

The contribution of hydrological fluxes to
carbon sequestration in a temperate forest
plantation

Research question

Proportion of C sequestered by forest ecosystems lost in water flux?



Study site: Griffin Forest (56.6°N, 3.8°E)

- Catchment area 4.5 km²
- Dalradian schist overlain by humic gley/ stagnohumic gley soils
- Sitka spruce forest planted 1980-1981



Field measurements of hydrological flux

April-December 2000

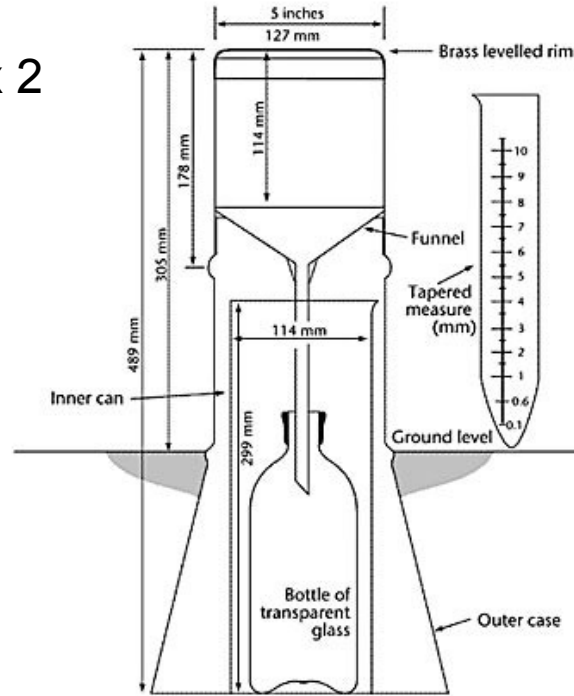


Logging
raingauges x 2



Throughfall
& stemflow
samplers x
24 trees

Storage raingauges x 5



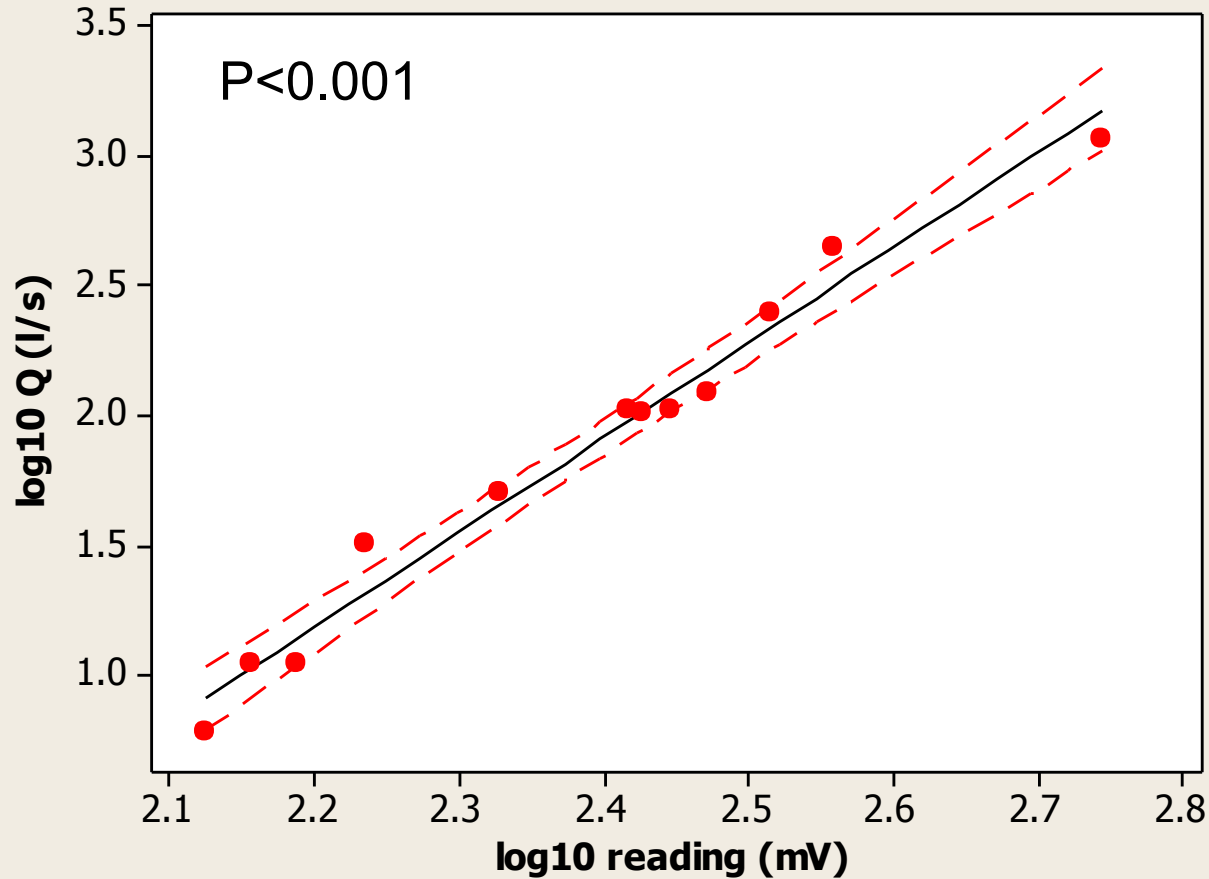
www.met-office.gov.uk



Cloudwater gauges x 2

Ratings curve for Cultullich Burn, Griffin Forest 2000

$$\log_{10}(Q) \text{ (l/s)} = -6.853 + 3.655 \log_{10}(\text{reading})$$



— Regression
- - - 95% CI

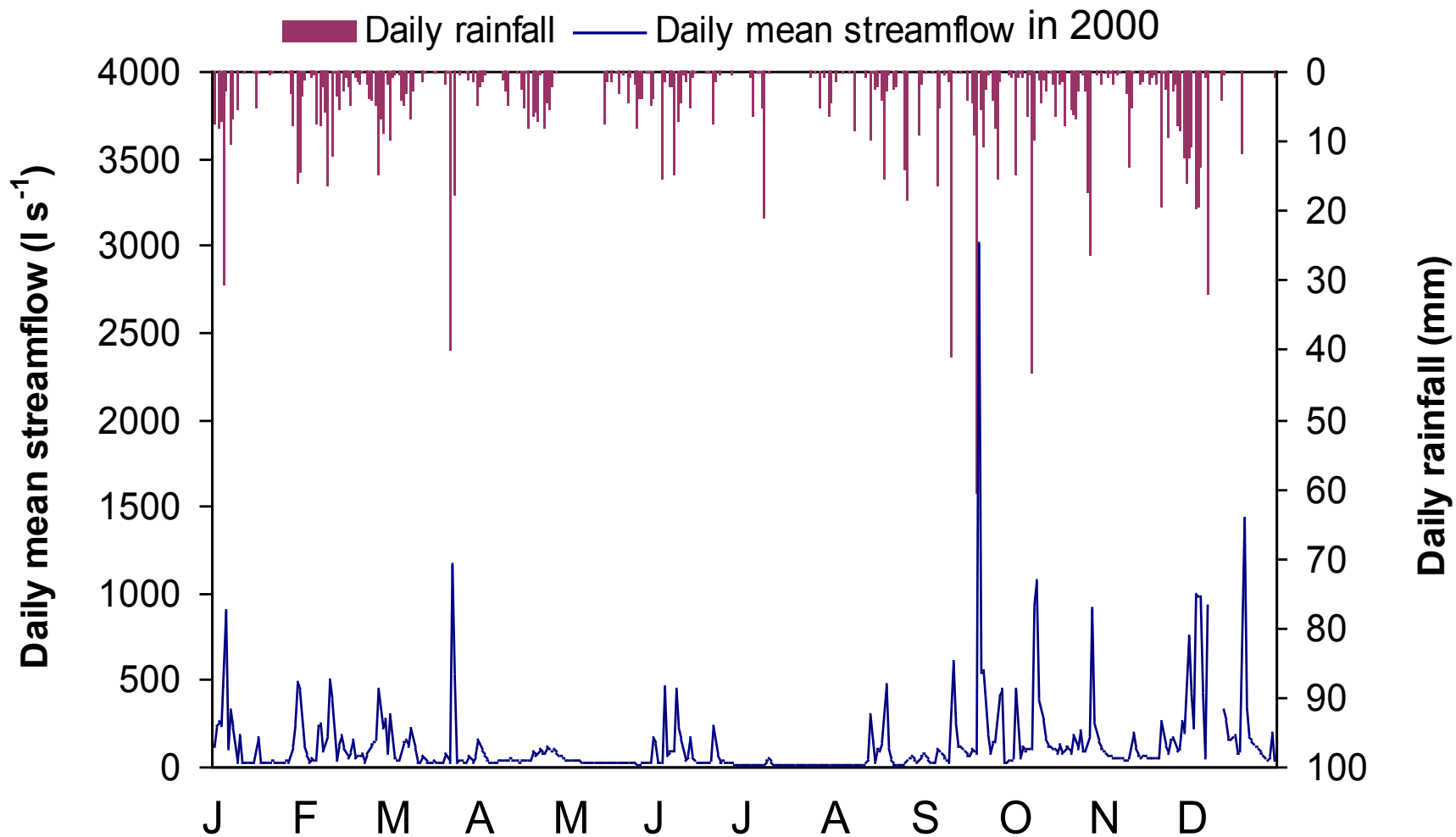
S	0.107552
R-Sq	97.8%
R-Sq(adj)	97.5%



CO₂ flux (eddy covariance)



- Movement of air parcels measured in 3 dimensions using a sonic anemometer
- Air analysis with IRGA => flux of CO₂ calculated
- Other micrometeorological measurements to check energy balance and calculate evapotranspiration



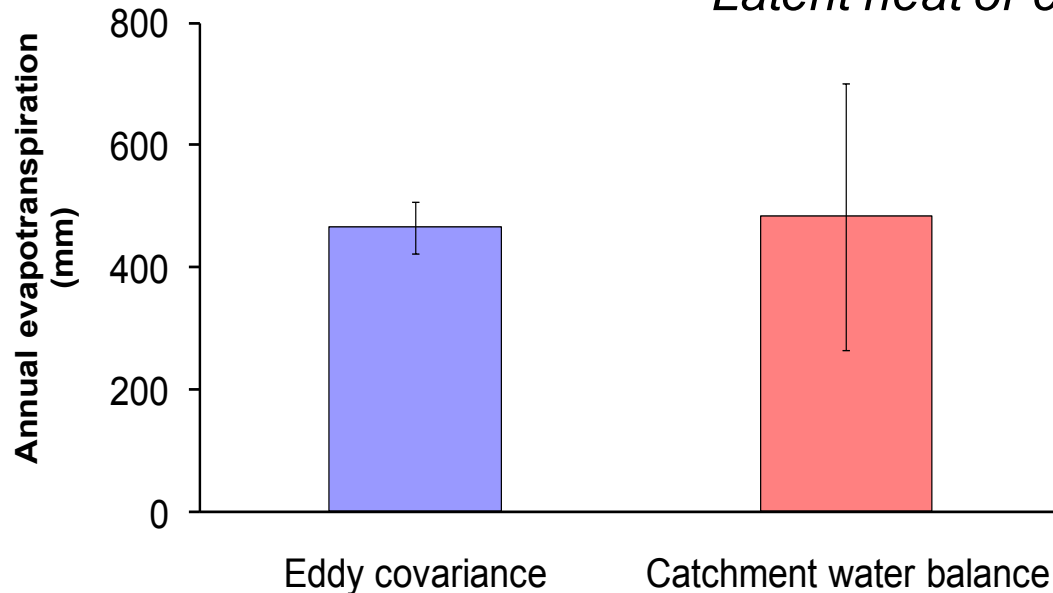
Annual evapotranspiration estimates 2000

- Catchment water balance method:

$E = \text{precipitation} - \text{streamflow}$

- Eddy covariance:

$$E = \frac{\text{Measured latent energy}}{\text{Latent heat of energy of evaporation of water}}$$

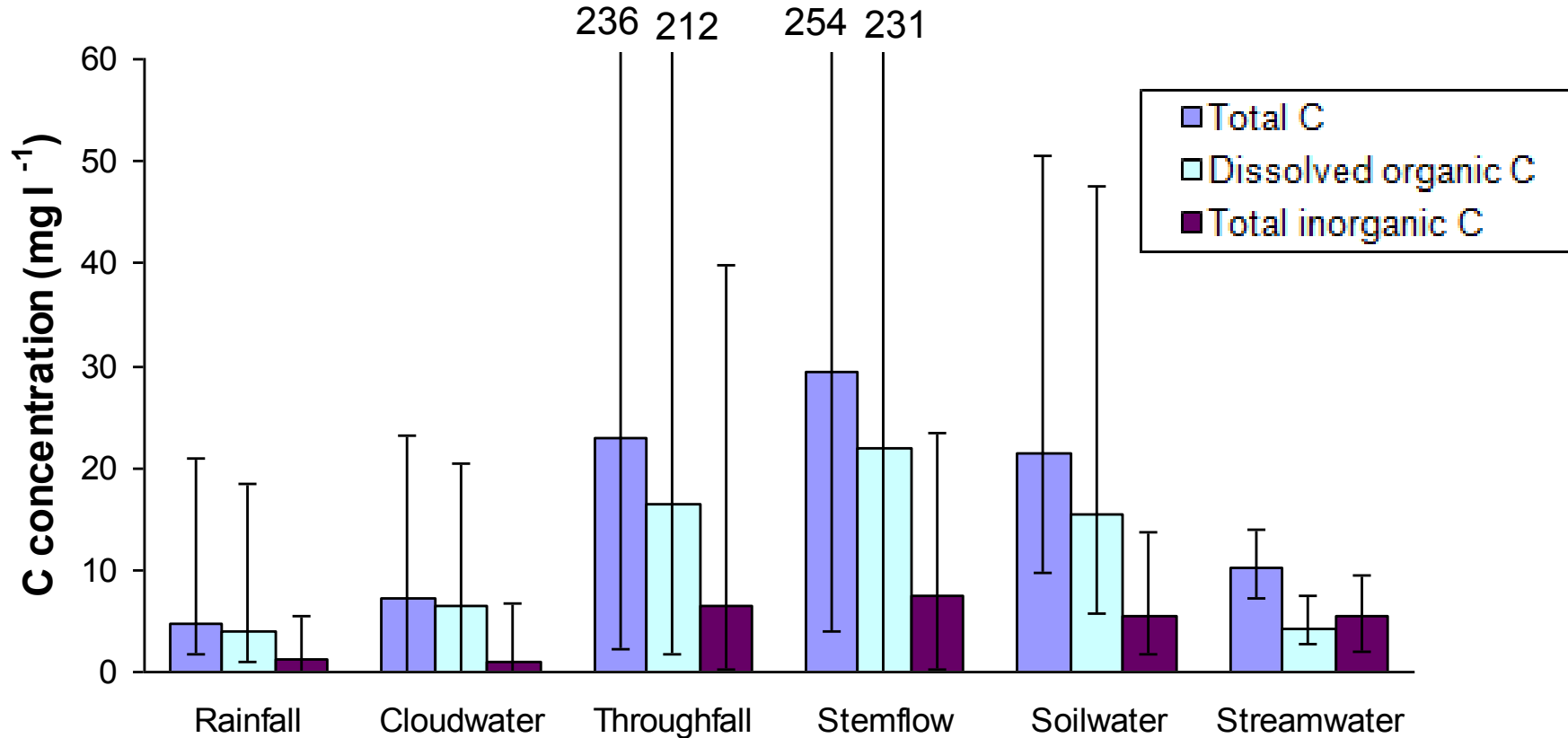


- Estimates of evapotranspiration by different methods show close agreement
- Catchment water balance closure within uncertainties

=> Confidence in measurements
of hydrological fluxes

Summary of chemical concentrations

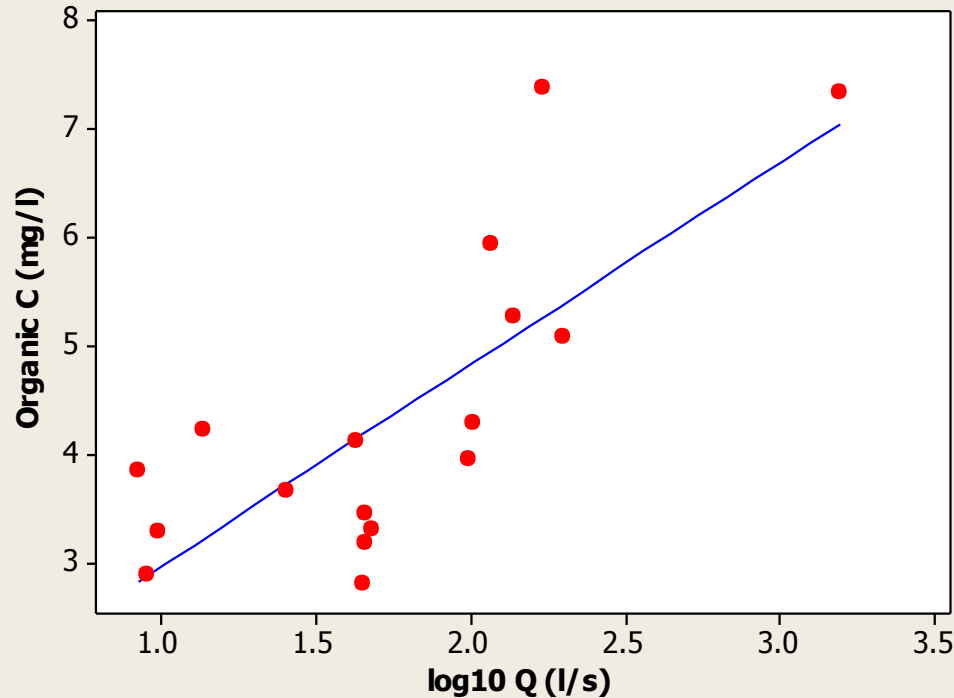
Mean values; bars show max and min values



DOC vs flow relationship

Organic C concentration in streamwater vs log₁₀ flow, 4 Apr-5 Dec 2000

$$\text{Organic C streamwater (mg/l)} = 1.101 + 1.863 \log_{10} Q$$



S	0.940832
R-Sq	58.5%
R-Sq(adj)	55.8%

P=0.001

DOC flushed from organic near-surface soil horizons at high flows

Impact of C loss in river on net C sequestration

Parameter	Study site		
	Griffin Forest (Scotland)	Hokkaido (N Japan)	Moor House (N England)
<i>Reference</i>		<i>Shibata et al. (2005)</i>	<i>Worrall et al. (2003)</i>
Vegetation	Sitka spruce plantation	Temperate deciduous forest	Heather (dwarf shrub)
C loss in water (t ha ⁻¹ a ⁻¹)	-0.026	-0.04 (incl. POC)	-0.348 (-0.149 without POC)
C sequestered (t ha ⁻¹ a ⁻¹)	6.1	2.6	0.55
% sequestered C lost in water	0.43	1.5	63 (27 without POC)

Interaction between catchment C and N fluxes

- 73% of atmospheric N input removed by canopy
- C sequestration per unit added N ($\Delta C:\Delta N$)
 - c.170 in 2000 at Griffin
 - 210 (Magnani et al., 2007)
 - 25 (De Vries et al., 2006)
- New NERC-funded project
 - BACIP design with 2 adjacent sub-catchments
 - 1 year before
 - 4 years after: treatment with 40 kg N ha⁻¹ yr⁻¹
 - (NH₄NO₃ 4 x year, minimise water volume)
 - Calculate ecosystem and catchment $\Delta C:\Delta N$

