Dissolved organic carbon: sources, sinks and future trends

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Percentage peat cover in Europe

Peat C stores

Drivers of [DOC]

Study site

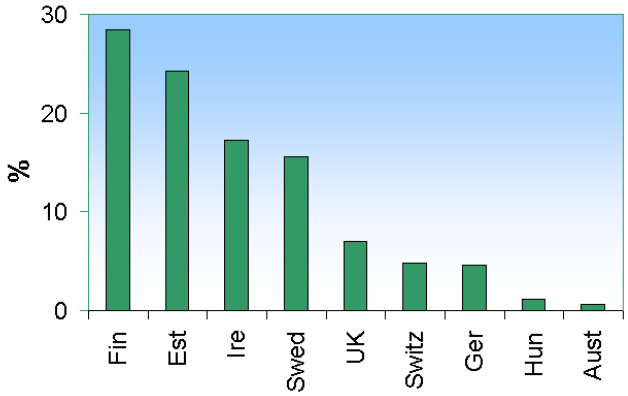
Instrumentation

DOC export

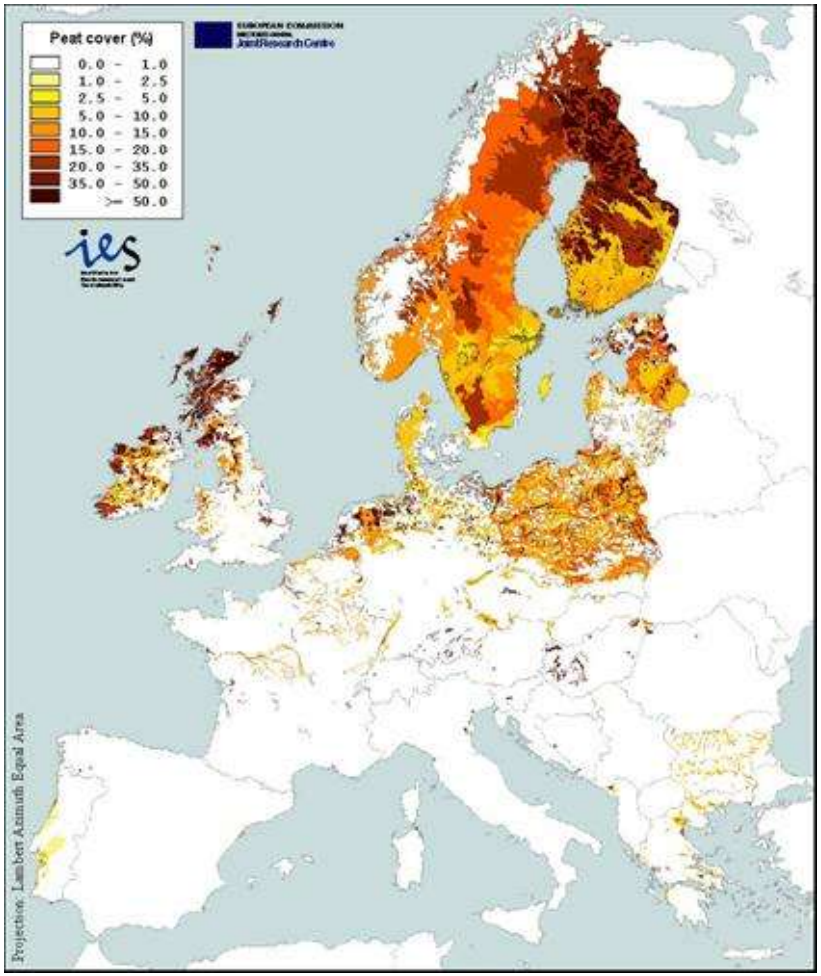
DOC model

Future climate

Future trends



Mayo, Ireland



Peat cover in Europe: Monterella et al. 2006

Dissolved Organic Carbon

Peat C stores
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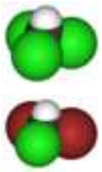
- High DOC concentrations in streams draining peat soils

- Major carbon source in downstream systems

- Issues for water treatment
  DOC + chlorination = THMs

e.g. $CHCl_3$
e.g. $CHBr_2Cl$



major health implications

Poulaphuca: colour 1980 to 2002

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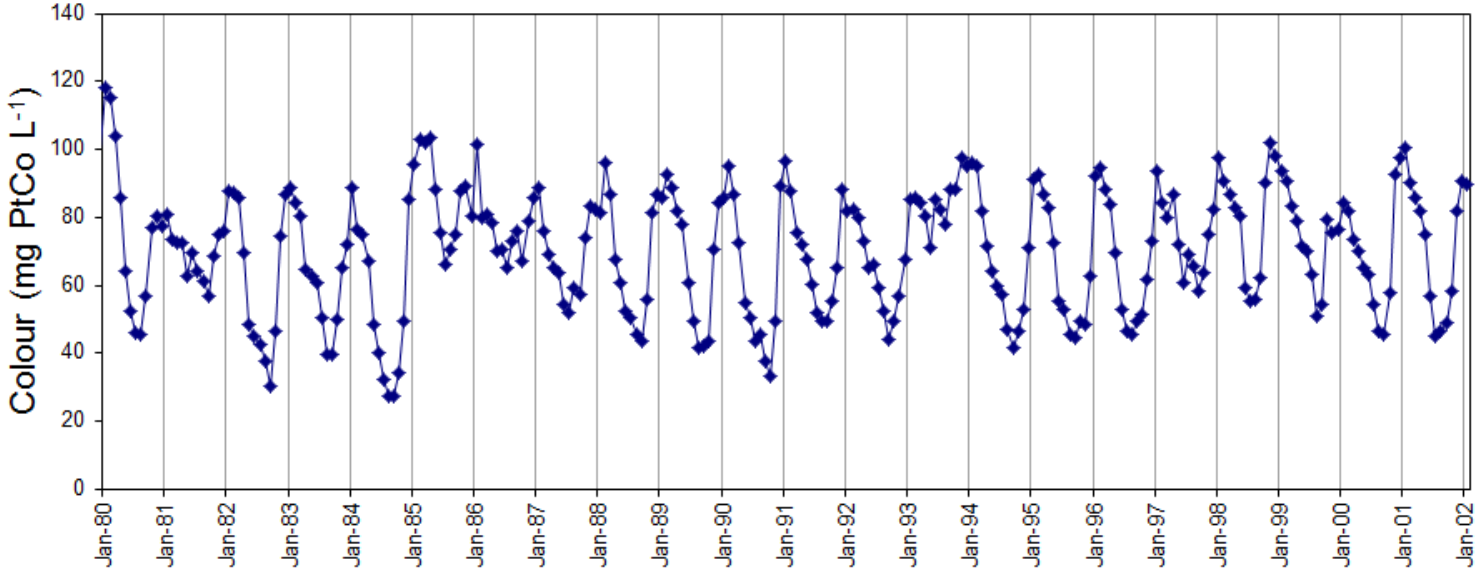

Data: Dublin City Council

Long-term increases in DOC export have been reported from many sites in Europe and N America

Peat C stores

Drivers of [DOC]

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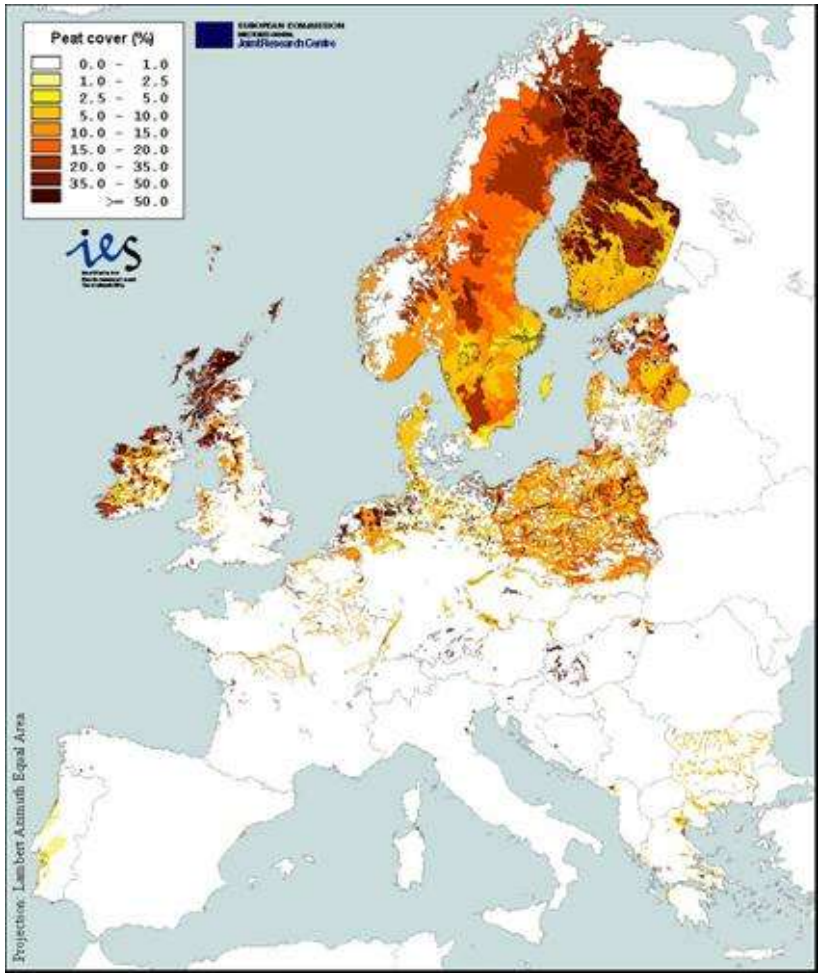
Forsberg and Petersen, 1990
S Sweden ↑

Hongve et al. 2003
SE Norway ↑



Andersen et al. (1991)
Sweden ↑

Worrel et al. 2004
77% of 198 catchments
↑

Skjelkvåle et al. (2001)
Norway, Sweden and Finland
↑

DOC export is largely driven by climate

Peat C stores
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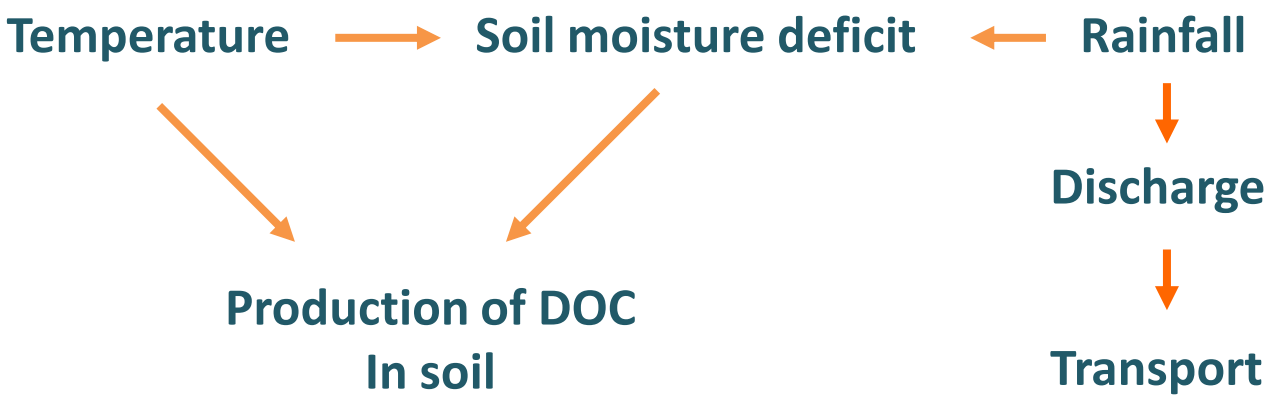

Effect of drought on water colour/DOC

Peat C stores

Drivers of [DOC]

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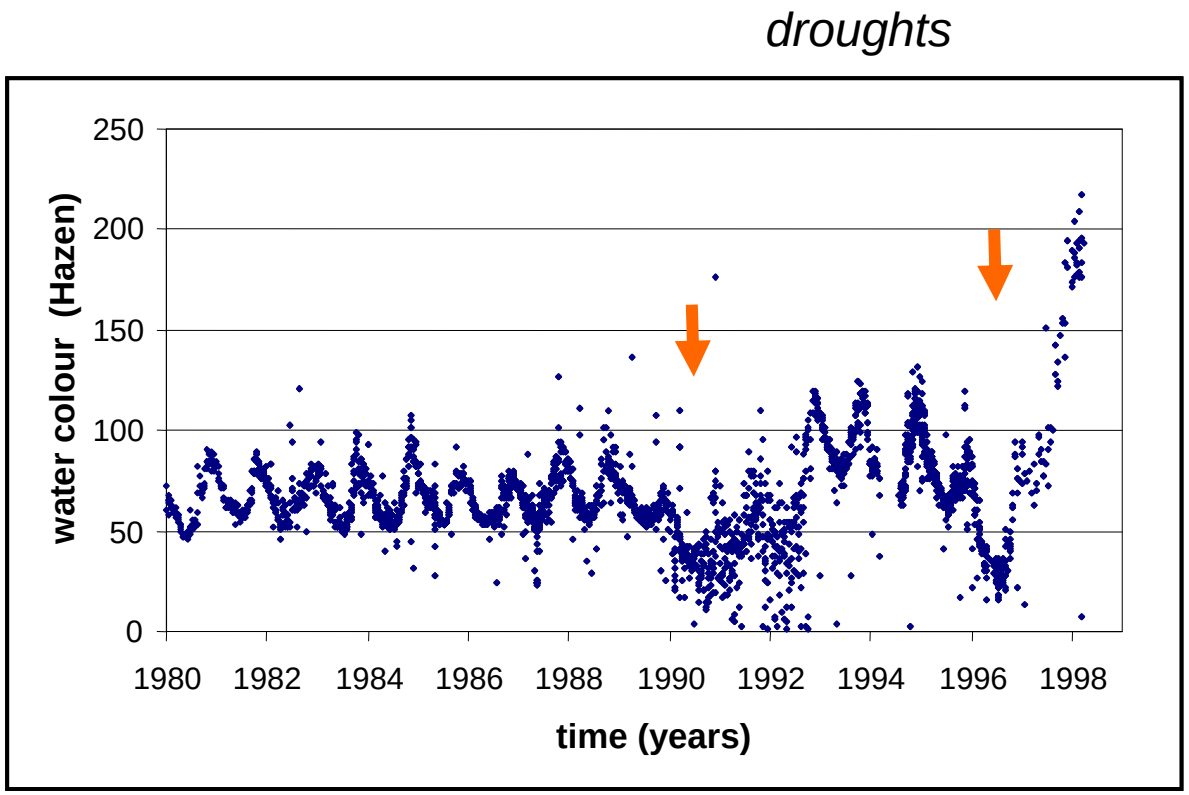

Water colour observed at Ewden treatment works, UK: a response to recent droughts

(*after Watts et al., 2001).*

Effect of drought on water colour/DOC

Enzymic latch mechanism

Freeman et al. 2001

Activity of hydrolase enzymes restricted by phenolic compounds

Water table drawn down

↓

phenol oxidase activity increases

↓

phenols decrease

↓

Hydrolase enzymes switched on by water table drawdown
but not switched off on rewetting

Switched on for 3-5 years

Showed changes in DOC are related in part to long-term decreases in acidification

Peat C stores

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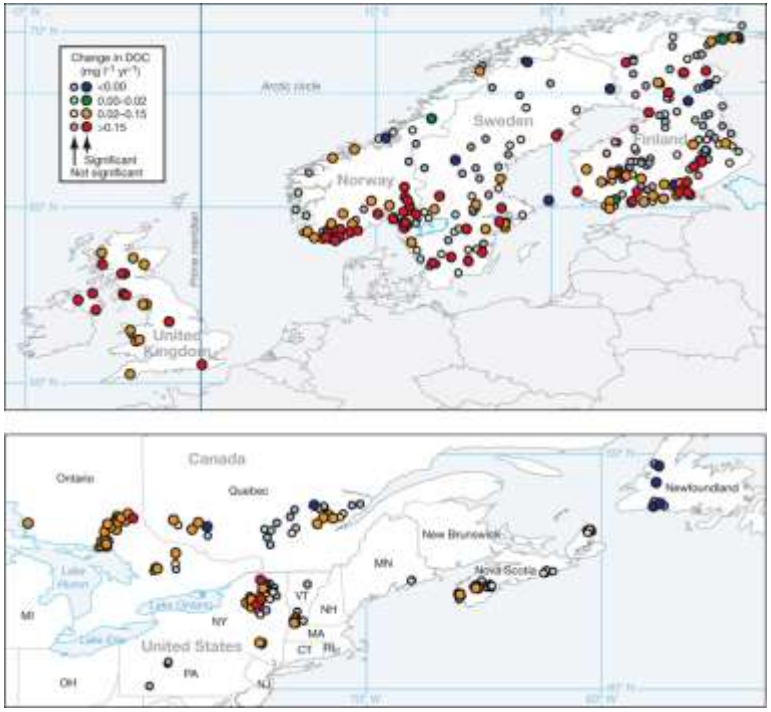
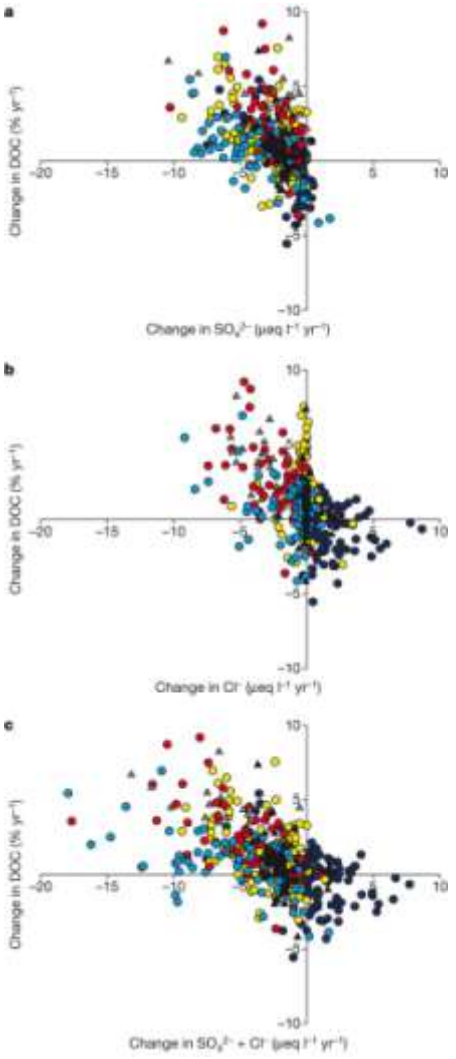
Monteith et al. 2007

Nature 450, 537-540





Burrishoole catchment

Peat C stores

Drivers of [DOC]

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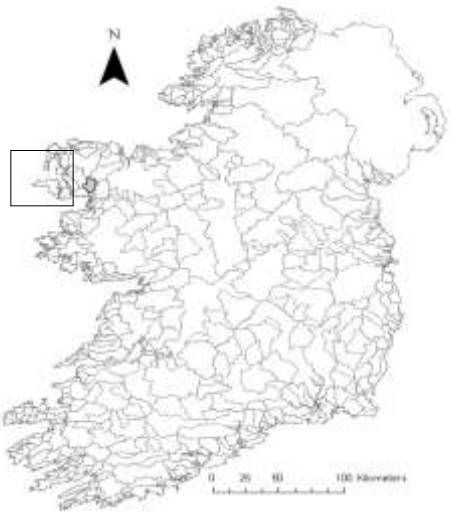

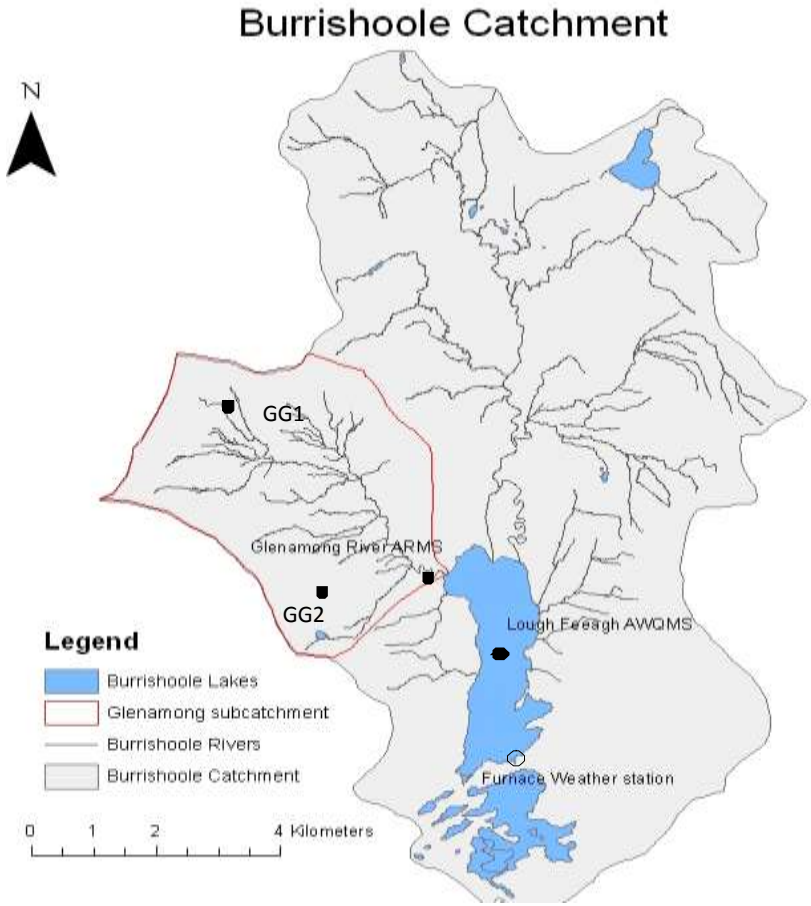

- **Glenamong sub-catchment area 1821 ha**
- **Forested area 408 ha = 22%**
- **Annual rainfall = 2000mm**
- **Lough Feeagh 392 ha, oligotrophic humic lake**
- **Maximum depth 45m**

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Burrishoole catchment

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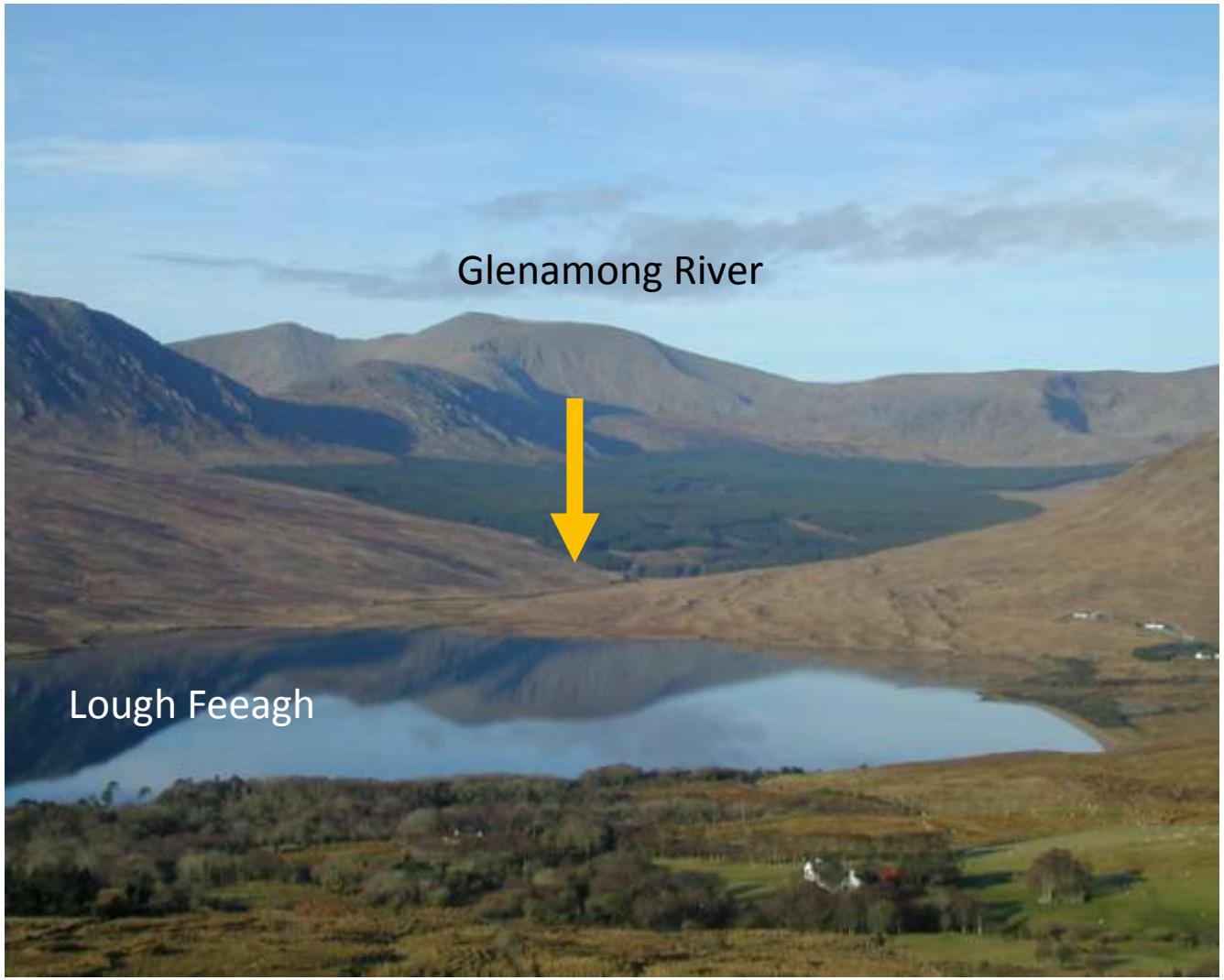

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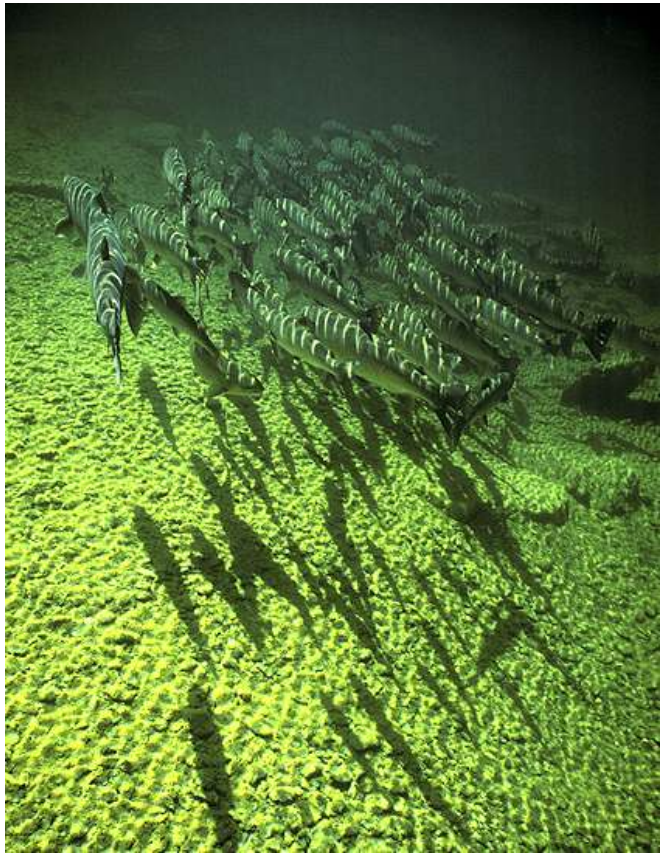

Important site for salmon, trout and eel research (Marine Institute)

Historical trends Burrishoole catchment

Peat C stores

Drivers of [DOC]

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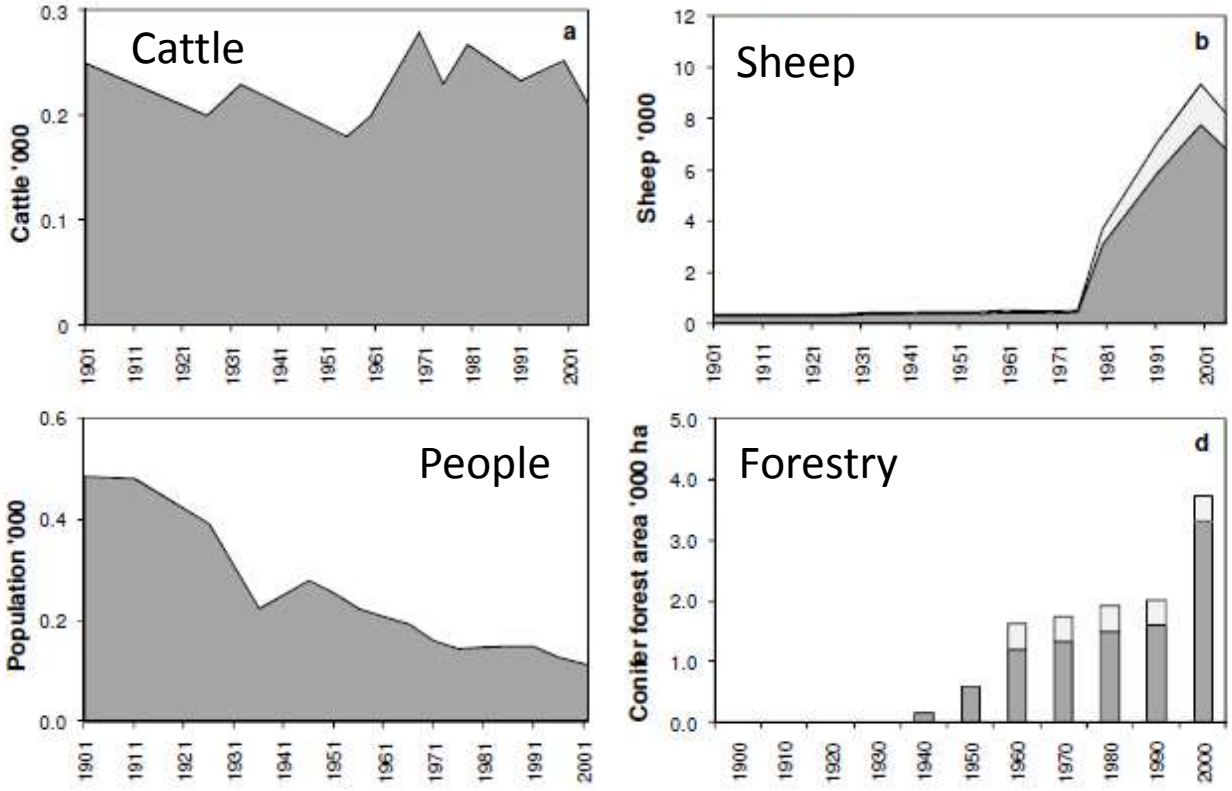

1900 to 2006

Dalton et al. 2010

Catchment instrumentation

Peat C stores

Drivers of [DOC]

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Glenamong River
Automatic River Monitor (ARMS)

pH, conductivity, temperature, dissolved oxygen, CDOM fluorometer and nephelometer

Lough Feeagh
Automatic Water Quality Monitoring Station (AWQMS)

pH, conductivity, temperature, dissolved oxygen, CDOM fluorometer, Chl fluorometer, nephelometer, thermistor chain and weather station

In-situ C instrumentation

Peat C stores

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CDOM fluorometer: Chromophoric dissolved organic matter is used as a proxy for dissolved organic carbon (DOC)

Instrumentation issues

Peat C stores
Drivers of [DOC]
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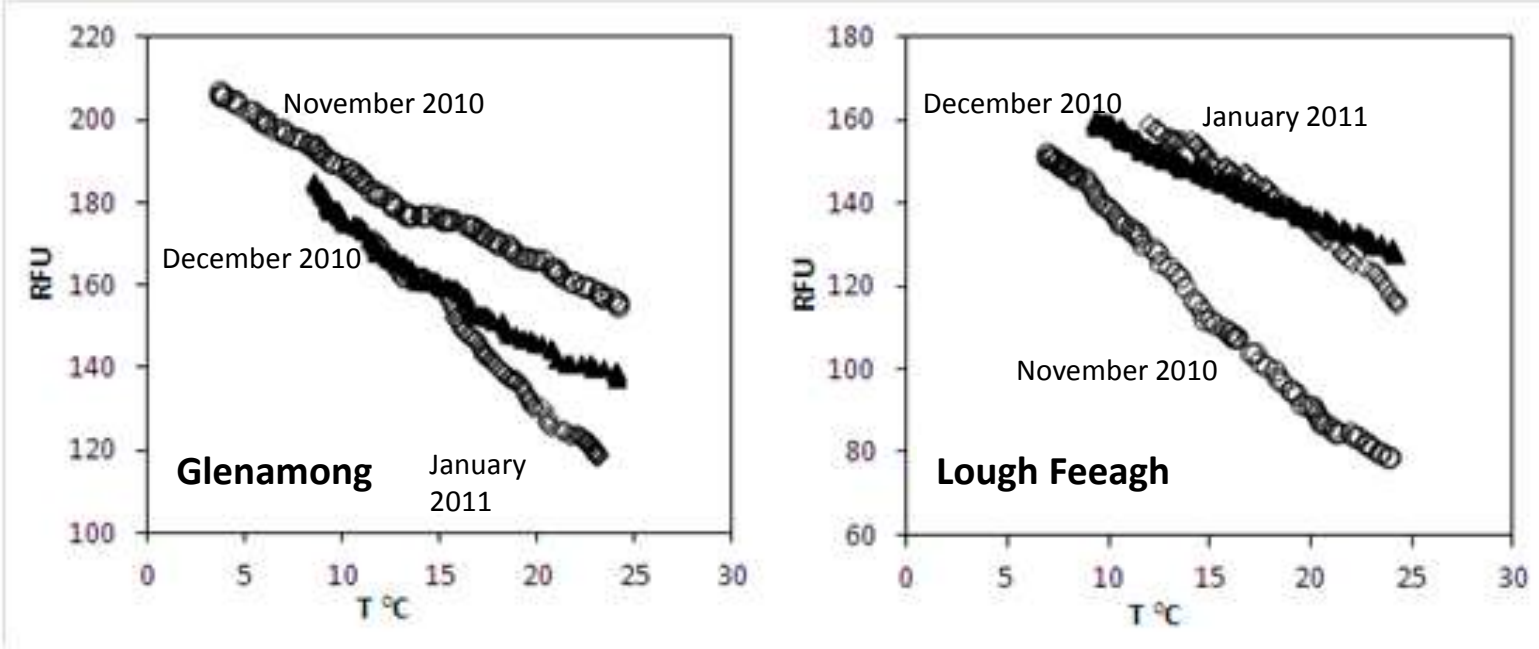

- The degree of temperature quenching is not constant
- Suggests that composition fluorescing substances changes
- Temperature correction ranges from 1% to 3% per degree

Ryder et al. 2013 L&O: methods

Corrected and uncorrected CDOM data

Peat C stores
Drivers of [DOC]
Study site
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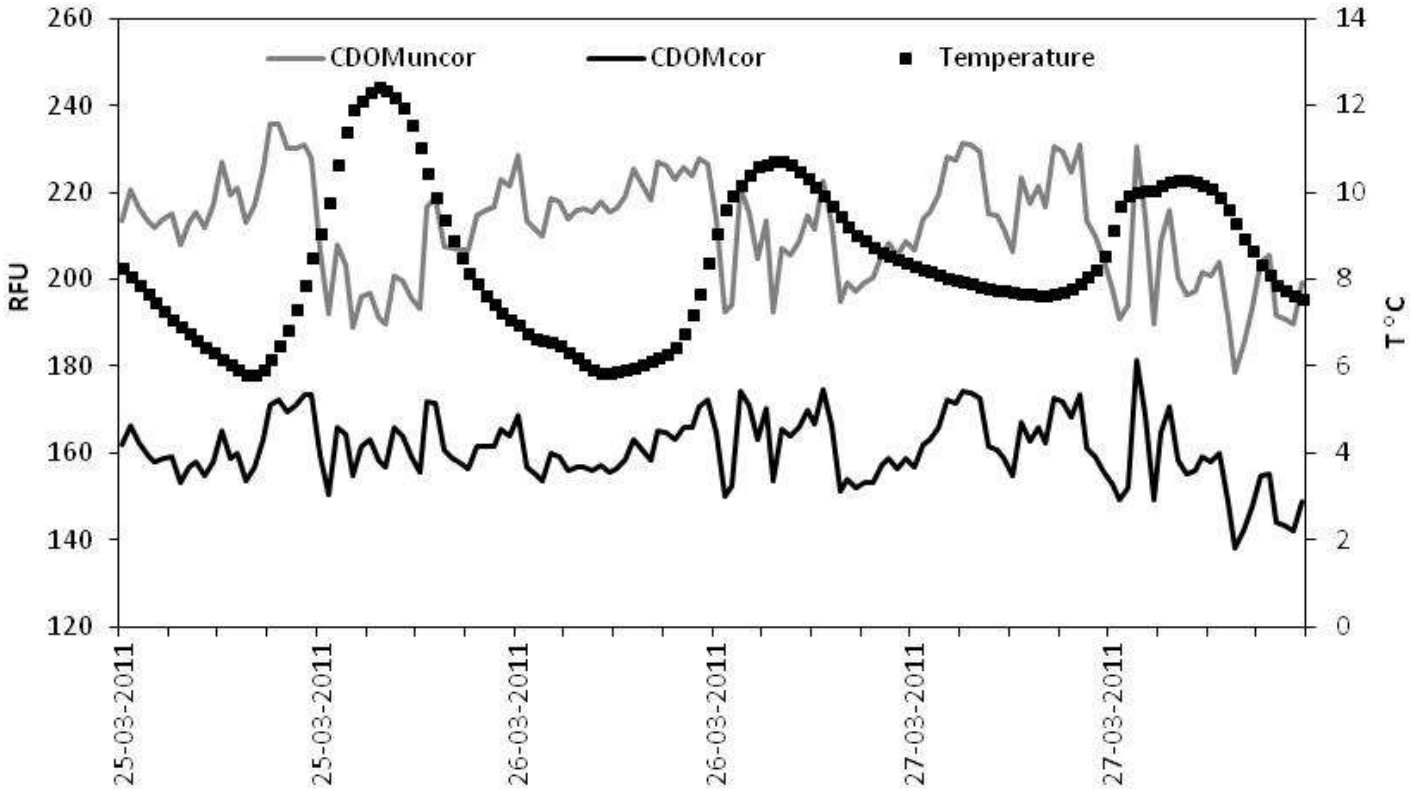
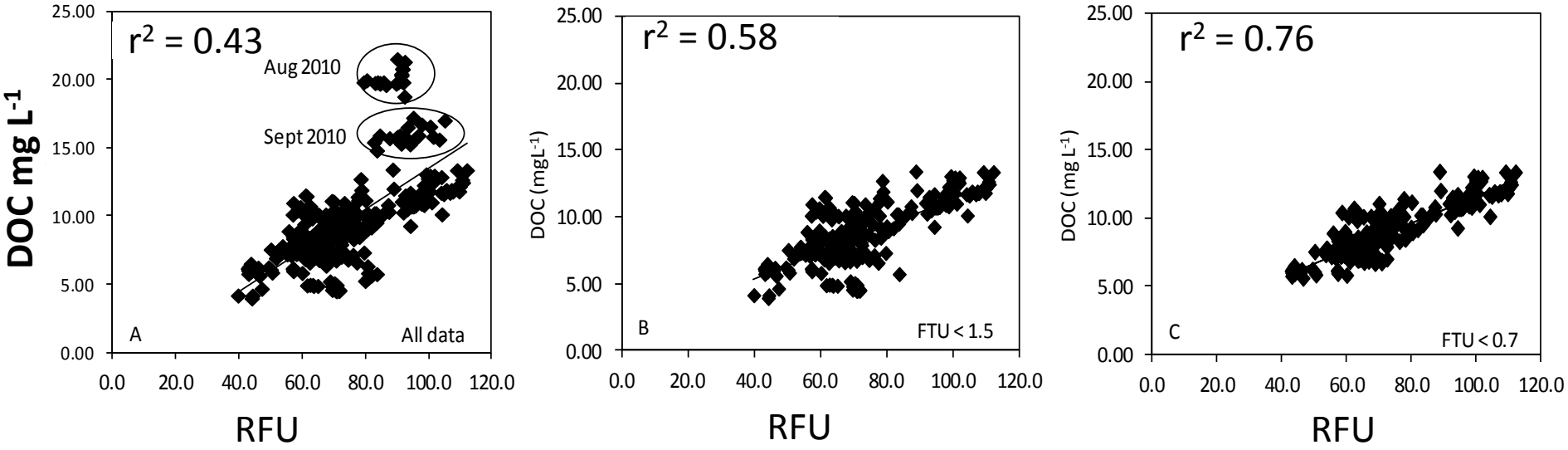


Raw fluorescence data were corrected using stream temperature data

Ryder et al. 2013 L&O: methods

Turbidity and CDOM fluorescence



Results indicate that concentrations of suspended sediments greater than 10 mg L^{-1} interfere with CDOM fluorescence signal

Rainfall and flow 2010-2011

Peat C stores

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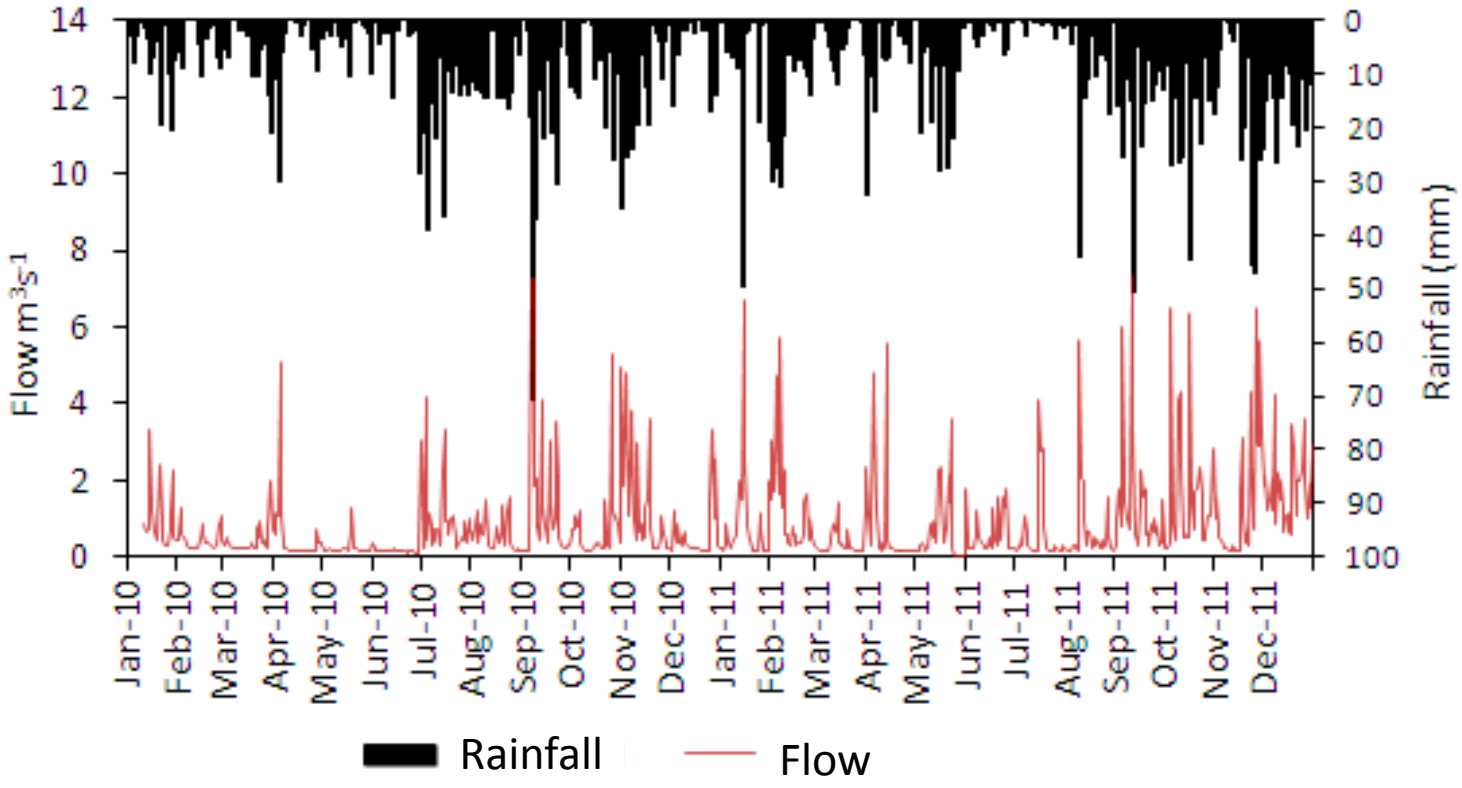

Mean daily DOC concentration the Glenamong River

Peat C stores

Drivers of [DOC]

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Future climate

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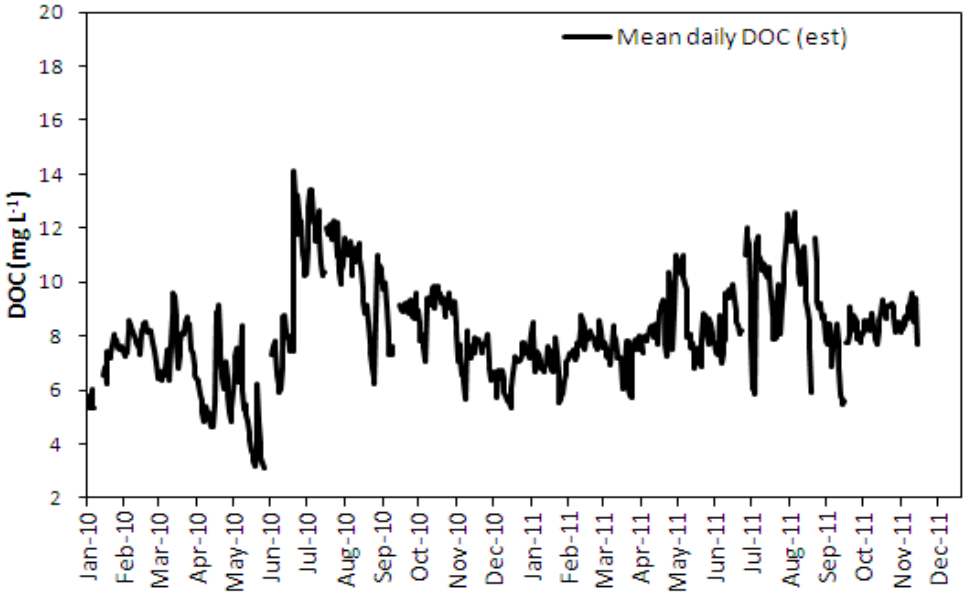
March 2010
Colour 70 mg PtCo L^{-1}

June 2010
Colour 44 mg PtCo L^{-1}

August 2010
Colour 187 mg PtCo L^{-1}



DOC export

9.75t C km^{-2} yr^{-1} 2010

12.64t C km^{-2} yr^{-1} 2011

Ryder et al. (submitted)

Mean daily DOC concentration the Glenamong River

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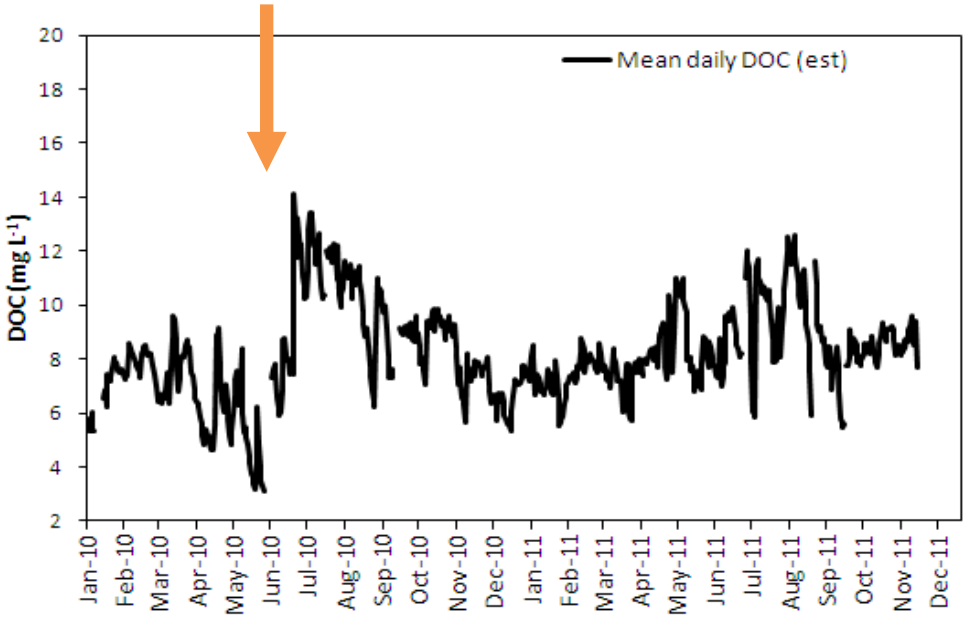

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Ryder et al. (submitted)

Standardised Precipitation Index 2002 to 2011

Peat C stores

Drivers of [DOC]

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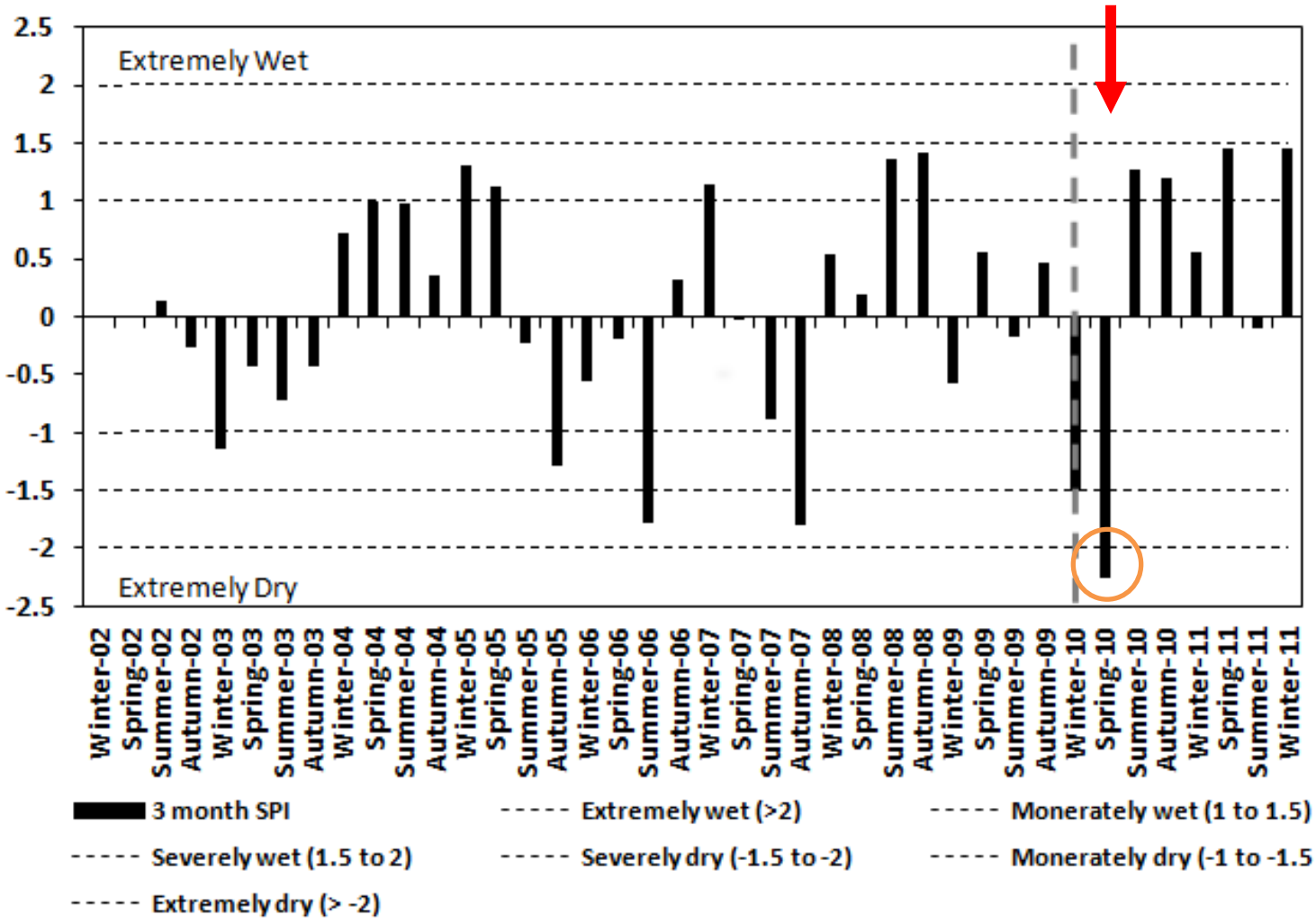

Mean daily DOC concentration the Glenamong River

Peat C stores
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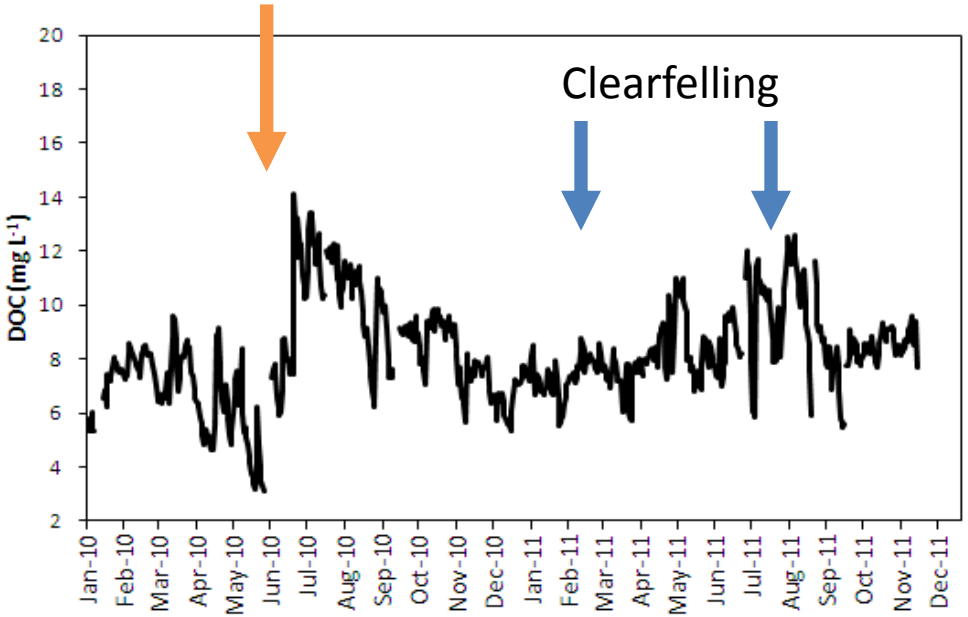
No step change response to forestry clearfelling



DOC export

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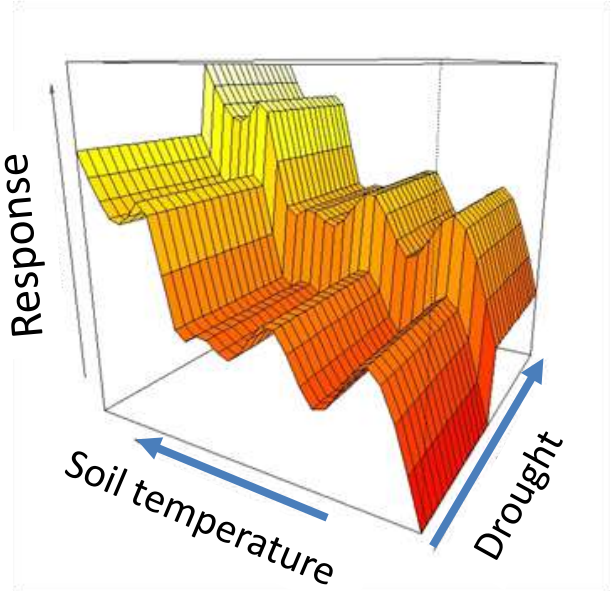
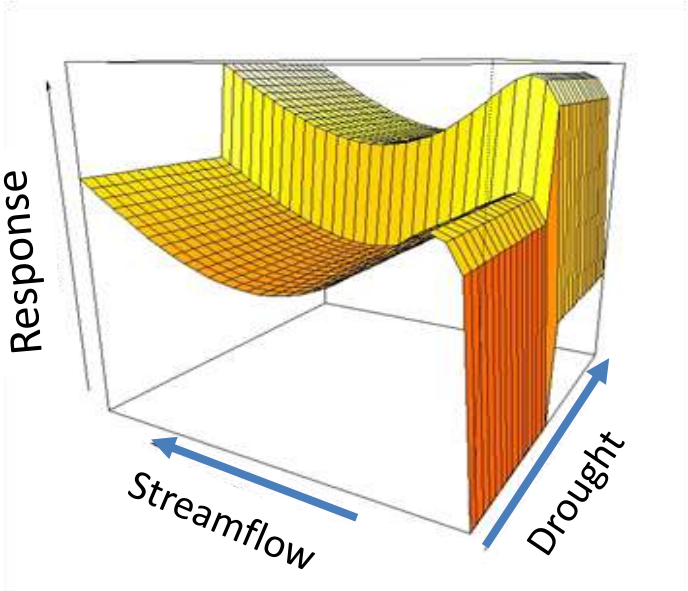
Ryder et al. (submitted)

Drivers of DOC export in the Burrishoole catchment





General additive model:

Significant factor: drought
Drought, soil temperature, and streamflow explain 60% of variance in DOC

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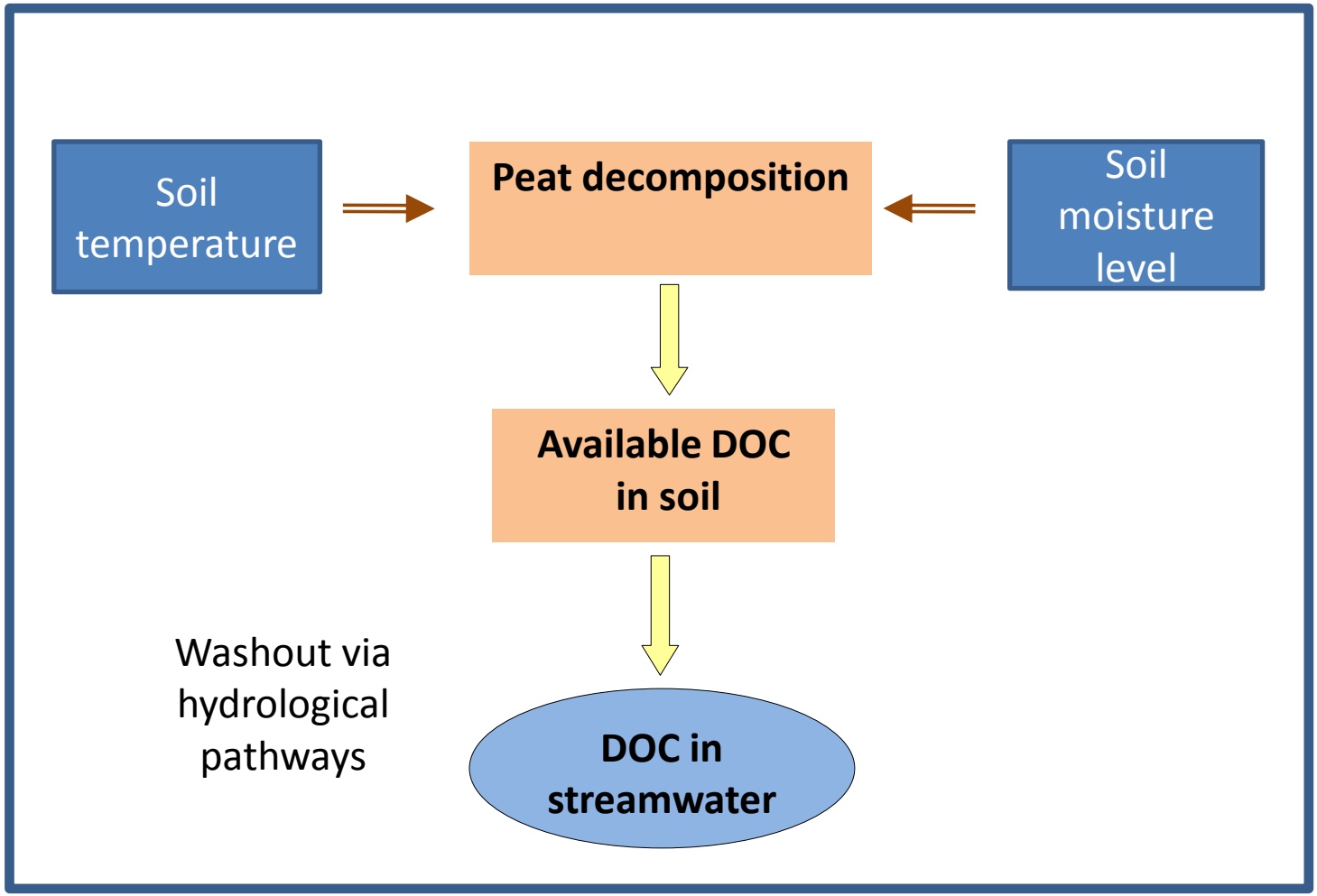
Model of DOC export used in RESCALE



Naden et al. 2010

Model of DOC export used in RESCALE

Peat C stores

Drivers of [DOC]

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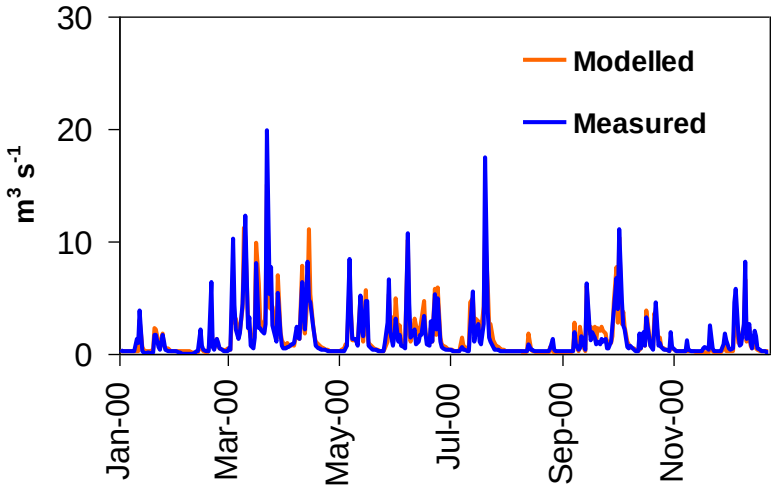
Hydrological parameters

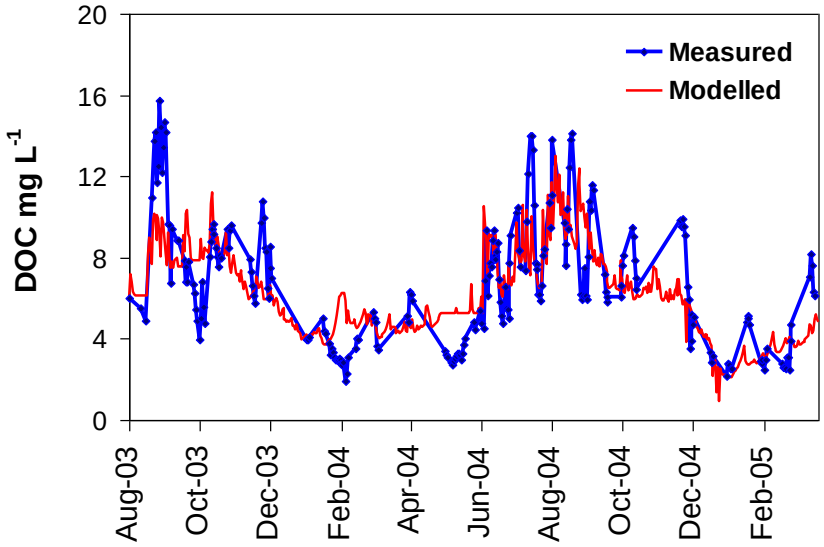


3 DOC production:

- rate of decomposition
- temperature dependence
- soil moisture dependence

2 DOC transport:

- rate of washout
- partitioning between surface and subsurface pathways



Naden et al. 2010

Climate change projections

Climate change scenarios
Selected GCMS (SRES A2 and B2): 1961-2100
Control period (1961-1990)

Statistical downscaling

Model parameters
Calibrated using measured data

DOC-GWLF model

Climate impact on DOC

100 realisations
3 GCMs
2 SRES

Projected change in maximum air temperature

Peat C stores

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Burrishoole catchment

	Winter	Spring	Summer	Autumn
HadCM3-A2				
2020s	0	0.3	0.3	0.3
2050s	0.7	0.7	0.8	1.2
2080s	1.3	1.6	1.9	2.3
HadCM3-B2				
2020s	0.2	0.4	0.4	0.7
2050s	0.4	0.6	0.8	1
2080s	0.7	1	1.2	1.6

Fealy et al. 2010

Projected change in precipitation

Peat C stores

Drivers of [DOC]

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Burrishoole catchment

	GLM			
	Winter	*Spring*	*Summer*	*Autumn*
HadCM3-A2				
2020s	-0.7	-3.3	-3.8	0
2050s	5.3	-5.4	-10.5	-5.9
2080s	20.2	1.9	-34.2	-4.5
HadCM3-B2				
2020s	1.2	3.2	-1.8	2.9
2050s	8.8	-3	-15.2	-2.2
2080s	11.1	4.4	-18.2	-2.7

Fealy et al. 2010

Projected increase in DOC concentrations

Peat C stores

Drivers of [DOC]

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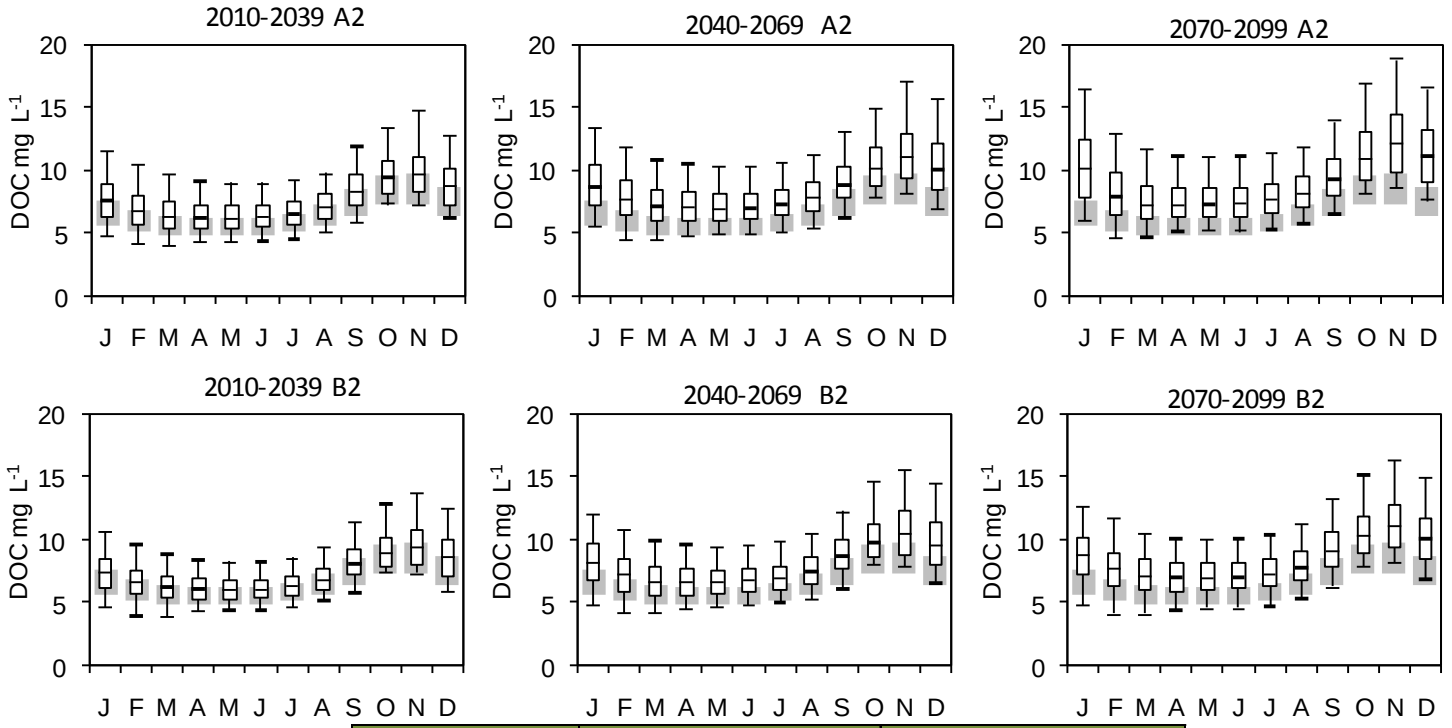

		mg DOC L^{-1}
A2 scenario	1961–1990	6.6
	2010–2039	**+0.9**
	2040–2069	**+1.8**
	2070–2099	**+2.4**
B2 scenario	1961–1990	
	2010–2039	**+0.6**
	2040–2069	**+1.4**
	2070–2099	**+1.8**

Fealy et al. 2010

Drivers of increase in DOC concentrations
A2 scenario 2070-2099

Peat C stores

Drivers of [DOC]

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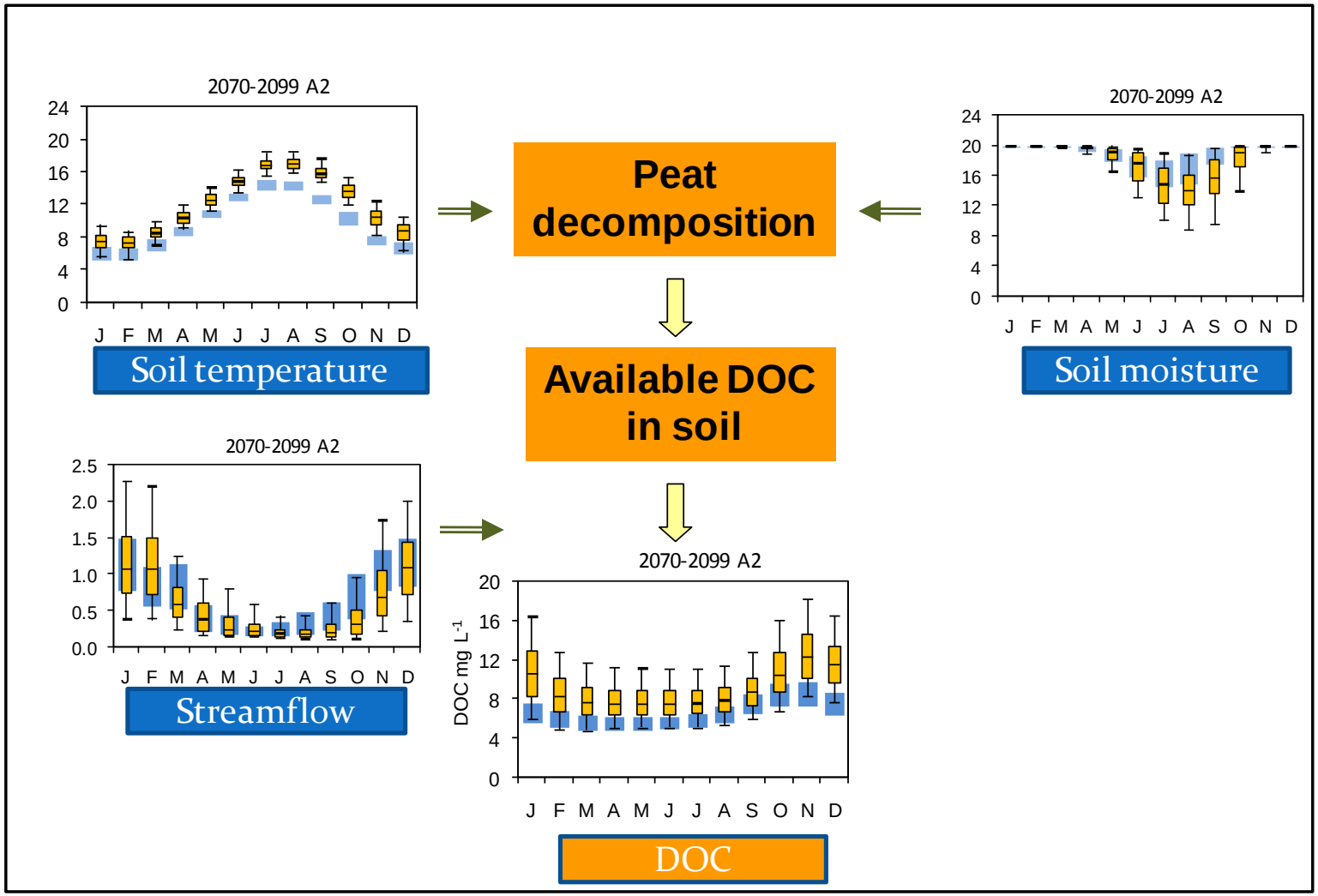

Fealy et al. 2010

Summary

- DOC export is highly sensitive to climatic factors.
- In-situ instrumentation can be used to give more accurate estimates of DOC export.
- Temperature quenching of CDOM fluorescence is variable and a correction should be applied. The inhibitory effect of turbidity should also be taken into account.
- Future climate projections: increase of 15% to 36% in DOC concentrations exported from peat catchments.
- Implications for ecology, drinking water, and long-term carbon storage.

Thank You

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References:

Ryder E, Jennings E, de Eyto E, Dillane M, Nic Aongusa C, Pierson DC, Moore K, Rouen M, Poole R. 2012. Temperature quenching of CDOM fluorescence sensors: temporal and spatial variability in the temperature response and a recommended temperature correction equation. Limnology & Oceanography: Methods. 10

Fealy, R., Allott, N., Broderick, C., de Eyto, E., Dillane, M., Erdil, R.M., Jennings, E., McCrann, K., Murphy, C., O'Toole, C., Poole, R., Rogan, G., Ryder, L., Taylor, D., Whelan K. and White, J. (2010) RESCALE: Review and Simulate Climate and Catchment Responses at Burrishoole Project-Based Award, Final Summary Report. Marine Research Sub-Programme (NDP 2007-'13) Series

Dalton, C., Jennings, E., Taylor, D., O'Dwyer, B., Murnaghan, S., Bosch, K., de Eyto, E. & Sparber, K. (2010). Past, current and future Interactions between pressures, chemicaL status and bioLogical qUality eleMents for lakes IN contrAsting catchmenTs in IrEland (ILLUMINATE). EPA/ERTDI Project # 2005-W-MS-40 Final Report 290 pp

Naden, P., Allott, N., Arvola, L., Jarvinen, M., Jennings, E., Moore, K., Nic Aongusa, C., Pierson, D. and Schneidermen, E. (2010) Modelling the effects of climate change on dissolved organic carbon. In D.G. George (ed.) The Impact of Climate Change on European Lakes. Springer.

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