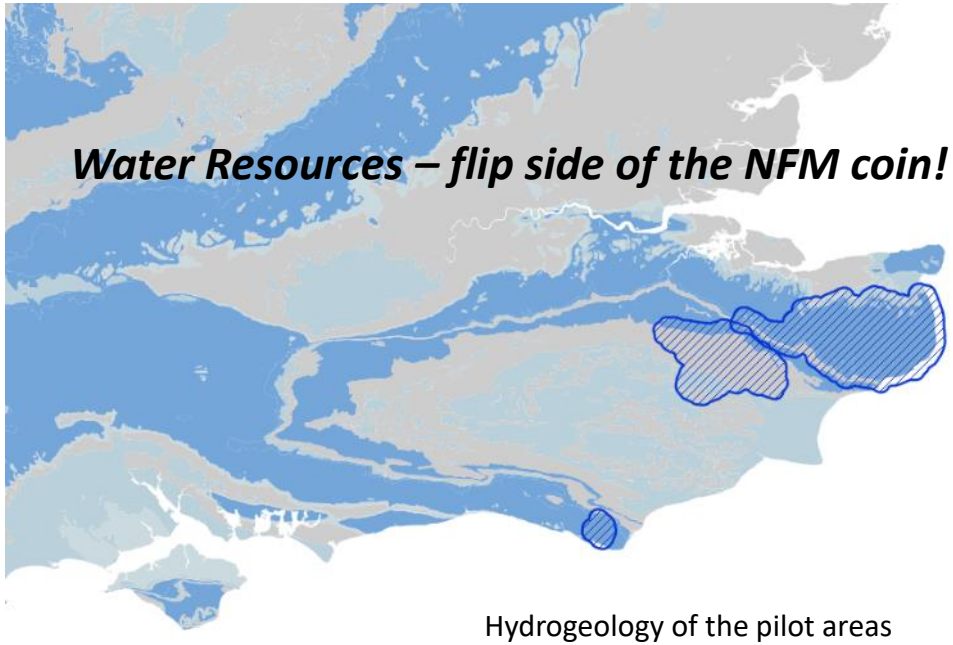


https://www.southeastriverstrust.org

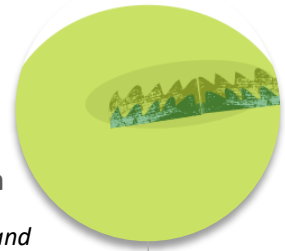
- Wandle Trust since 2000
- SERT since 2014, working in 12 catchment partnerships across 7 counties and 5 water company areas
- Conserve and restore rivers and their catchments across the South East of England
- My role: Natural Capital Coordinator – wide range of tasks and topics focused on water resources & natural capital

PROWATER: Protecting & Restoring Raw Water Sources through Actions at the Landscape Scale

- Interreg 2 Seas – ERDF funded, 2018-2022
- South East England: South East RT, Kent CC, South East Water
- 3 pilot areas:
  - Friston Forest (chalk),
  - East Kent Chalk/Little Stour (chalk),
  - Beult (clay)
- Use of Ecosystem-based Adaptation measures to protect and restore water resources
- GIS based targeting and impact assessment tool
- Develop a natural capital approach for investment in catchment – water & wider benefits
- (not a research project)



Hydrogeology of the pilot areas



Attenuation Features — Storage, Infiltration

Intense rainfall events can be captured and slowed down in attenuation features such as grassed swales, slowing water reaching the stream network and so buffering flows.

Soil management — Infiltration

Good soil management can double infiltration rates compared to poor soil management. Reduced tillage, cover crops, and diverse species mixes are some options to aid infiltration and water retention ability of the soil, reducing pollution risk.

Temporary wetland restoration — Storage, Infiltration

Less than 10% of potential wetland area are likely functioning as such, reducing retention ability of the catchment. Restoring habitats through reduced drainage and regrading of banks will increase capacity of the catchment to buffer flows.

River restoration — Storage, Infiltration

Increasing the ability of the river to retain water in wetland habitats can slow drainage and retain water in high flows to reduce flood risk. Adding diversity in the channel increases resilience of the ecosystem by providing support in a range of extreme conditions.

Measuring change in natural capital & ecosystem services

- Natural capital = stock of assets
  - Extent
  - Location
  - Condition
- Ecosystem services = flow of benefits from NC
  - Physical
  - Monetary
- Natural England NC Logic Chains/Indicators (represented in National Natural Capital Atlases) – indicators suggested, but data not always available
- Monitor change (is NC improving or deteriorating, providing more or less) and understand what 'good' looks like

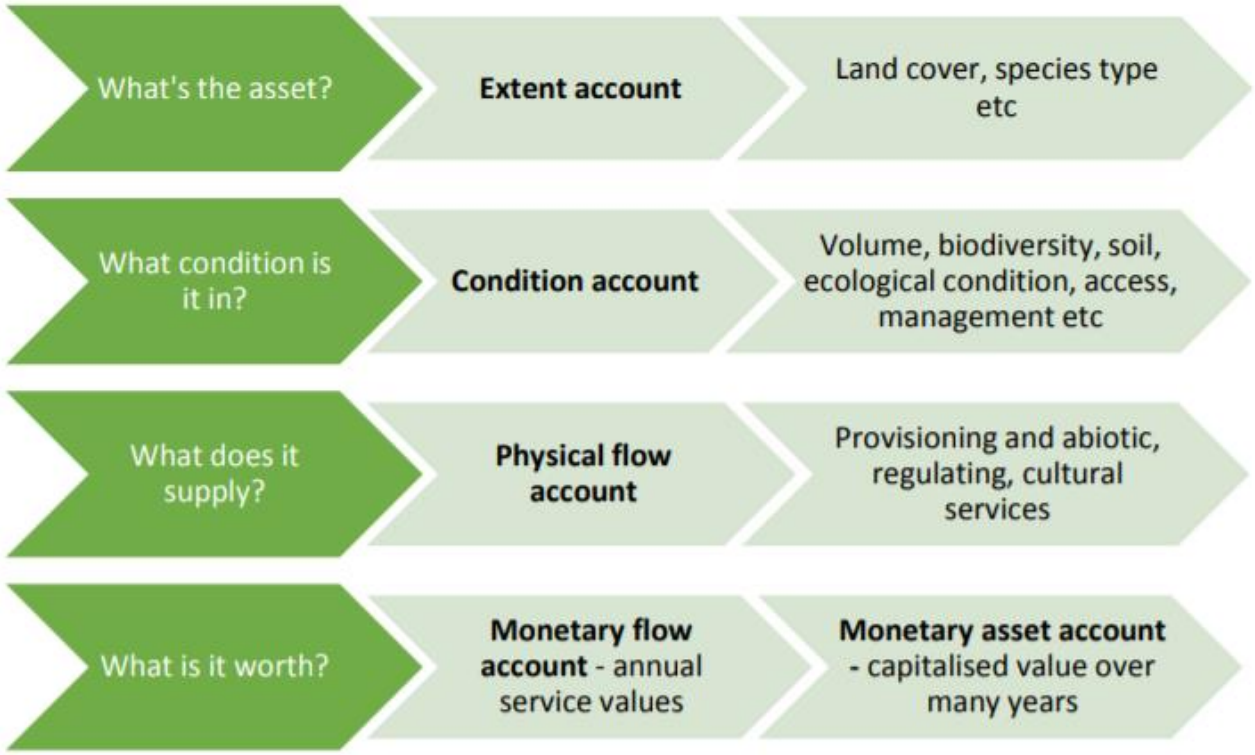
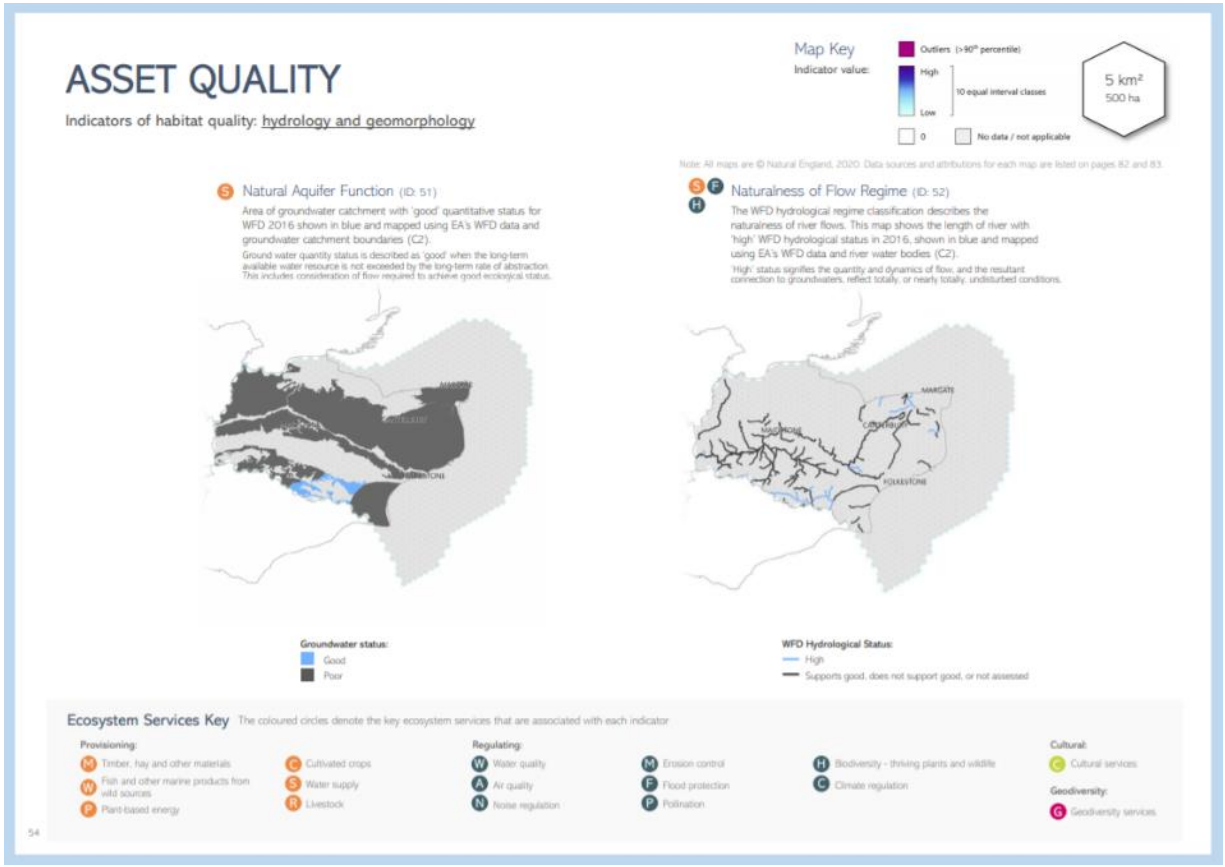
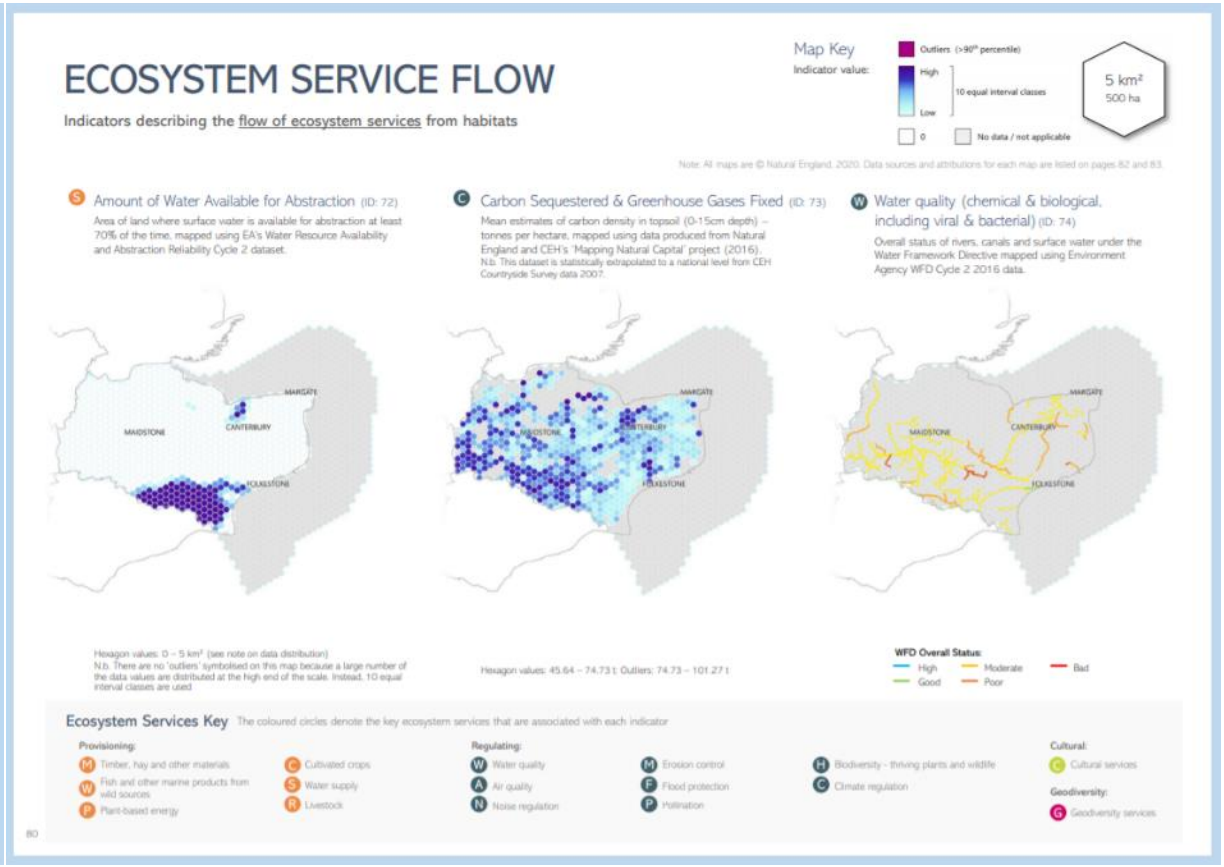


Image: ENCA

Natural Capital – national evidence & logic chains





Wigley et al, 2020: Natural Capital Atlas – evidence based on nationally available data to inform baseline understanding of stock of assets and service delivery

Natural assets providing water – project focus

Thinking back to the NC Framework & indicators…

Asset	Location	Hydrology	Nutrient & chem status	Vegetation	*Water provision*
Headwater streams/ wetlands*	Impermeable catchment Headwater zone (could also include active floodplain wetlands)	Extent of artificial drainage Naturalness of flows	Nutrient status	Vegetation next to waterbodies	Flow towards abstraction
Semi-natural grassland	Chalk aquifer Permeable soils Abstraction catchment Topography	See soil (Evapotranspiration)	See soil	Species diversity Proportion of bare ground	Drainage to groundwater (infiltration)
Soil	In relation to river Groundwater catchment Topography	Structure, compaction, & water retention capacity	N, P, K, C OM		Drainage to groundwater (infiltration)
Freshwater	Upstream of abstraction / dependent ecosystem	Naturalness of water regime	WFD chem. status	Vegetation next to waterbodies	Flow towards abstraction

*incl. wet woodland

Aim: provision of water resources

- Protect/increase **recharge to the chalk aquifer**
  - Reduce interception & ET loss from vegetation
  - Increase infiltration & retention capacity of soil
- 'slow the flow' – buffer extreme events to **retain more water in the clay catchment**
  - Increase infiltration capacity of soil
  - Increase retention capacity of the landscape
  - Reduce rapid drainage
- Improve water quality
  - Sediment
  - Nutrients
- **Monitor how our interventions impact the indicators set out by NE for the service/asset**
- **Validate tools (and assumptions)**

PROWATER Monitoring – a tale of three loggers

- Measure 1: Land cover conversion over chalk aquifer
- Measure 2: headwater wetland restoration in a clay catchment
- Measure 3: soil management on clay and chalk

Measure 1: Land Cover Conversion

Convert high water use land cover (trees) to low water use (grass/heath) on (shallow) soils over chalk

→ Established evidence base on a range of habitats and conditions

→ But: local conditions have a big influence – eg aquifer type/geology, species

→ **Aim:** increase recharge to the chalk aquifer (*& protect biodiversity)*

Indicator: Drainage - Volumetric Water Content across soil profile → Proxy for potential recharge (focus on ES flow)

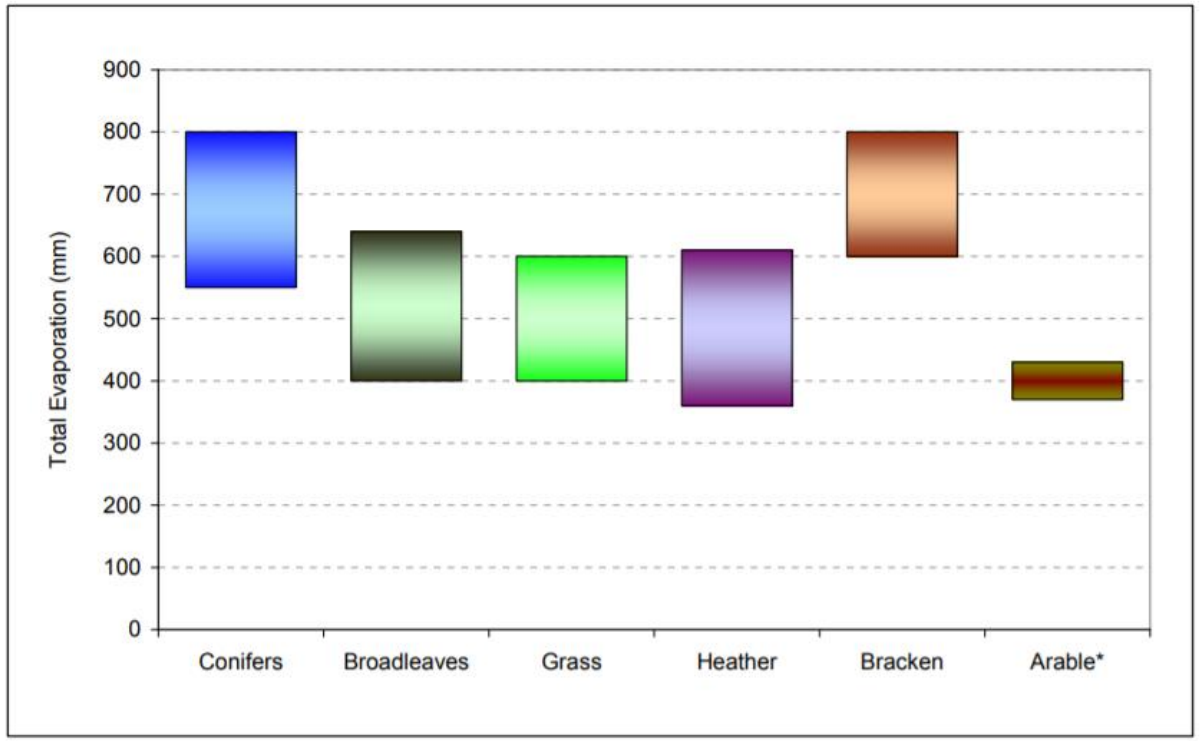


Figure 11. Trees generally use more water than other types of vegetation. Plot compares typical range of annual evaporation losses in mm for different land covers receiving 1000 mm annual rainfall in UK (from Nisbet, 2005). * Assuming no irrigation

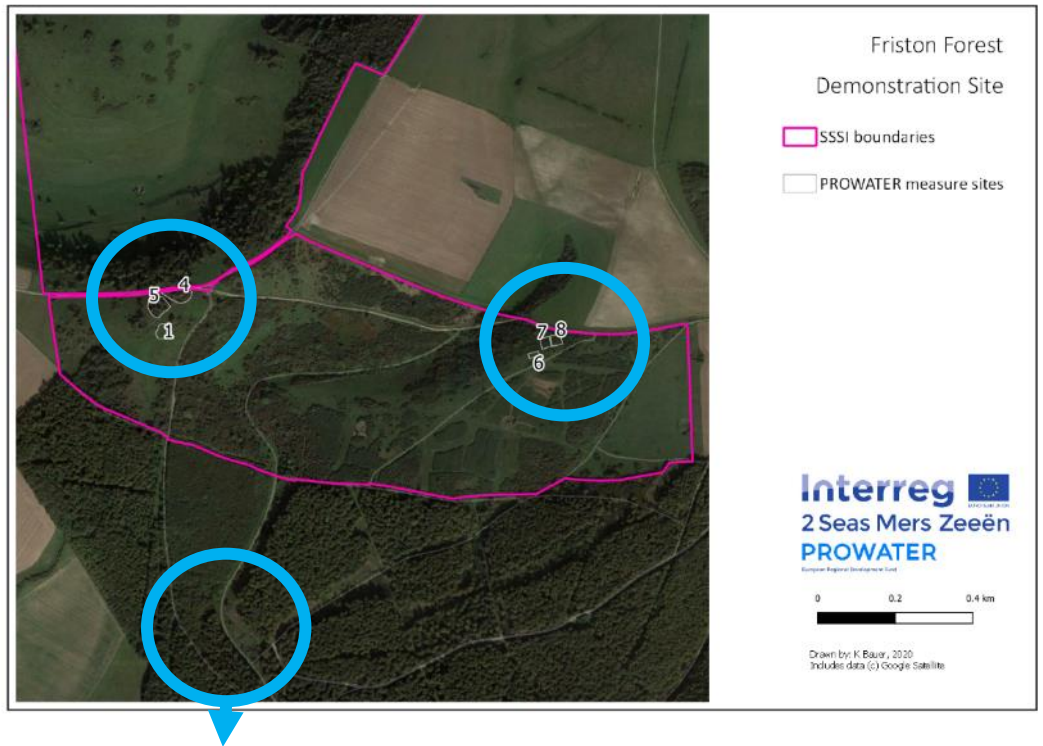
From: Nisbet et al 2011

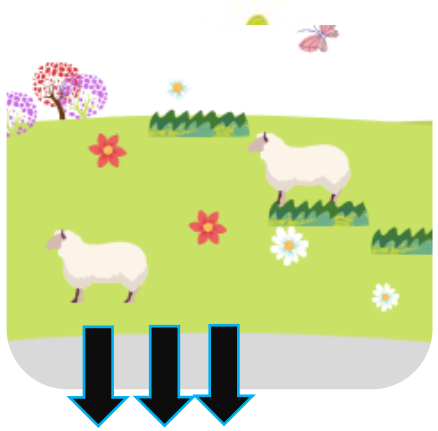
See also eg Calder et al 2002 and Roberts et al 2001 for specific evidence on chalk & broadleaved woodland

Land cover conversion – Friston Forest (chalk)

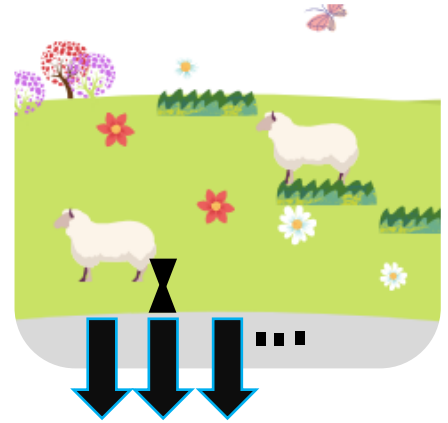
3 comparison sites – set up:

Habitat	Measure	Control
Gorse	3 SMP	3 SMP, 3 PP
Scrub	3 SMP	3 SMP, 3 PP
Decid. Woodland	3 SMP	3 SMP, 3 PP
Chalk Heathland	-	3 SMP, 3 PP
Chalk Grassland	-	3 SMP, 3 PP

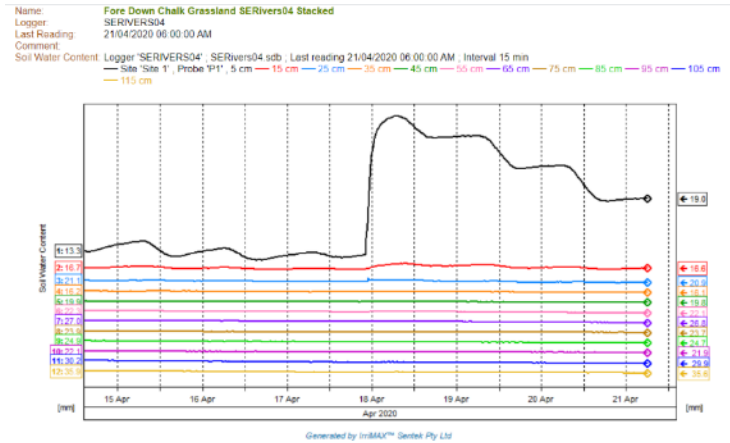




1 year 'before' data – conversion in Jan 2021, until Aug 22



2.5 years control data (Jan 20 – Aug 22)



Sentek Drill & Drop 120cm soil moisture profile probe (Volumetric Water Content every 10cm) + Raingauge w telemetry (from www.soilmoisturesense.com/)

Why does it matter what grows on Friston?

777mm rain per year
= 770m³/ha

Changing landcover from this...

1 hectare woodland =
2797 m³ pot. recharge

+310m3

... to this...

1 hectare of grassland =
3108 m³ pot. recharge

=

... has the potential to protect water availability:

Enough water to supply 3 more people for a year

1 hectare gorse/conifer =
1554 m³ pot. recharge

+1476m3

1 hectare of heather =
3030 m³ pot. recharge

=

Enough water to supply 25 more people for a year

Rough calculation based on maximum water loss per habitat[1], per capita consumption o 151/day

- Site selection: similar soil, level of exposure, height, topography
- Hydrological years – October as starting point
- SSSI – choose probes & installation that allow for as little disruption as possible & allow for time to get assent in place
- Agricultural equipment can be cheaper than research
- Sheep, rabbits and ponies are curious about cables and poles
- Solar panels are limited in woodlands
- Who has to crawl into the gorse?

Measure 2: Headwater wetland restoration – River Beult (clay)

Reverse or reduce artificial drainage to support natural processes

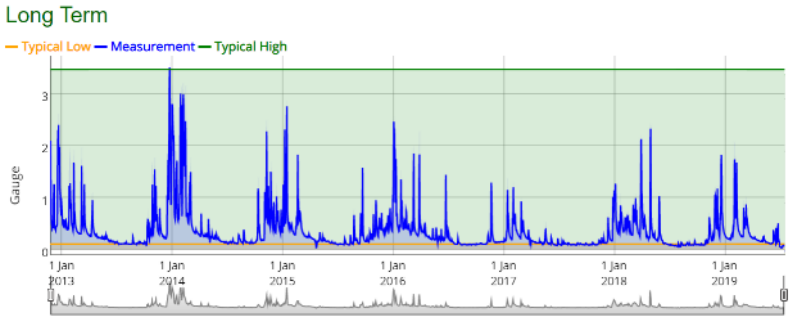
Focus on headwaters (identified using UoAntwerp TPI approach developed for project)

→ Headwater streams and wetlands are important and rarely undisturbed

→ Wetland hydrological function is complex

→ **Aim:** retention & storage, moderated flows (no groundwater body present)

Indicator: surface water flow (ES flow & asset condition), soil water table (asset condition)



Long-term flow data for the River Beult at Stilebridge (bottom of catchment)

Andy Bullock and Mike Acreman

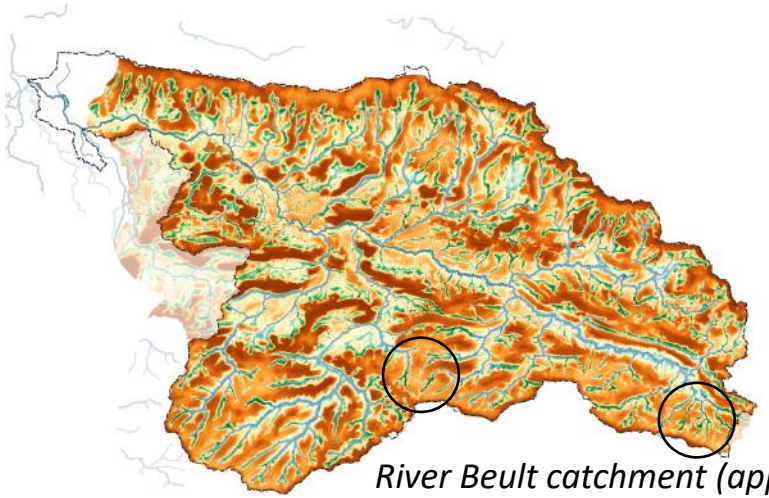
Table 5

Bullock & Acreman 2003

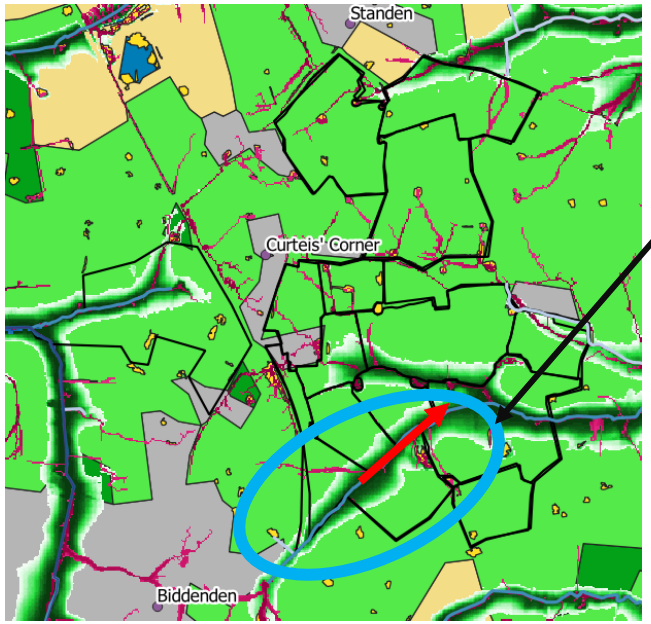
a Gross water balance

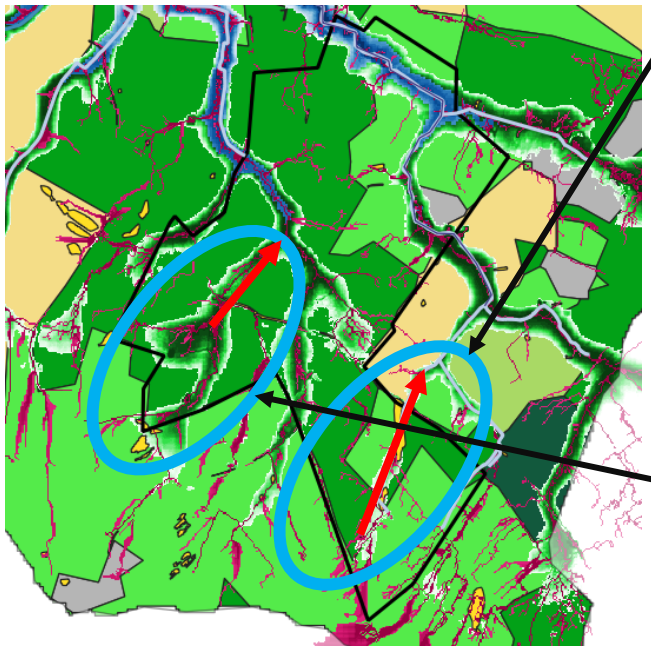
			FP	SW/D	SW/S	GW/D	GW/S	General	Total	
Mean annual flow	MAF	+		2				2		4
		-		8	1	5	1	7	1	23
		.		2	1	4		8	1	16
Mean annual actual evaporation	MAAE	+		12	1	4	1	6	1	25
		-					1	2		3
		.		1	1	1				3
Wet period flow	WPF	+		1		3		5	6	15
		-		1				2	2	5
		.		1	1		1	1		4
Wet period actual evaporation	WPAE	+							1	1
		-				1		1		2
		.								0
Dry period actual evaporation	DPAE	+		4		3		15		22
		-						1		1
		.								0
increased flow or reduced evaporation				3	0	4	1	11	6	25
reduced flow or increased evaporation				25	2	2	2	30	5	76
not increased or reduced				4	3	5	1	9	1	23

→ Increased water availability vs natural processes?



River Beult catchment (appr 290km²) with appr. location of sites





3 comparison sites – all headwater areas

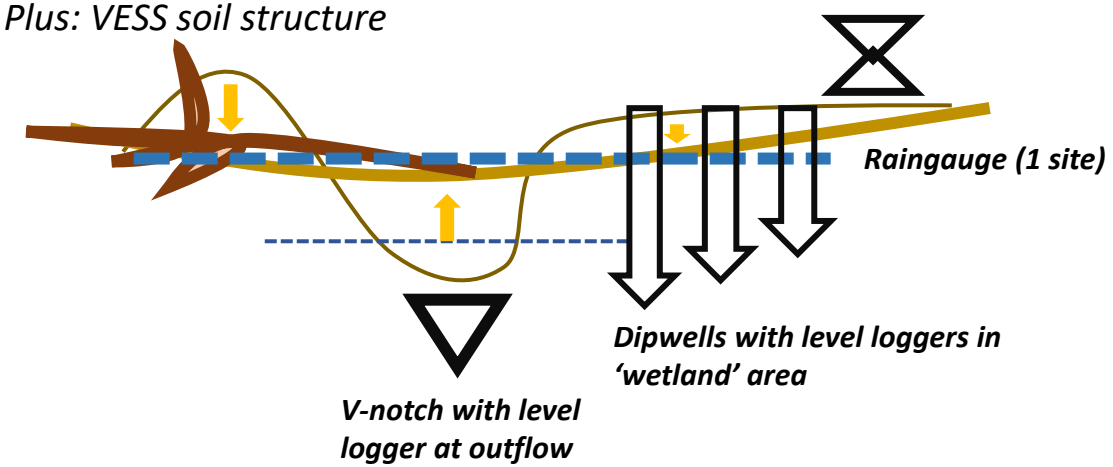
with typical drainage ditches and catchment <3km^2 :

- Productive livestock farm
- Conservation grazing meadow
- Deciduous woodland

→ Could have focused on one location, but this gives us 3 interesting land uses/covers

Set up:

- Level loggers in streams since early 2020
- 1 winter v-notch & dipwells before intervention (2020/21)
- 1 winter after intervention (2021/22)
- *Plus: VESS soil structure*



Schematic image of intervention:
Before: *incised ditch drains area rapidly and provides no retention.*
After: shallow, wide area allows slow flow and filtration, retaining water for longer. Large trees create barriers and lead flows onto the plain.

Flow = rainfall*catchment area – ET – soil storage

→ Before/after flow duration curve

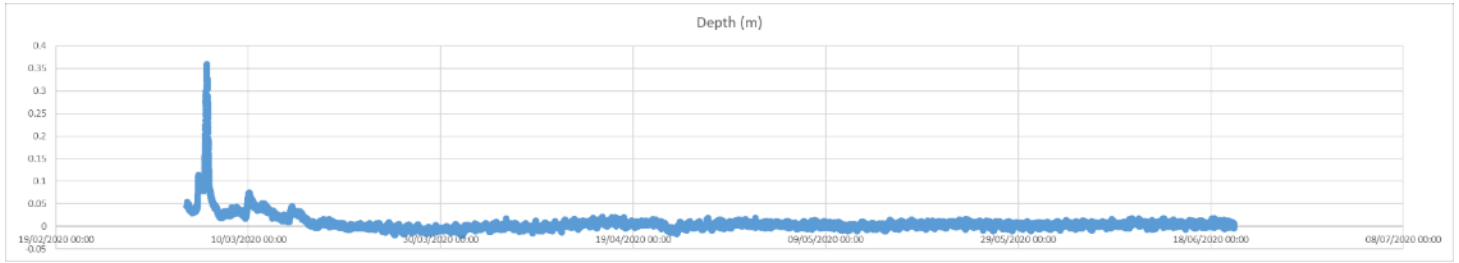
→ Event comparison

→ Flow: total volume (vs total rainfall) the headwater is contributing, seasonal volume, dry period

→ Dipwells & soil structure: additional evidence & understanding on soil water table

→ *Plus: water quality*

(v-notches yet to be calibrated… no flow yet!)



- Monitoring/delivery timing – need for baseline data vs not knowing exactly what will be delivered
- Do you know upstream inputs/losses?
- A little bit everywhere or everything in one location?
- Is the equipment in the right place to record every change?
- Regular sampling – worth investing in telemetry or at least loggers
- Quality of loggers and error range, need for baro compensation
- Check on your equipment…

Measure 3: Improving Soil Health

Introduce more diverse, deep rooting species mix on permanent pasture to improve soil health

Focus on agriculturally managed soils – livestock pasture & equestrian

→ Equestrian: less evidence & engagement, livestock: most common land use in Beult catchment

→ Soil management impacts are context specific (soil type, climate, landcover) and complex

→ **Aim:** increase infiltration and retention to improve drainage & water quality *(and farm resilience)*

Indicator: Volumetric water content/drainage (ES flow), soil structure & infiltration rate, nutrient and OM status (asset condition)

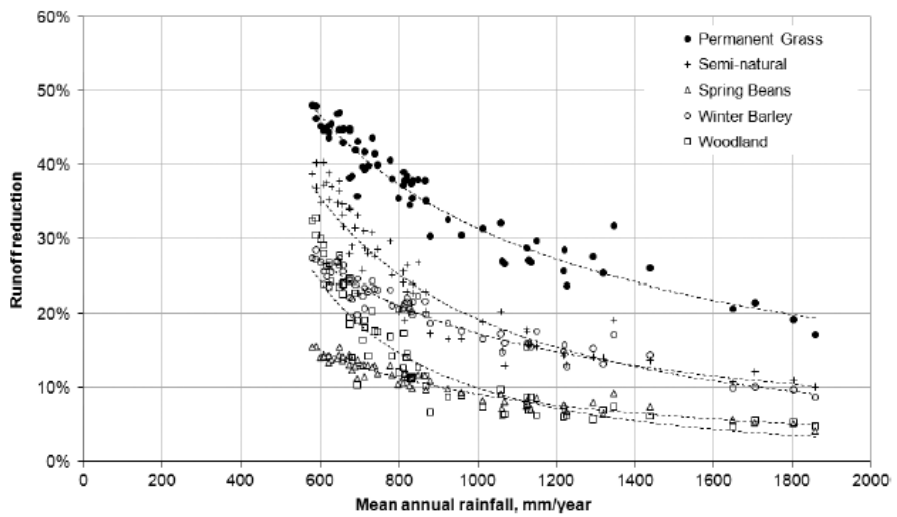
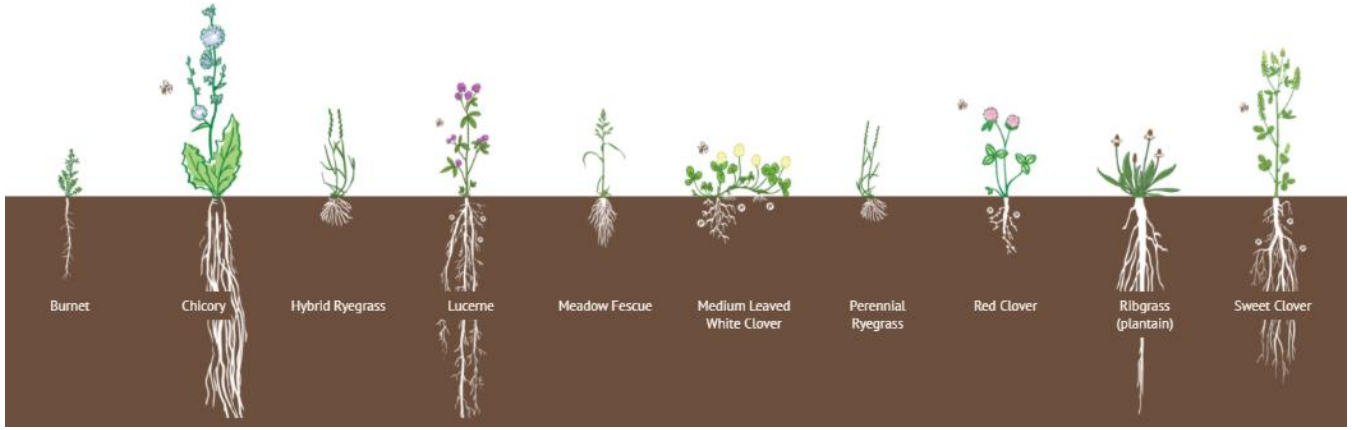


Figure 6. Relative runoff reduction from 1 in 5 year storm due to changing from 'Poor' to 'Good' field–soil class on different land covers in relation to mean annual rainfall for 68 agroclimatic regions in England and Wales

Hess et al 2010



(Image: Cotswold Seeds)

Clay: break up lower layers of clay and improve drainage on field adjacent to watercourse/ wetland

Chalk: build up OM to increase drought resilience and improve infiltration on slopes (runoff) and in valley bottom (drainage); reduce N inputs

Set up:

- Measure/Control set up,2 winters monitoring (2 recharge periods)
- 60cm SMPs (2M/ 2C)
- 5 x VESS, 5 x infiltration test each
- Infiltration test: 20cm ring, 1 inch of water, 3 repeats
- 15 soil samples (OM, N, P, K, BD, VWC) each
- Repeated in 2021 & 22

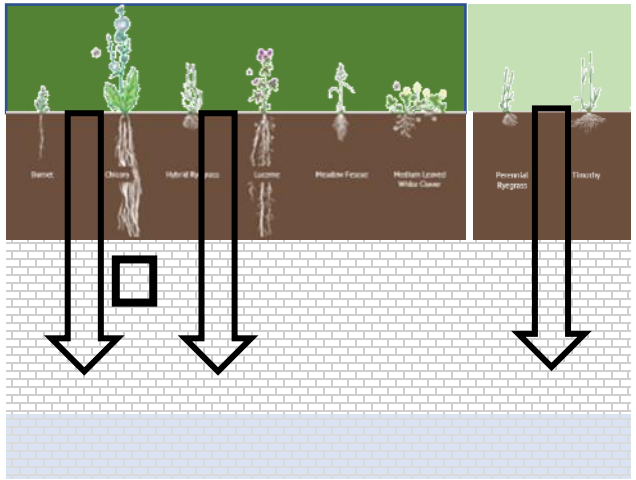
→ Comparison infiltration rate & VESS score measure/control

→ Mapping soil condition & VWC + comparison M/C

→ Chalk: volume & duration of drainage to 60cm

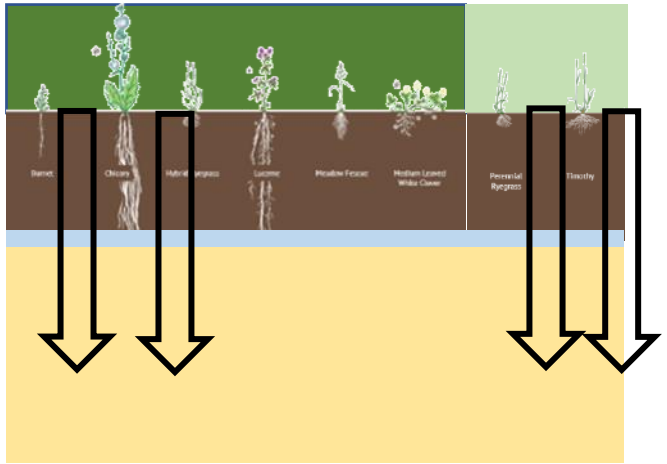
Equestrian, chalk

3 60cm soil moisture probes in measure, 1 in control, raingauge
3 porous pots



Livestock, clay

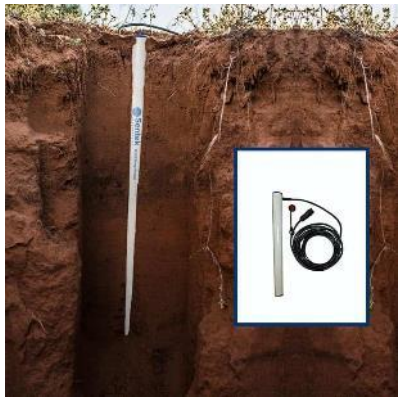
2 60cm soil moisture probes in measure, 2 in control, raingauge
Water quality in stream

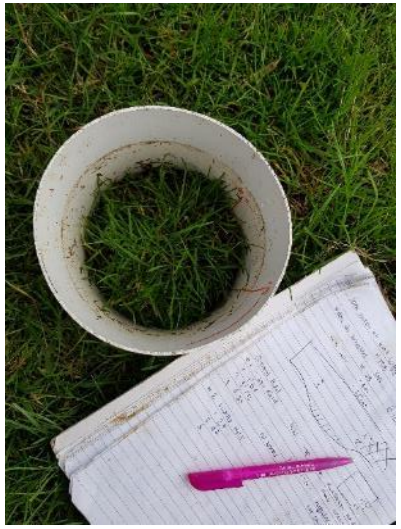


- Infiltration test: could use double ring infiltrometer, or use FAO method (how much water can infiltrate in an hour?) – but take 10 hours, compared to 3-5…
- Soil variation on site, previous management
- Access to water? (if not, you might have to do fewer tests)
- Not too dry, not too wet for sampling
- Strong arms help

Costs

- Level loggers & Baro logger (250+)
- V-notch weirs (200+)
- Dipwells & stilling wells (plastic pipes & gauze) (£5+)
- Soil moisture profile probes (800+)
- Rain gauge (200+)
- Infiltration ring (plastic pipe) (£3)
- Soil sampling (lab costs) (15-50£/sample)
- Telemetry access and/or comms kit
- Water quality – handheld monitoring (£5000)
- Water quality – porous pots
- Installation kit
- Time (design, investigation, research, advice, installation, check up, repair, data download analysis…)





Get help if you can – this would have been even harder without colleagues from various organisations (and check the resources – e.g. https://catchmentbasedapproach.org/learn/catchment-science-fieldscale-monitoring-handbook/)

Use the guidance to think through what you want and need – e.g. RRC's PRAGMO (https://www.therrc.co.uk/monitoring-guidance)

Everyone is going to tell you something slightly different - keep it simple, and to some extent, just give it a go.

But you can get what you need!

Using our evidence

- → Understand both asset condition and flow of service – capacity to deliver services depends on asset condition
- → Improved knowledge of different elements of our catchments
- → Multiple benefits – this is adding one more detail to the picture
- → Local evidence for local decisions
- → Make a case for investment in nature-based solutions for resilient water resources

Thank you!

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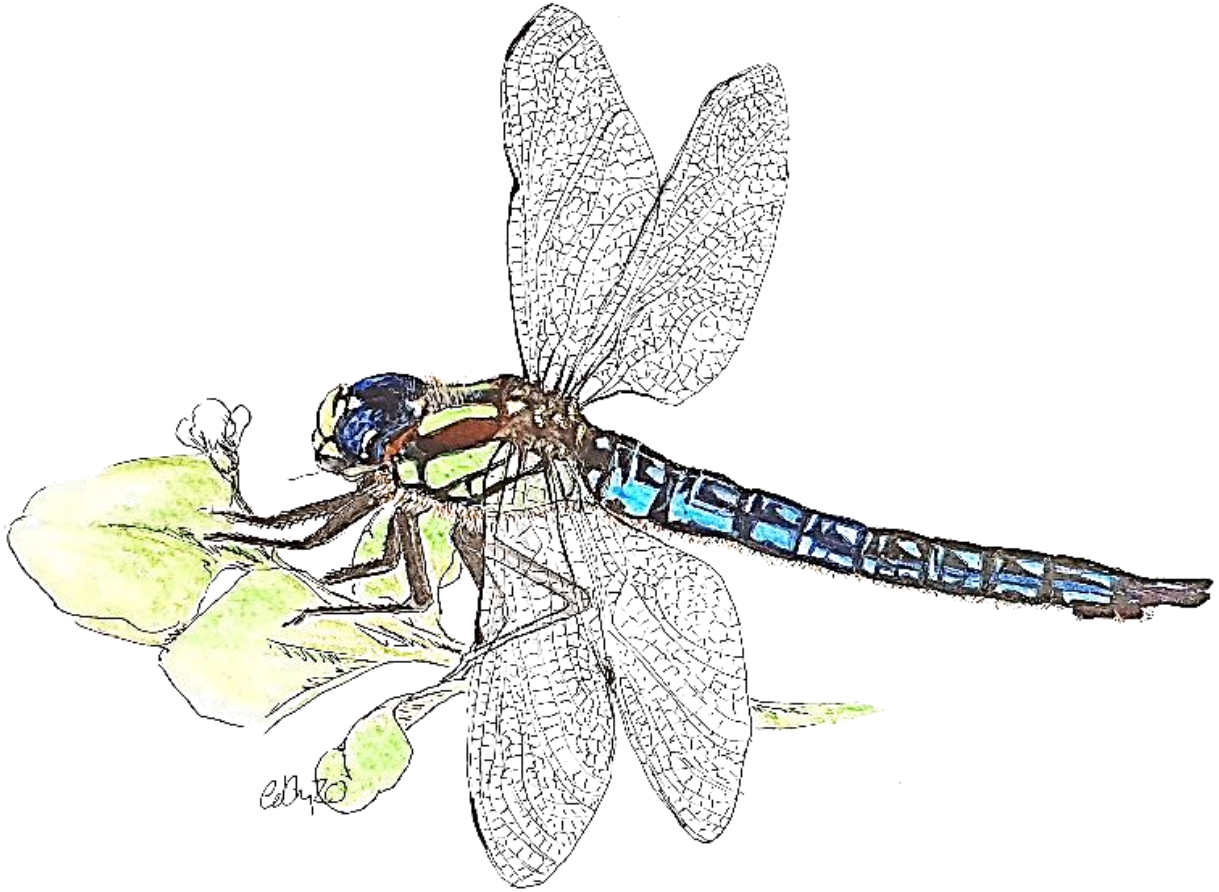

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