Tracing hydrologic soil carbon loss from a mountainous watershed during extreme rainfall events

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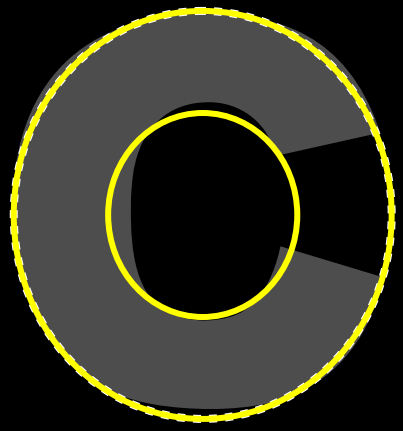
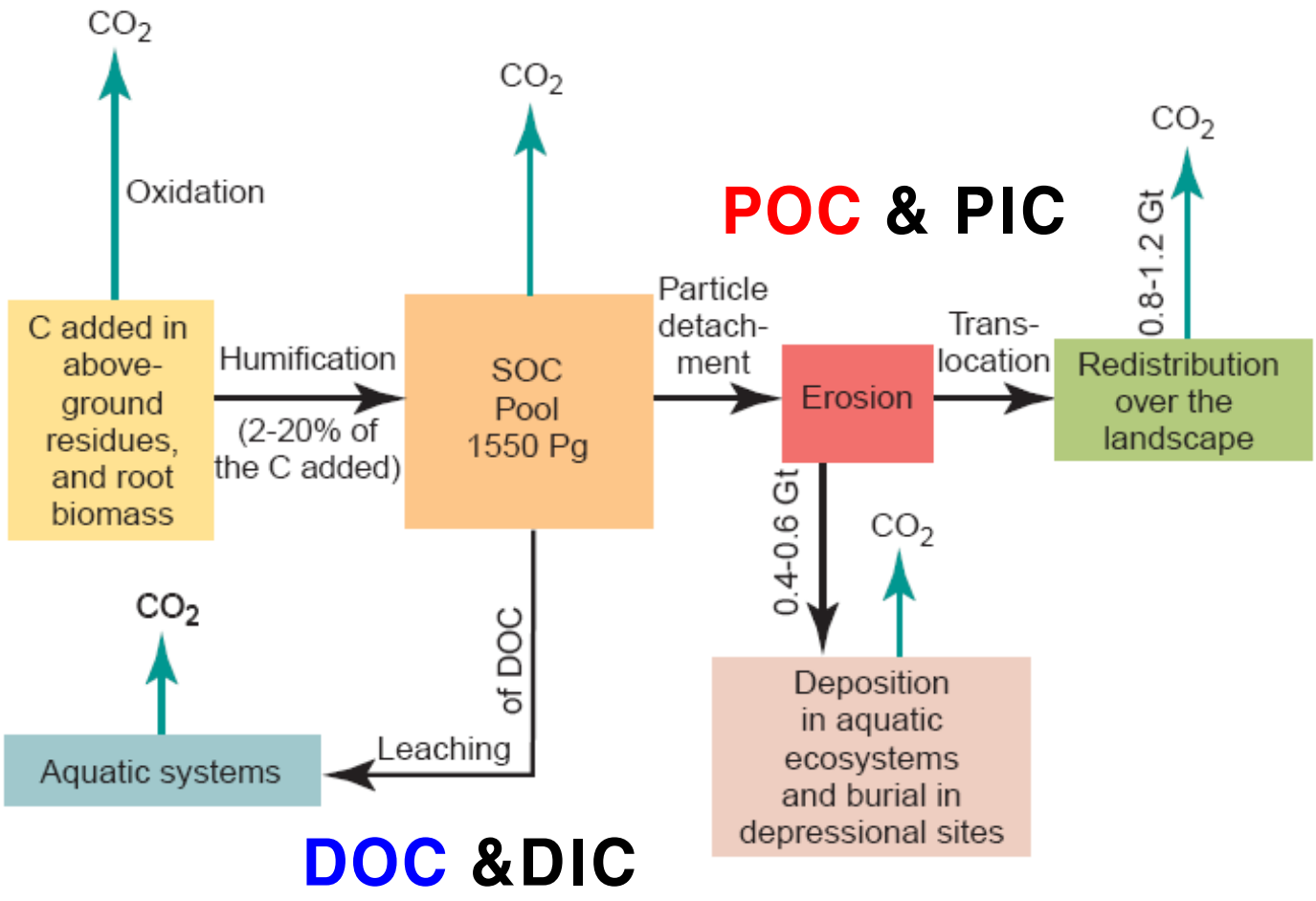
Guesstimating C Fluxes from Black Box ‘Soil’



Missing Soil C Fluxes

- Hydrologic soil C losses – DOC, DIC, POC & PIC

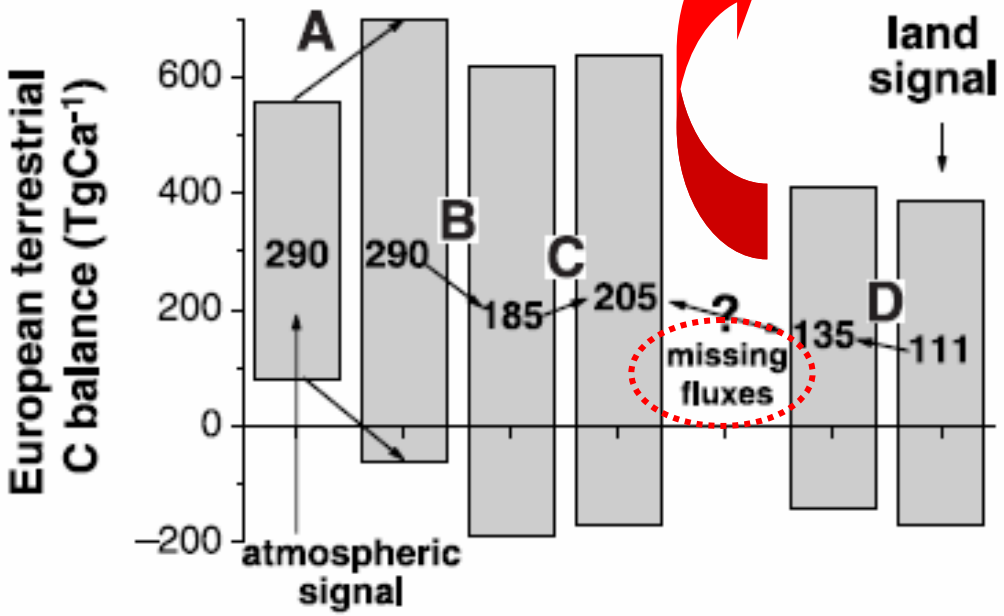


Lal. 2004. Science 304: 1623-1627

Missing Fluxes in C Balance

The gap between the atmosphere-based and land-based estimates of terrestrial C sinks in Europe

70 Tg C



Carbon balance estimates (CarboEurope)

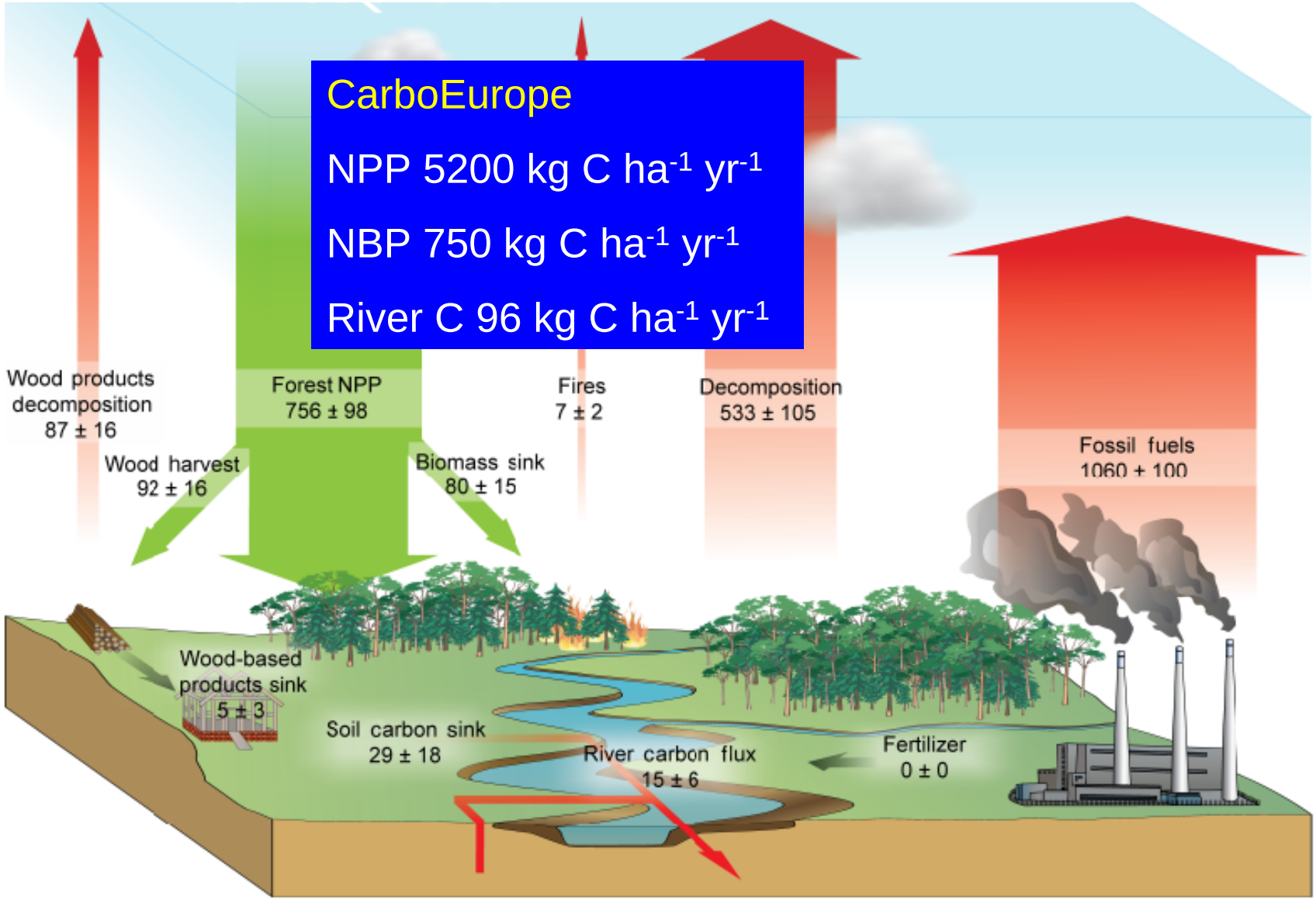
Drainage export of dissolved organic C and inorganic C

114 ± 83 Tg C

Siemens. 2003. Science 302: 1681

Janssens et al. 2003. ***Europe's terrestrial biosphere absorbs 7 to 12% of European anthropogenic CO_2 emissions****. Science 300: 1538-1542.*

Hydrologic C loss – a Missing Flux?



Luyssaert et al. 2010. GCB 16: 1429-1450

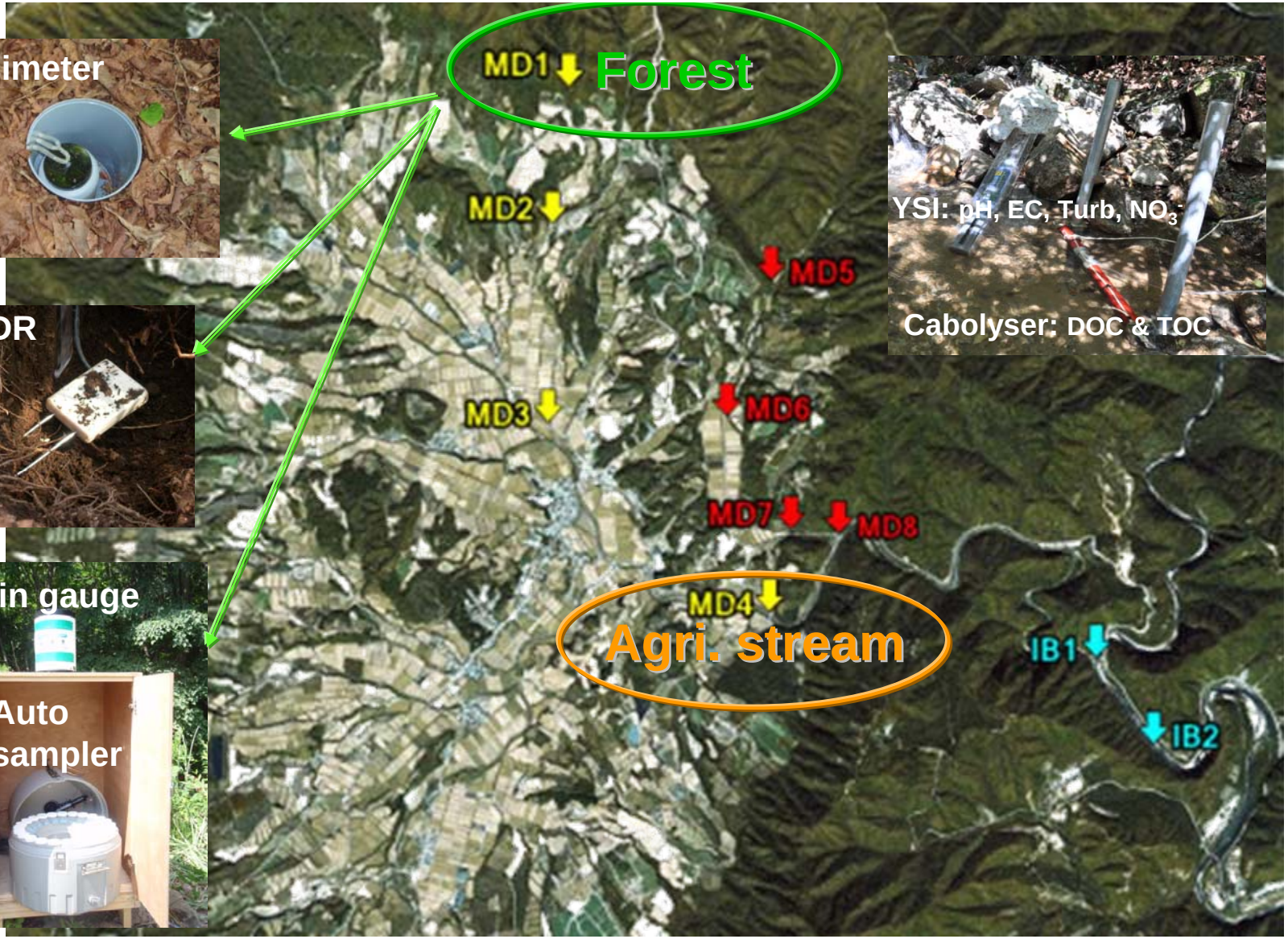
‘Hydro’ Carbon Tracking in Haean Basin (“Punch Bowl”)

- How much soil C is lost via hydrologic export from a mountainous, mixed land-use watershed in response to rainfall variability & extremes?
- Major sources & fates of DOC & POC released during rainfall events?

Punch Bowl Watershed

DMZ (North Korea)

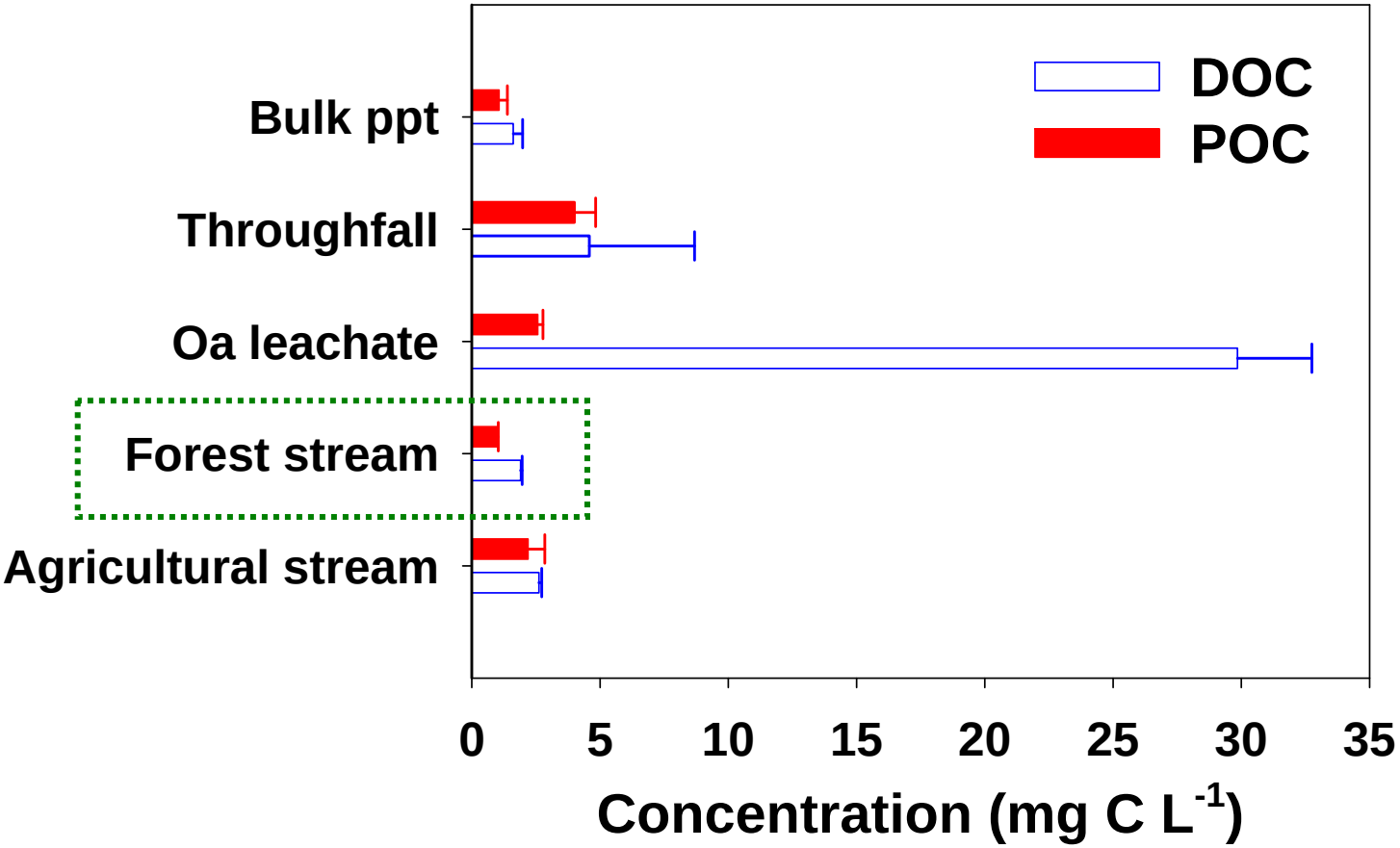
Study Site – Punch Bowl Watershed



Annual Mean DOC & POC Conc. (May 08 – Apr 10)

2-yr biweekly monitoring results

- Higher conc. of DOC than POC along hydrologic pathways
- Relatively low stream C conc. (esp. POC) compared to those for throughfall & forest floor leachates

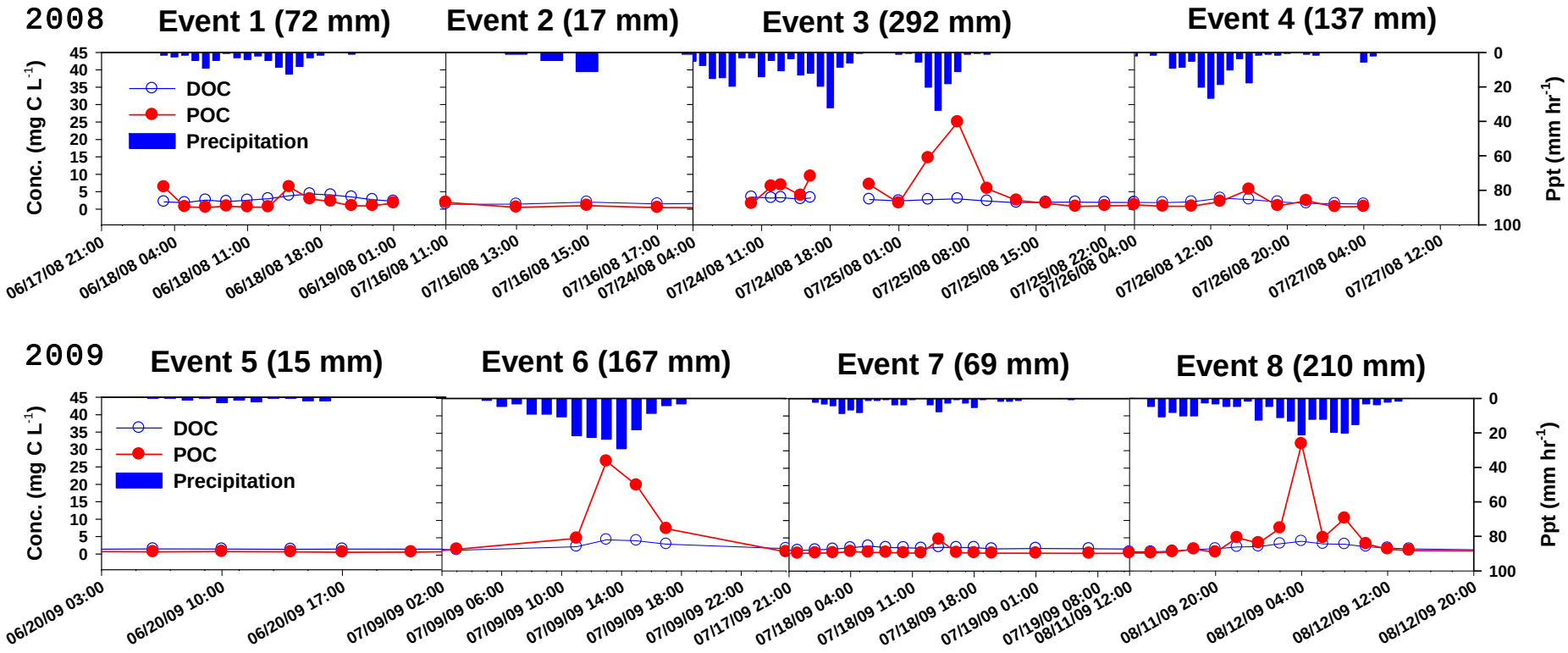


Lee et al. unpublished data

Rapidly Changing C Conc. during Storm Events

- Lower streamwater POC conc. under base- to low-flow conditions
- Stronger, non-linear responses of POC to intense storm events

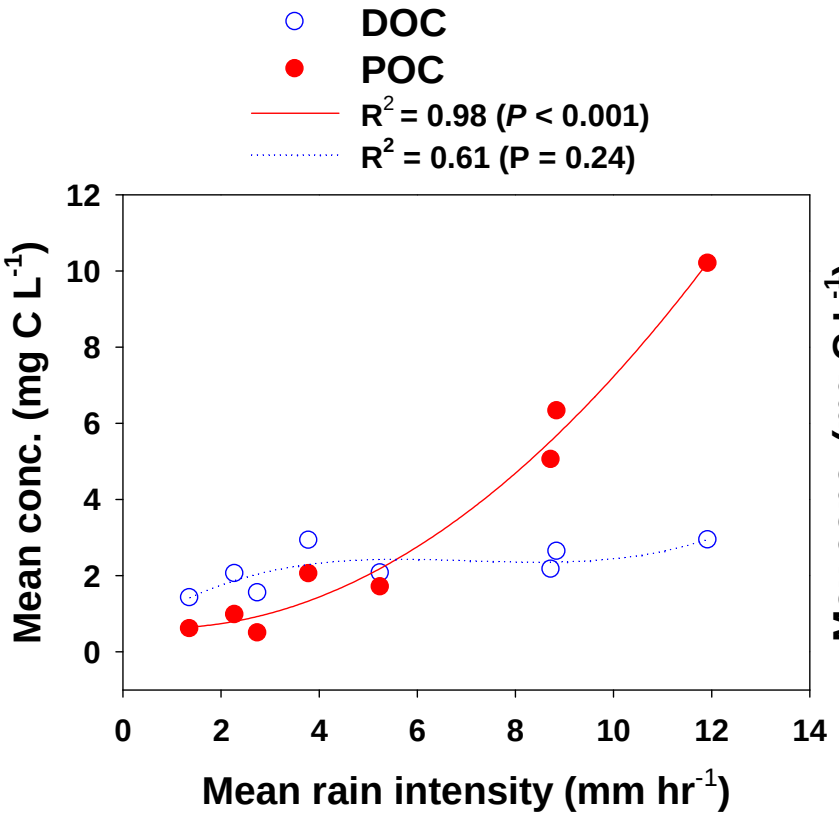
Forest stream

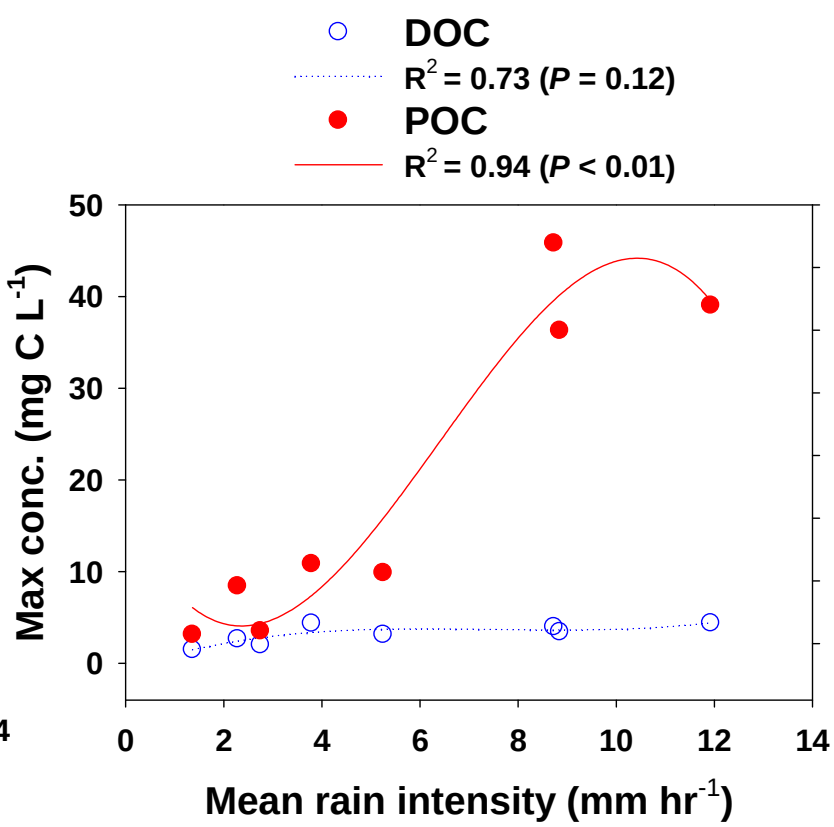


Lee et al. unpublished data

Differential Responses of DOC & POC during Storm

- Stronger, non-linear increases in both event mean and max. POC conc. with increasing mean rainfall intensity of each storm event





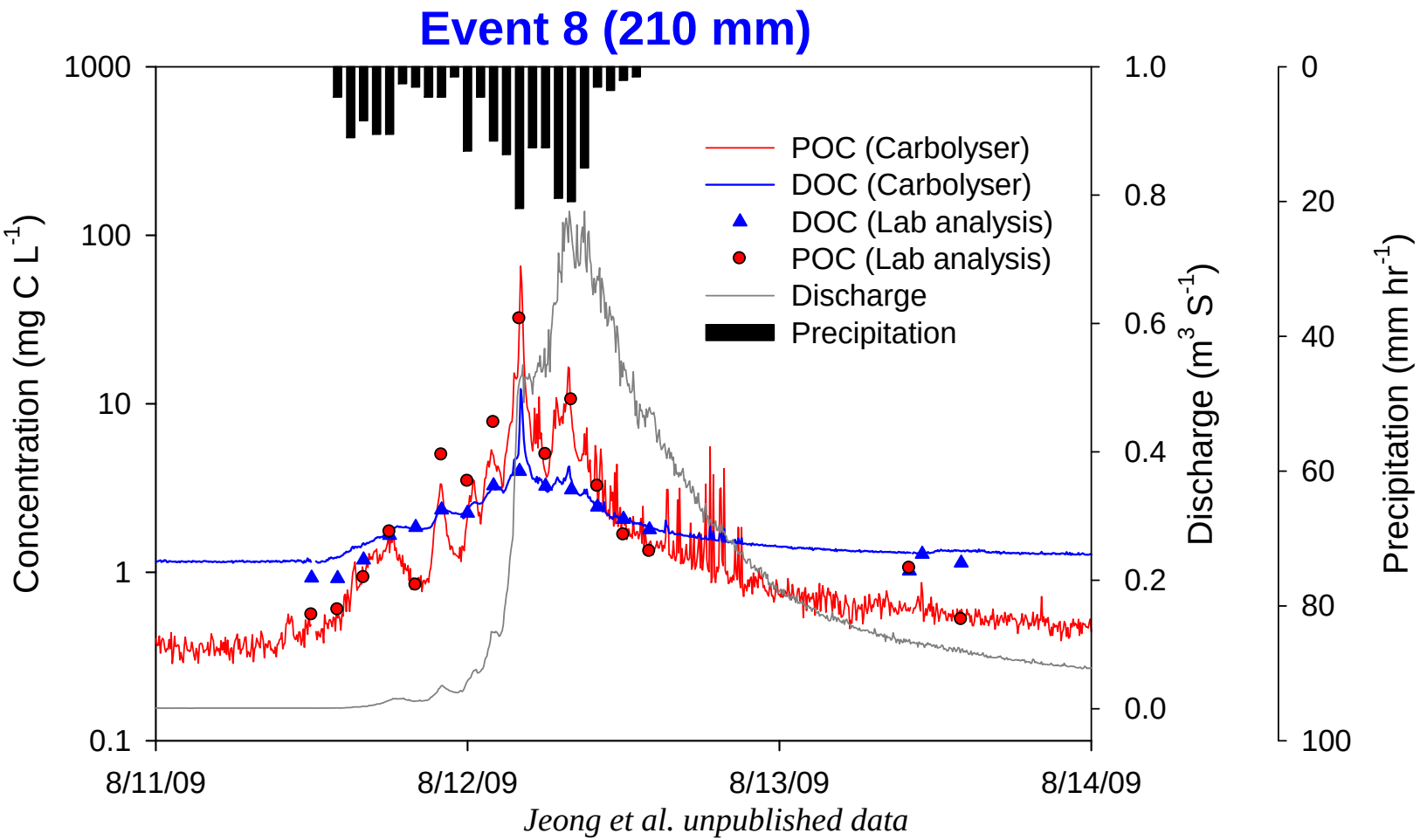
Lee et al. unpublished data

Real-Time Monitoring of DOC & POC

- **Measurements of streamwater DOC & POC**
  - Carbolyser (starting July 2009): measuring TOC & DOC conc. every 5 min, based on UV/Vis spectrophotometry
  - Lab analysis: measuring DOC & POC conc. in samples taken every 2 hr using an autosampler

Short-Term Changes in DOC vs. POC during Storm

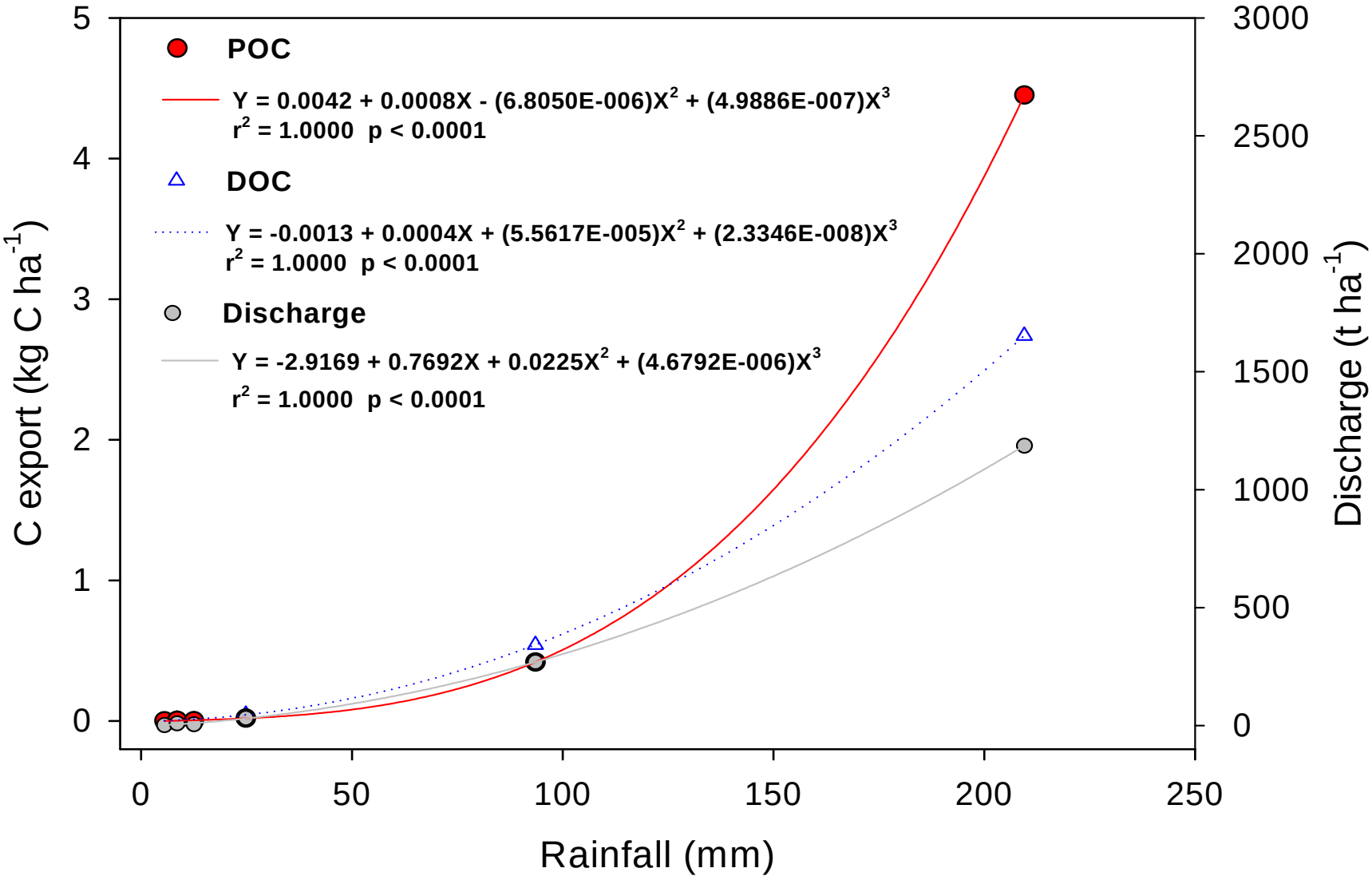
- **Real-time measurement of DOC & POC conc. every 5 min**
  - Baseflow: very low POC conc. vs slightly higher DOC conc.
  - Peakflow: higher increases in POC relative to DOC conc.



Jeong et al. unpublished data

Non-Linear Responses of POC/DOC Export

Six storm events (Jul 17 – Sep 3, 2009)



Jeong et al. unpublished data

Hydrologic C Loss – Importance of Extreme Events

- **DOC/POC export (Jul 17, 2009 – Jul 16, 2010)**
  - DOC: Baseflow export comprised 80% of the annual DOC export.
  - POC: 1-d extreme event accounted for 29% of the annual POC export.

Period	Event #	Ppt (mm)	Duratioin (d)	POC (kg C ha^{-1})	DOC (kg C ha^{-1})
Stormflow	30	1037	27	7.12	6.18
(%)			(7.4)	(46.7)	(18.3)
Event 8		210	1	4.45	2.74
(%)			(0.3)	(29.2)	(8.1)
Baseflow		0	338	8.12	27.60
(%)			(92.6)	(53.3)	(81.7)
Total				15.24	33.78
(%)				(100)	(100)

CarboEurope

NPP 5200 kg C ha^{-1} yr^{-1}

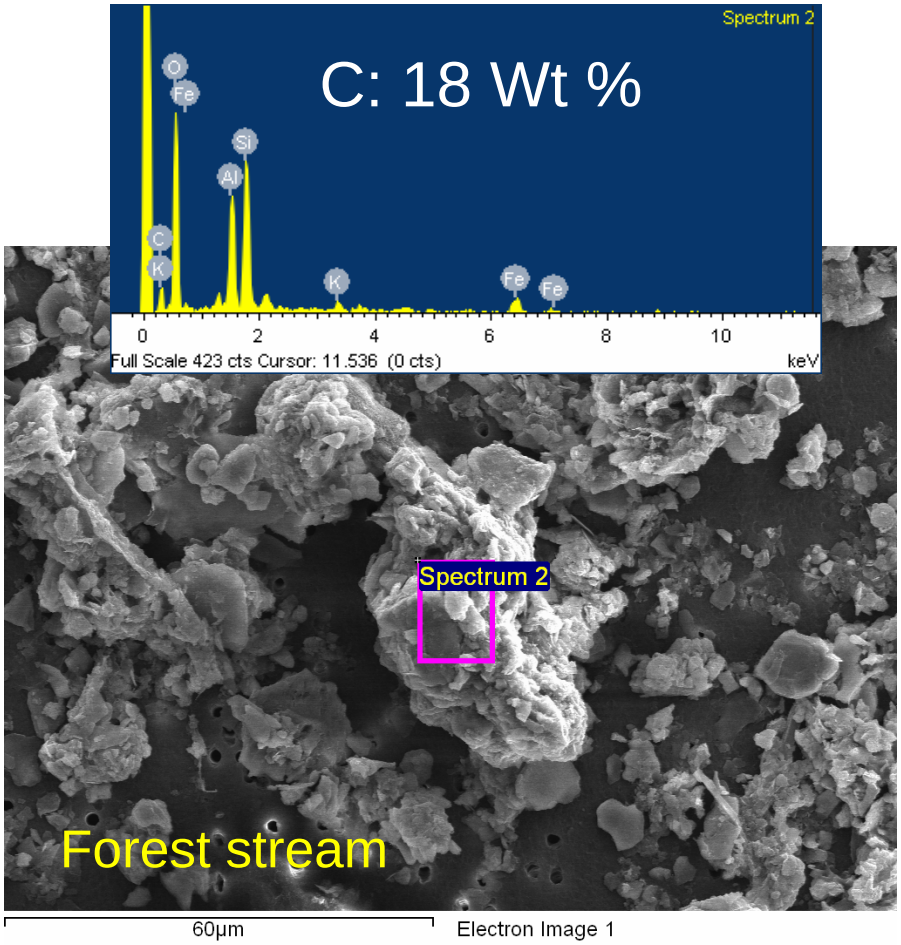
NBP 750 kg C ha^{-1} yr^{-1}

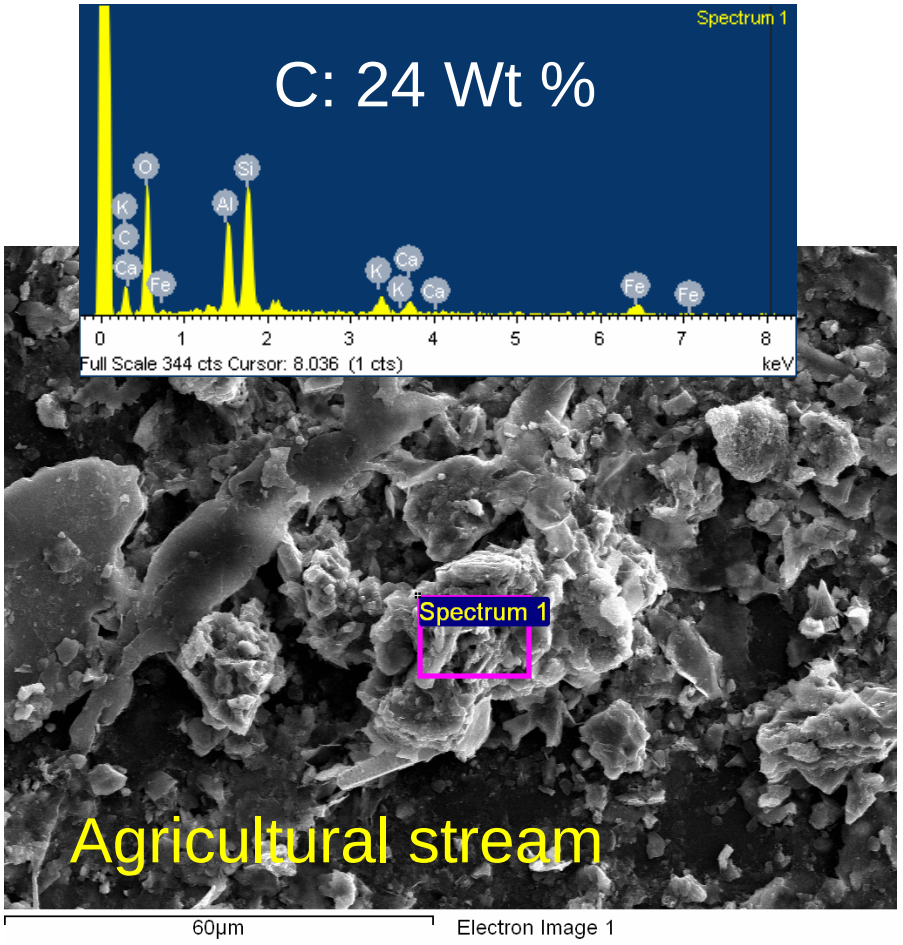
River C 96 kg C ha^{-1} yr^{-1}

49 kg C ha^{-1} yr^{-1}

Carbon in Suspended Sediments

- **Silt-size sediments in forest & agricultural stream**
  SEM coupled with EDX: C comprising a sizable proportion of silt element composition

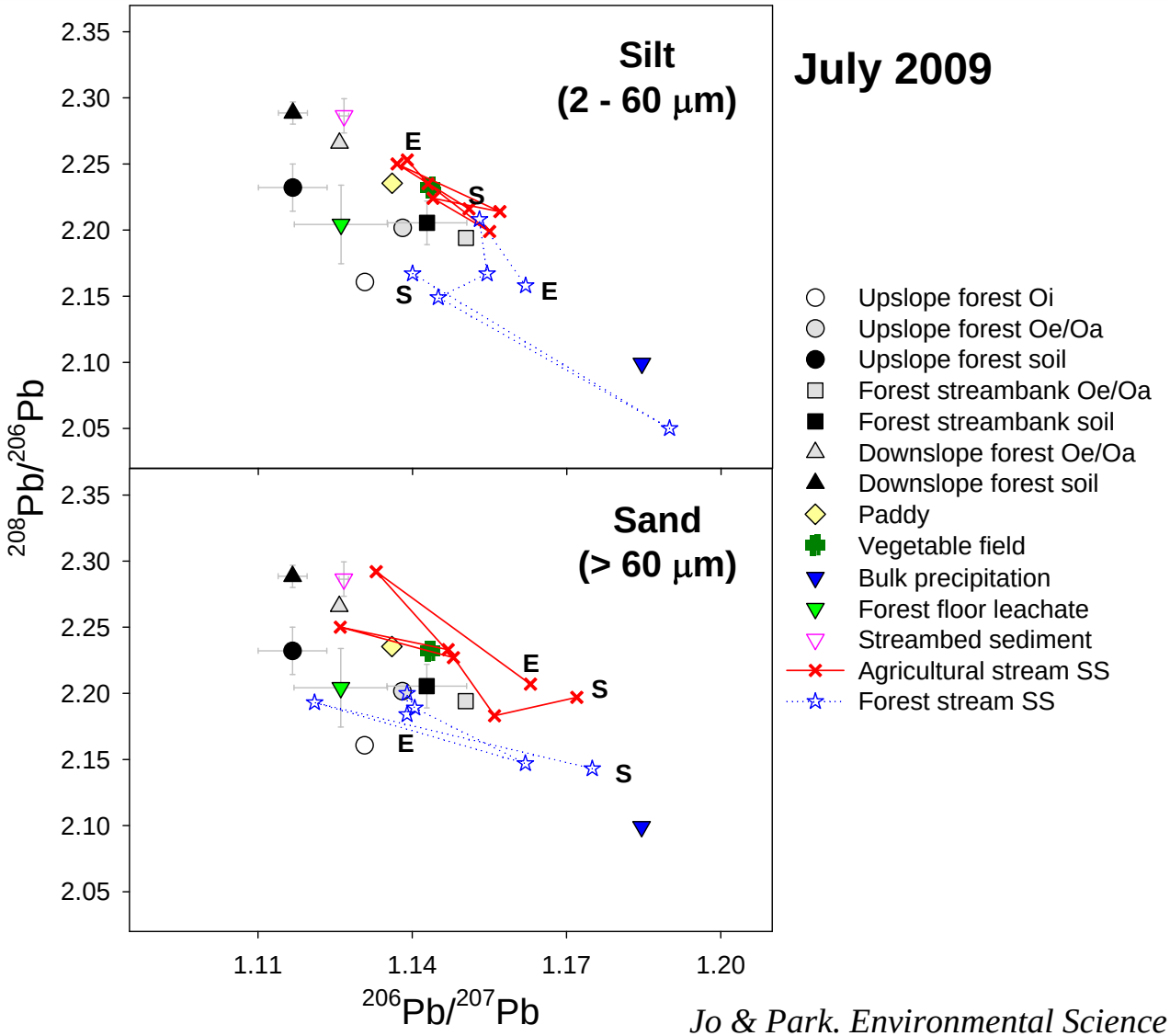




Jo et al. unpublished data

Tracing Sediment Sources

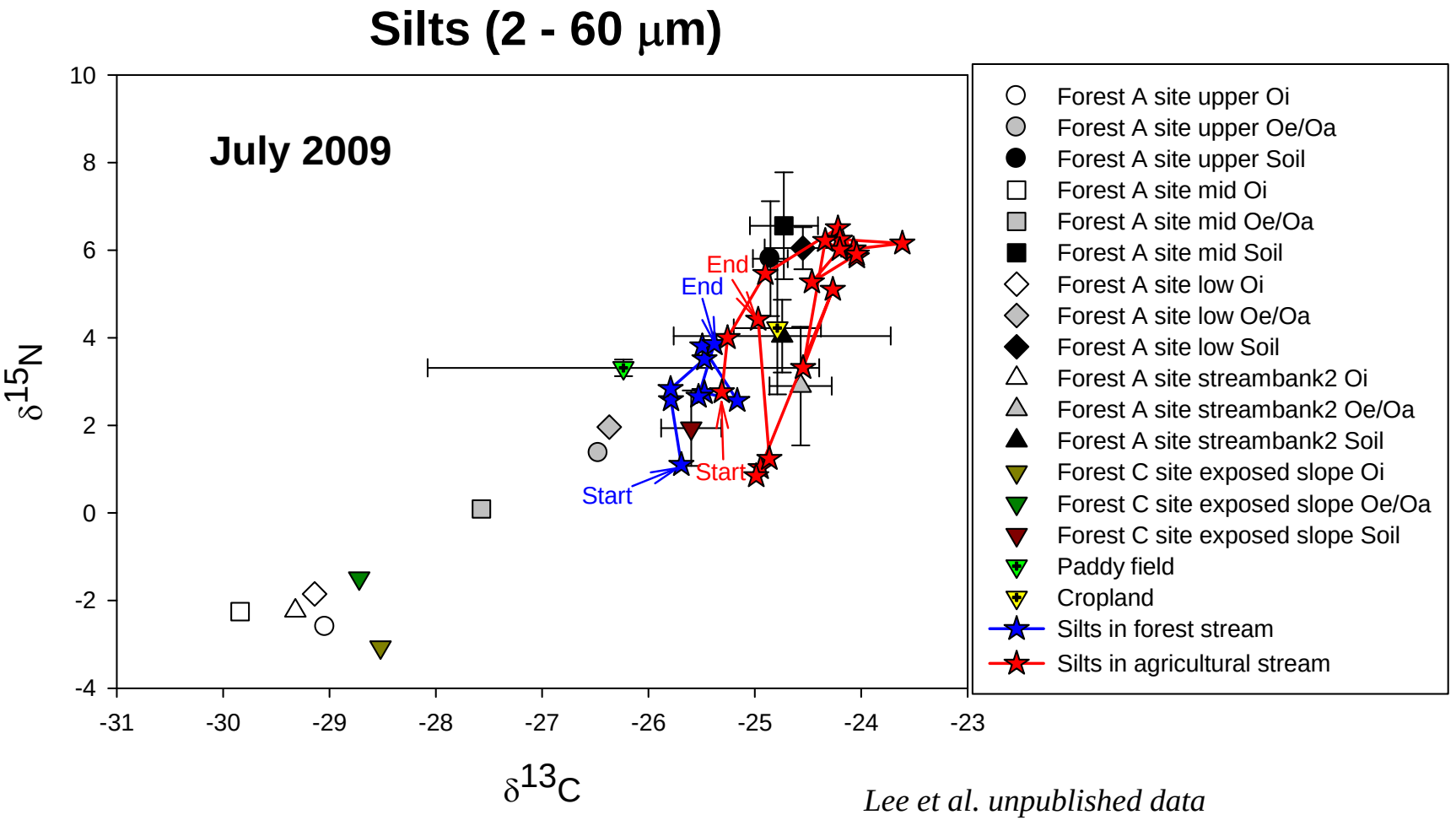
- Sediment source tracing using Pb stable isotopes
  - **Forest stream**: forest floor & streambank
  - **Agricultural stream**: vegetable field & forest soils (added to croplands by farmers)



Jo & Park. Environmental Science & Technology (revision in review)

Tracing POC Sources

- Carbon source fingerprinting using C & N isotopes
  - **Forest stream**: forest floor & streambank
  - **Agricultural stream**: vegetable field & forest soils (added to fields)



Lee et al. unpublished data

Summary & Implications

❖ DOC & POC export – an important soil C loss

- **Bi-weekly sampling**: DOC conc. were usually higher than POC from precipitation through the forest to the basin outlet.
- **Storm sampling & real-time monitoring**: Flashy, nonlinear responses of POC (& DOC) to intense rainfall events can result in a 'missing C loss' that is not captured by routine monitoring.

❖ 'Erosion of soil C' in a changing climate

- Deforestation and agricultural expansion on steep terrain can amplify the vulnerability of soil carbon loss (via erosion-associated POC export) to rainfall variability & extremes.

“To protect soil C leaks, protect your mountains.”

To protect your rivers, protect your mountains.

- *Emperor Yu, China.*