Indirect Effects and Distributed Control in Ecosystems #3

Temporal Variation of Indirect Effects in a Seven Compartment Model of Nitrogen Flow in the Neuse River Estuary: Time Series Analysis

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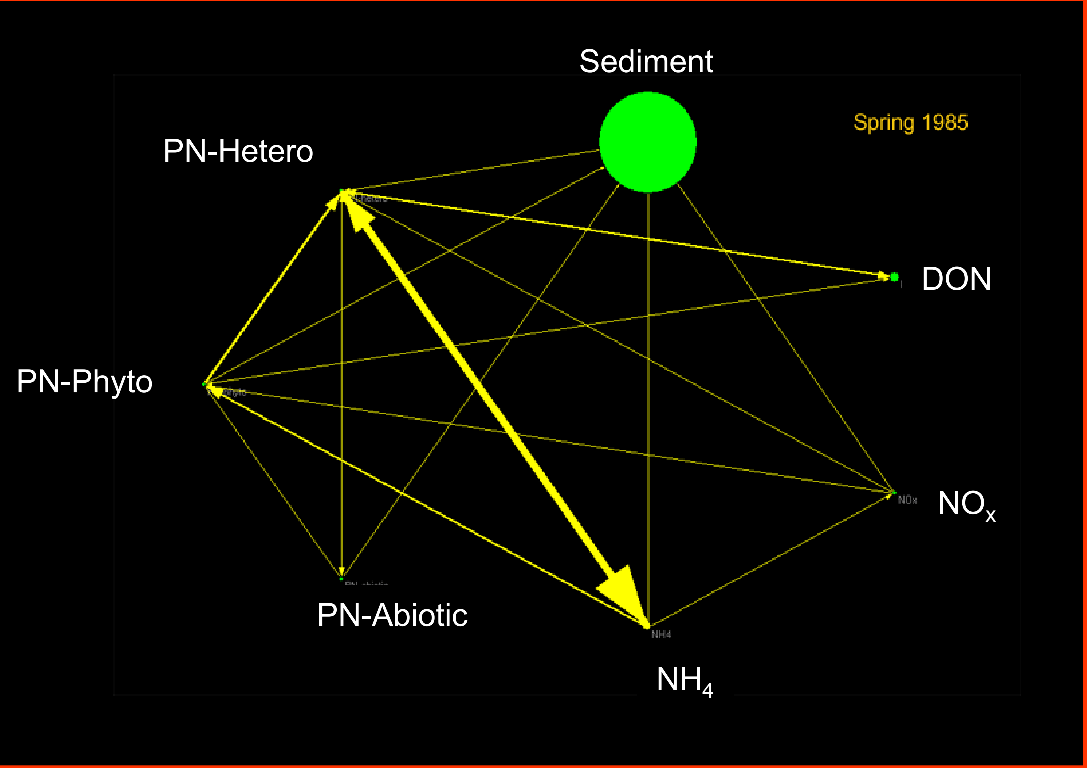
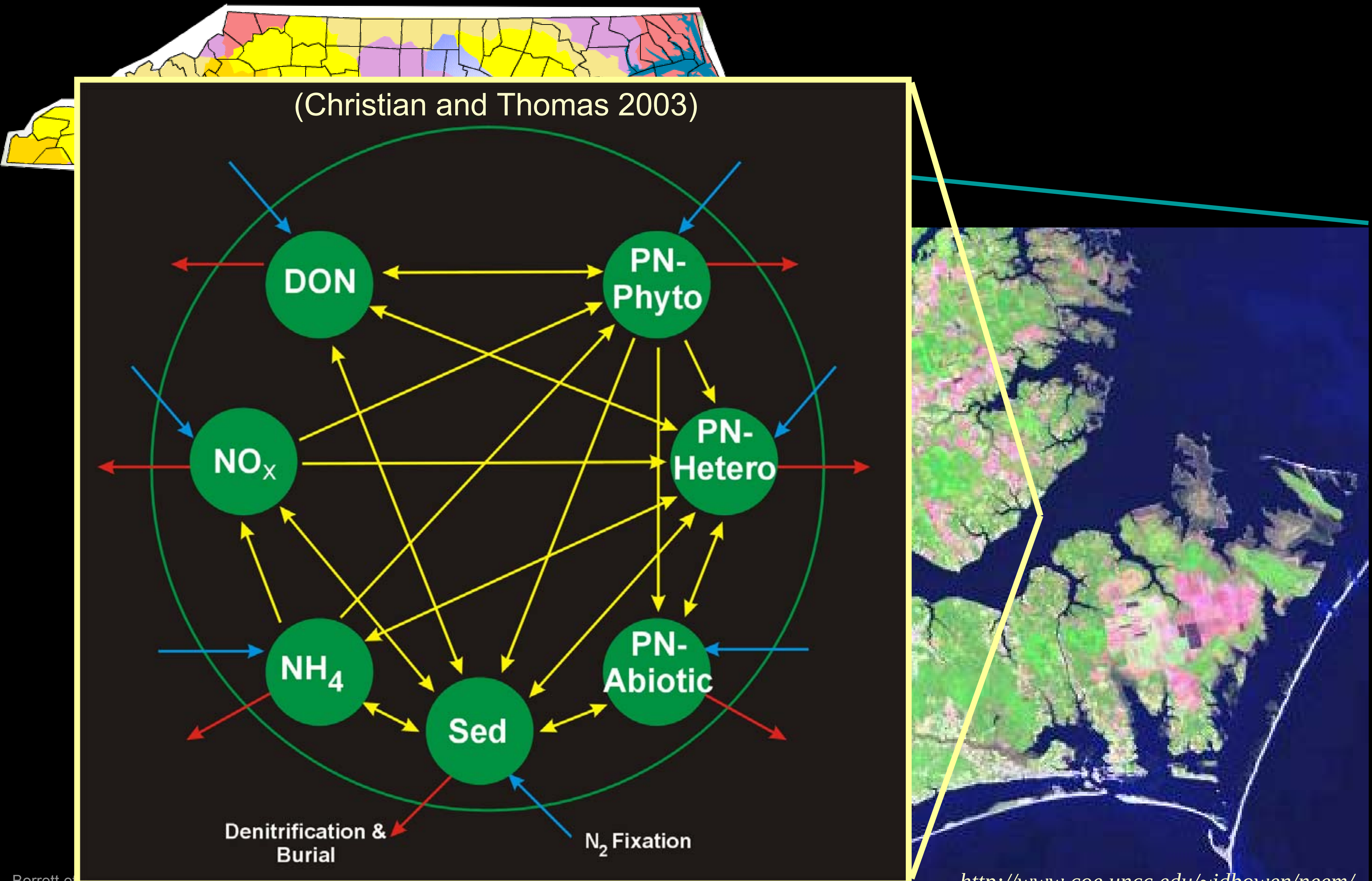
ECEM 2004
Bled, Slovenia



Neuse River Estuary, NC



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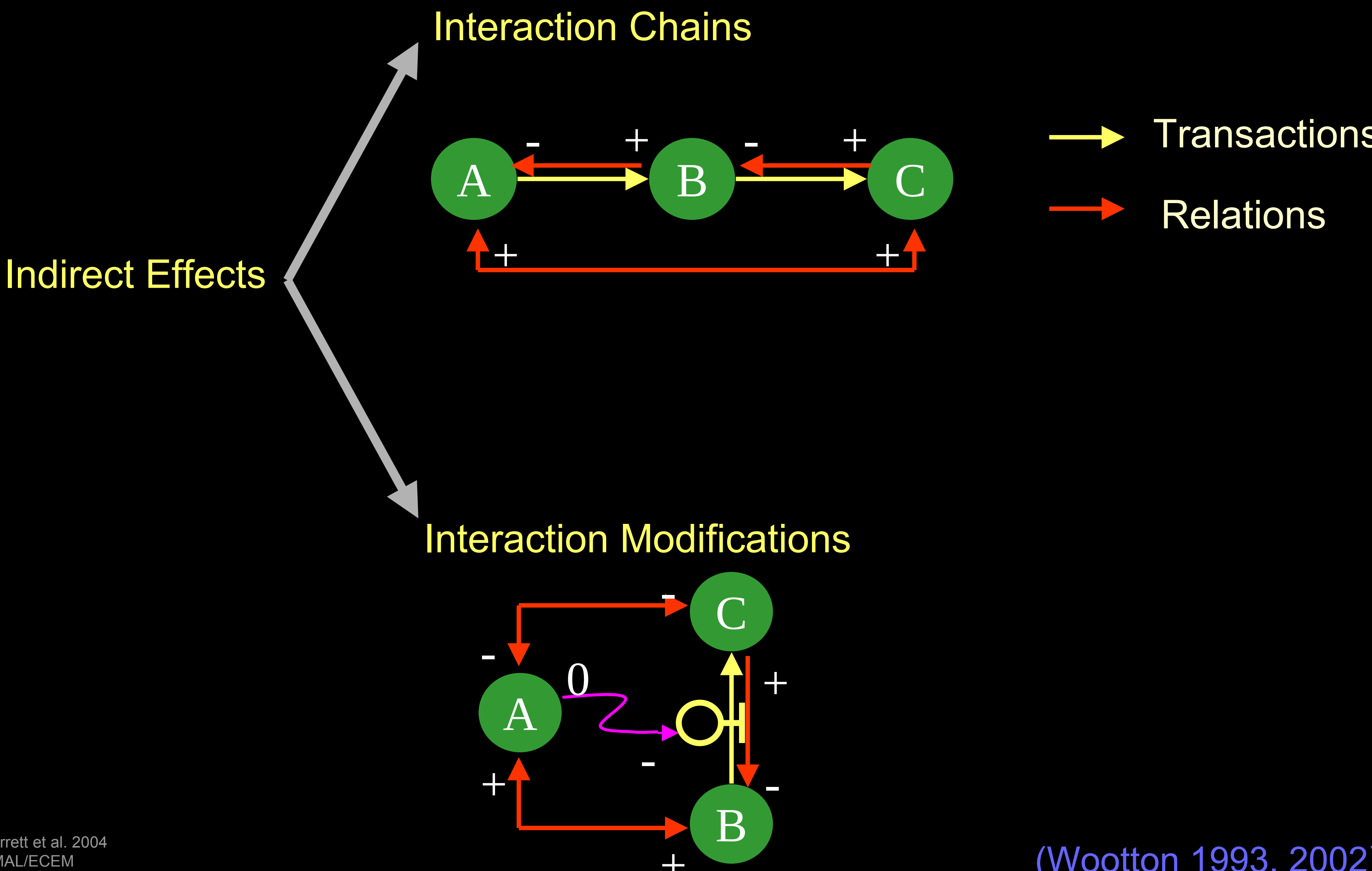
http://www.coe.uncc.edu/~jdbowen/neem/

Indirect Effects



(Wootton 1993, 2002)

Network Environ Analysis (NEA)

- Environmental application & extension of Input-Output analysis
  - Structure, Throughflow, Storage, Utility, Control
- Developed for static, steady state models
- Analysis of indirect flows
  - Dominance of indirect flows
  - Indirect flow = f(# nodes, Connectance, Direct, Cycling)

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Objectives

- Develop a discrete-time NEA to characterize temporal variation of indirect effects in nitrogen cycling mode for Neuse River Estuary

- Evaluate

  H_1: Indirect flows are dominant

  H_2: Indirect flows vary seasonally; moderate inter-annual variation

  H_3: Indirect flow = *f* (Boundary, Direct, <u>Cycling</u>)

Throughflow Decomposition Methods & Indirect Flows

1. $T = N z$

$$T = (I + G + G^2 + G^3 + \ldots + G^m + \ldots)\, z$$

$$\Sigma T = \Sigma(Iz) + \Sigma(Gz) + \Sigma((N - I - G)z)$$

$$TST = \text{Boundary} + \text{Direct} + \text{Indirect}$$

$\boxed{\text{Indirect/Direct}}$

$\boxed{1 = \text{Boundary/TST} + \text{Direct/TST} + \text{Indirect/TST}}$

2. TST = non-Cycled + Cycled (Finn 1976)

$\boxed{\text{Finn Cycling Index} = \text{Cycled/TST}}$

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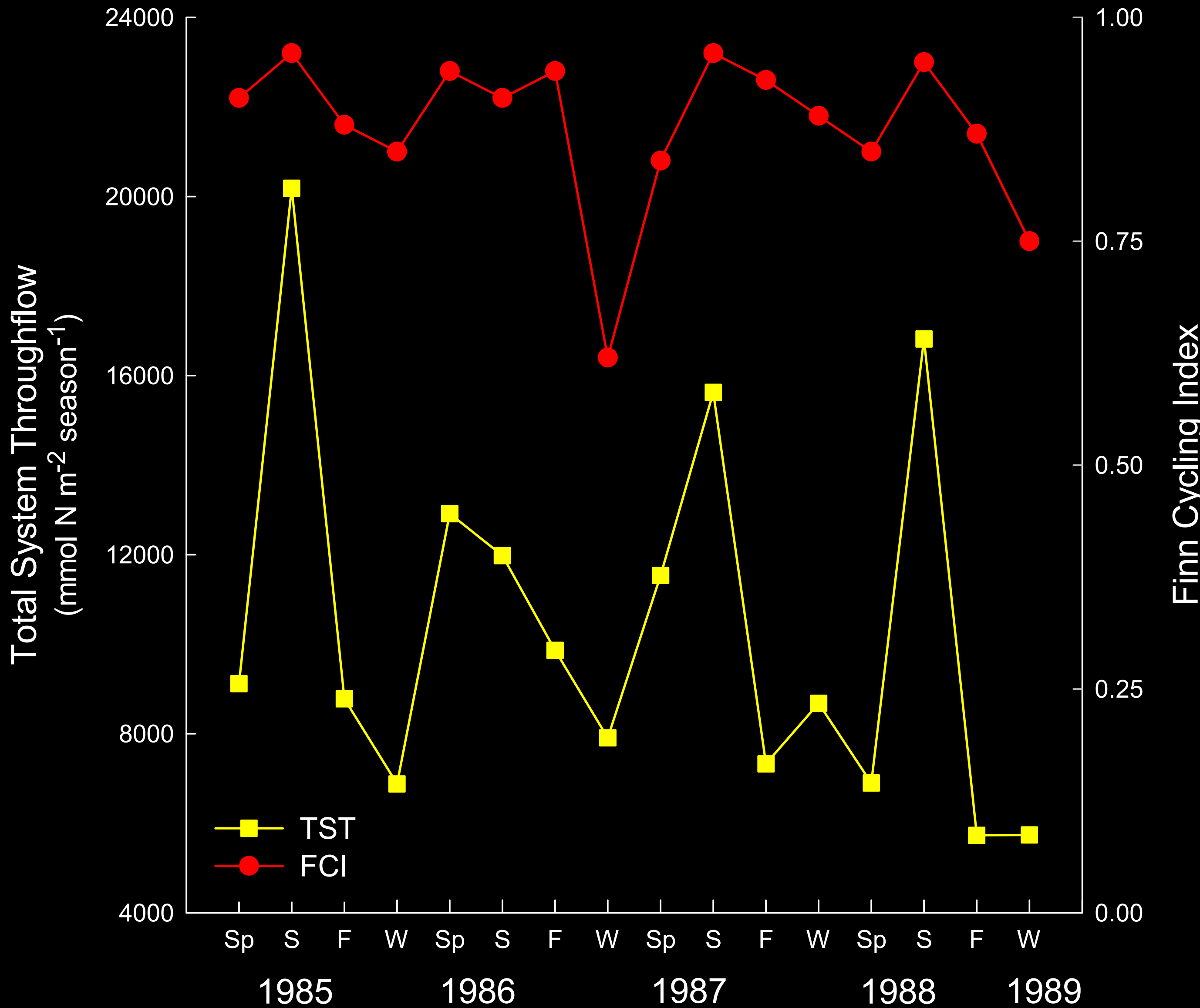
TST and FCI



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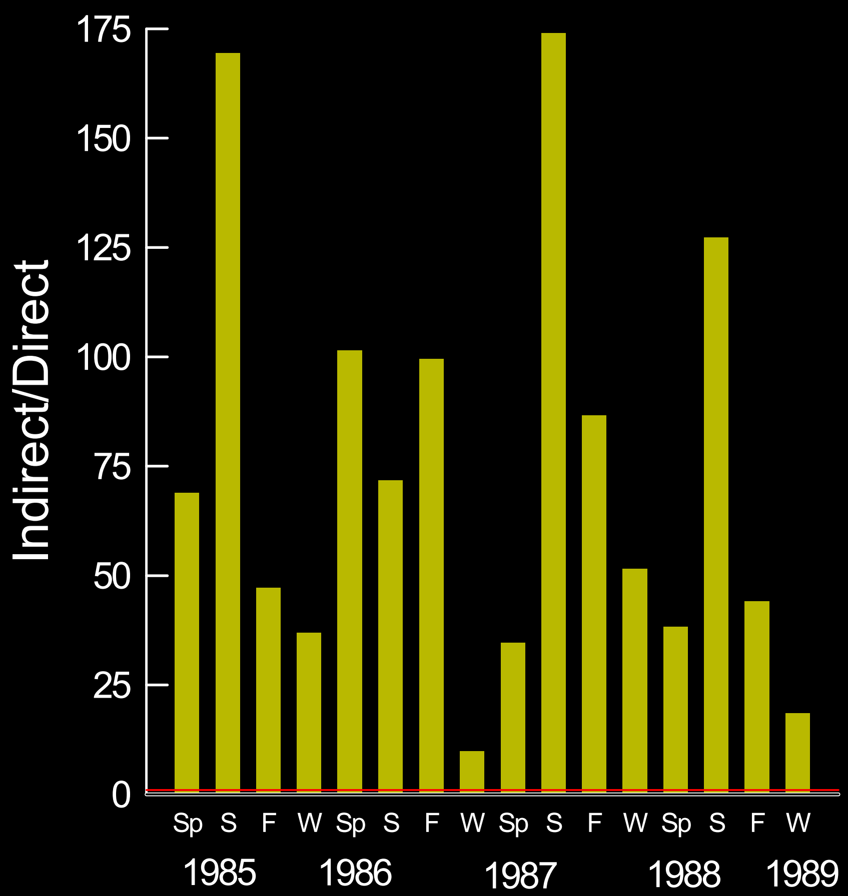
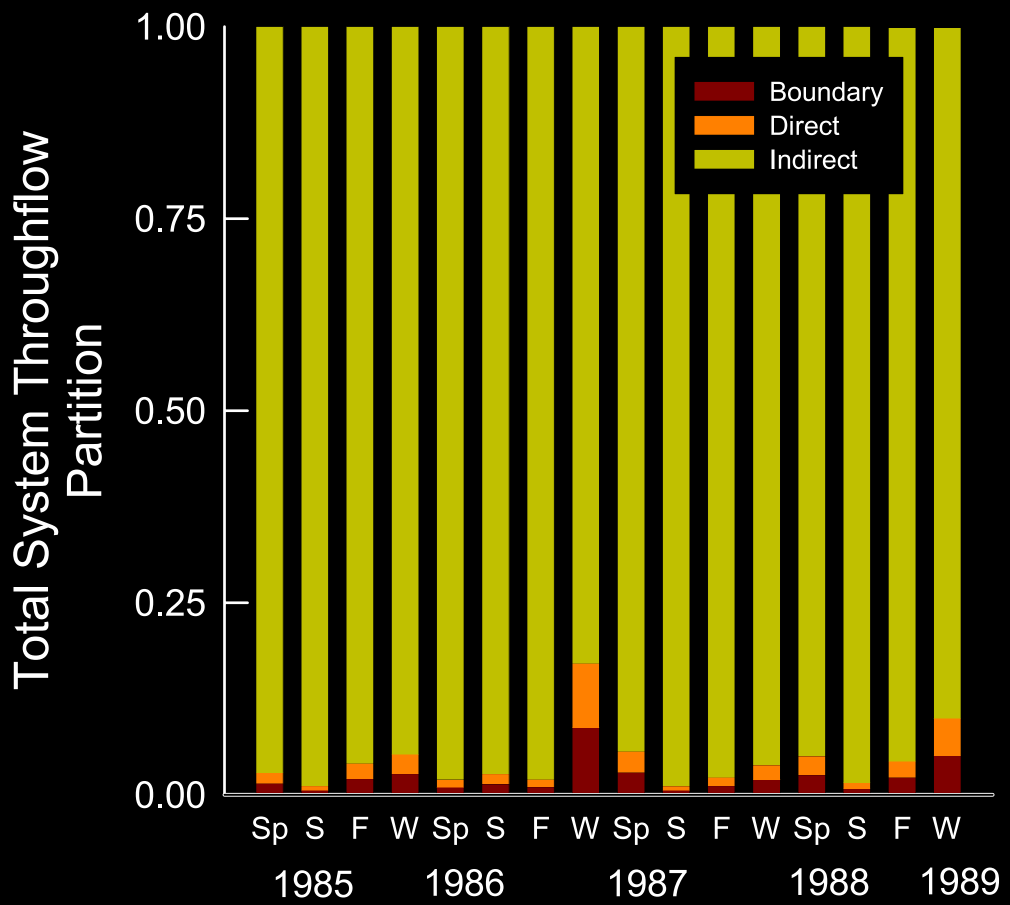
Indirect Effects

H$_1$: Indirect flows are dominant





Indirect Flows Dominate

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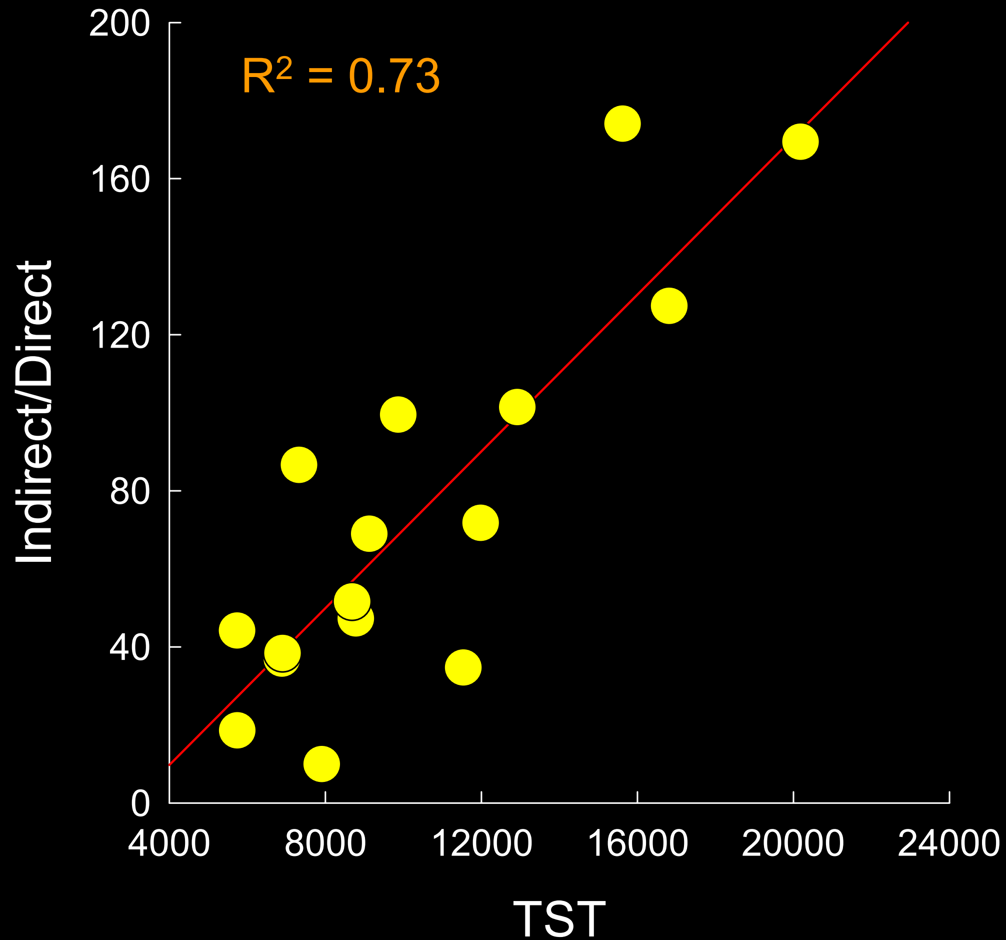
Indirect/Direct Varies with TST

H_2: Indirect flows vary seasonally; moderate inter-annual variation



So…

Use Indirect/TST to evaluate temporal variability in indirect flow

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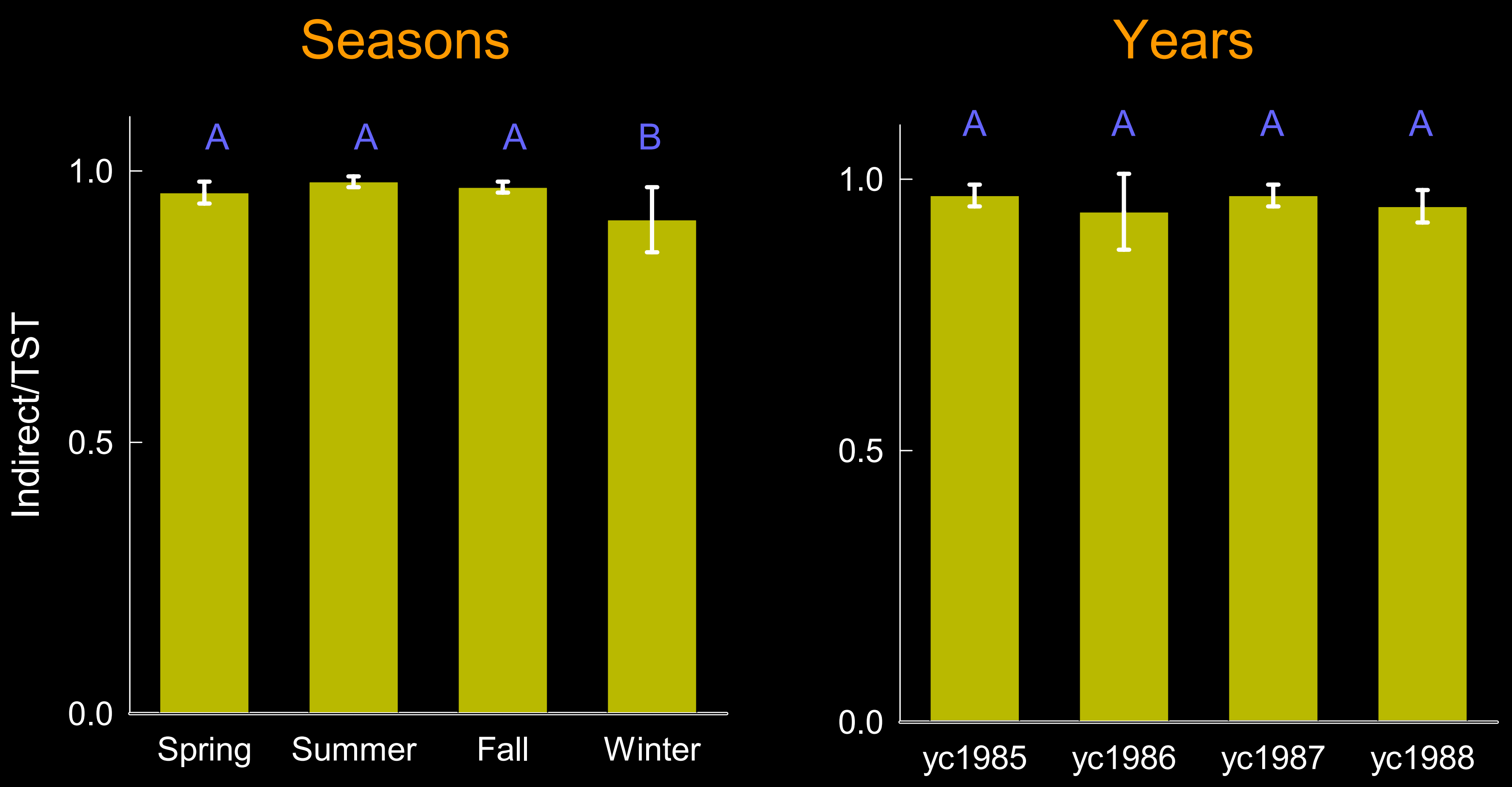
Temporal Variation

H_2: Indirect flows vary seasonally; moderate inter-annual variation



Little Temporal Variation

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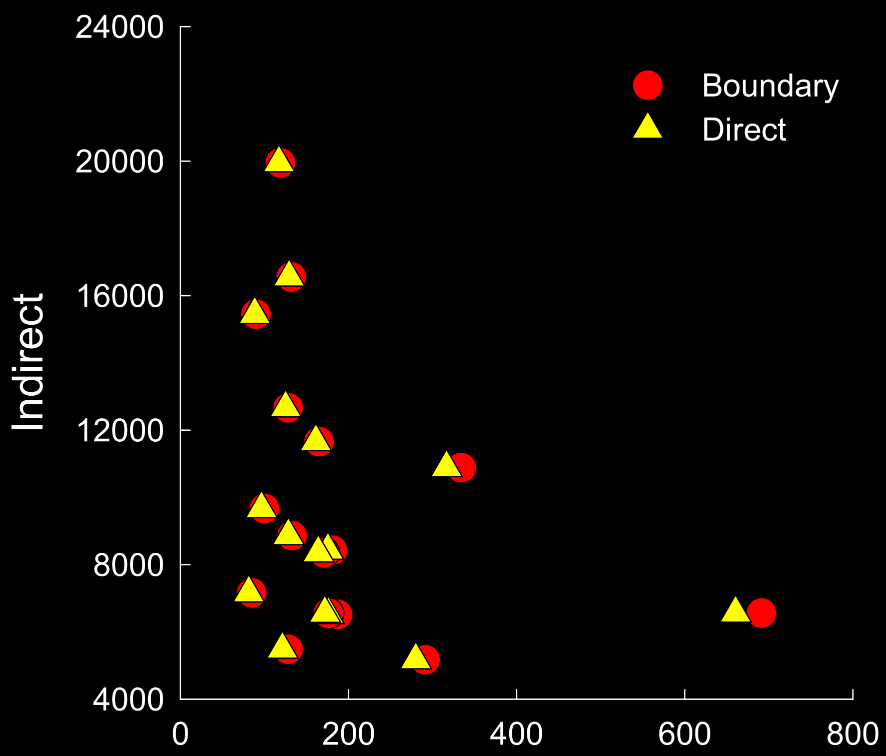
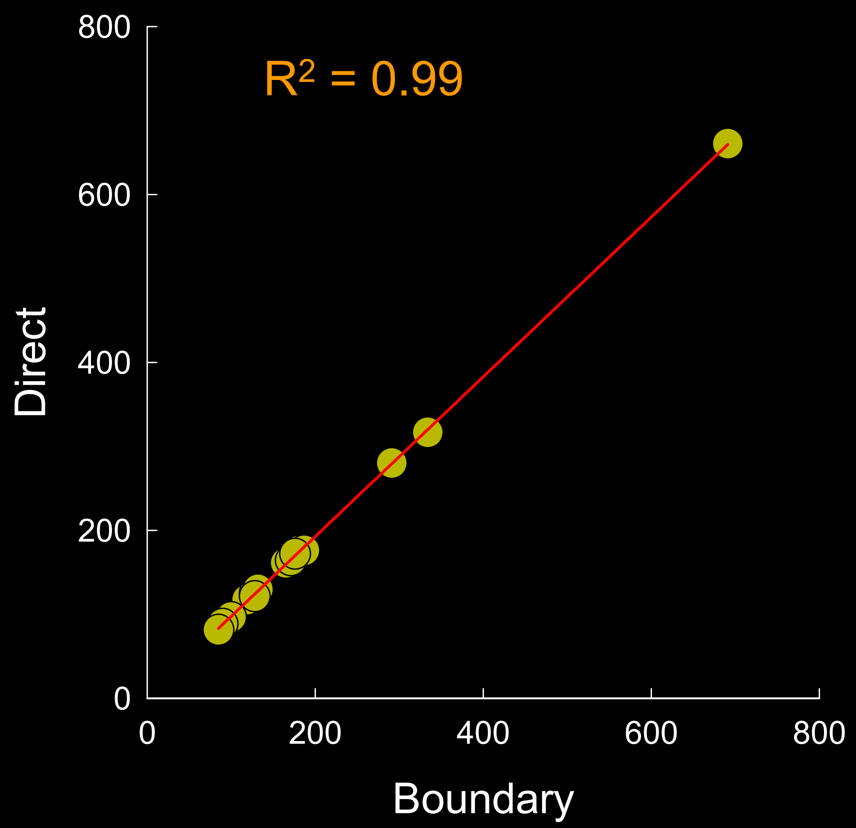
Determinants of Indirect Flow (1)

H_3: Indirect flow = *f* (Boundary, Direct, Cycling)





Boundary ≈ Direct

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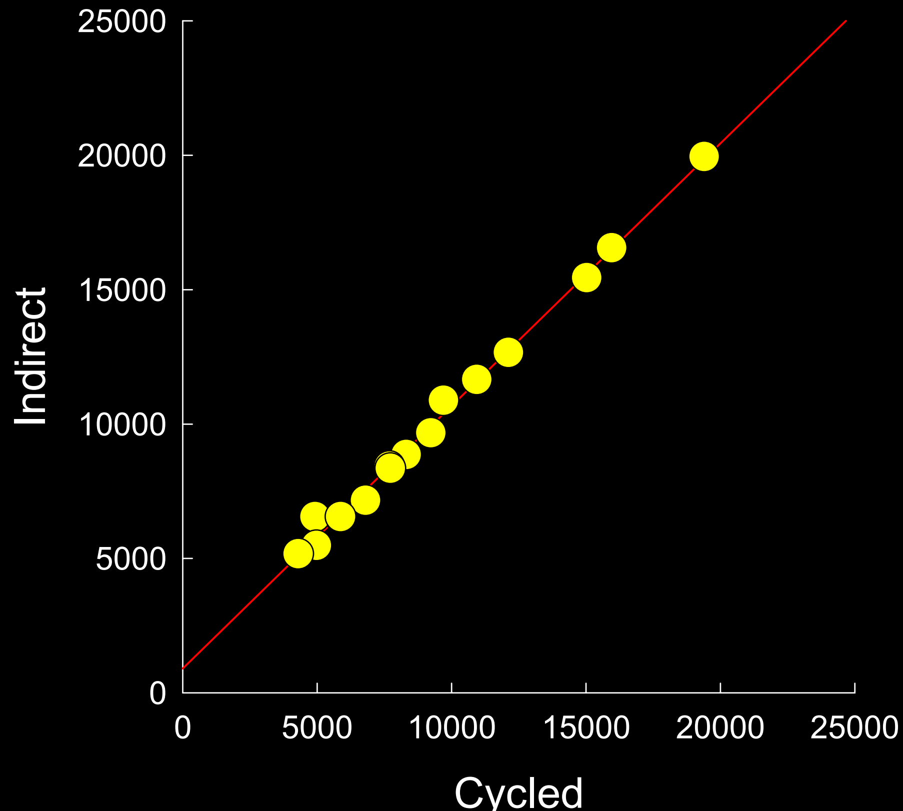
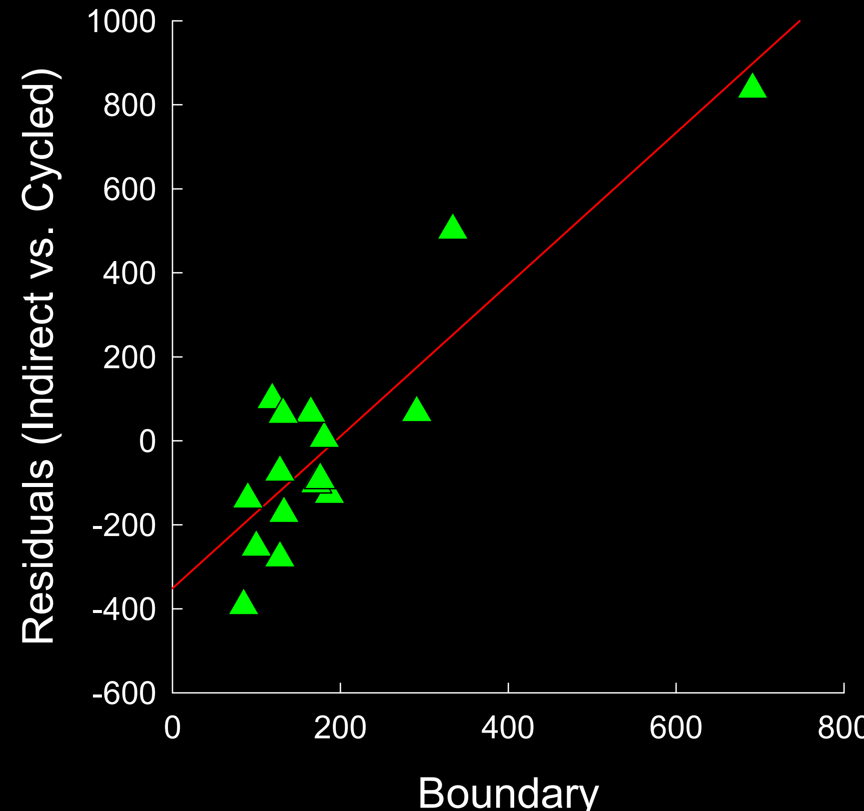
Determinants of Indirect Flow (2)

H_3: Indirect flow = *f* (Boundary, Direct, Cycling)





Indirect = 906 + 0.97(Cycled)

R^2 = 0.995, $p < 0.0001$

Residuals = -351 + 1.8(Boundary)

R^2 = 0.79, $p < 0.001$

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Most variation in Indirect is explained by Cycled

Summary & Conclusions

- Indirect flow dominates direct
- Indirect/Direct sensitive to TST
- Little temporal variability (Indirect/TST)
- Indirect is highly correlated with Cycled

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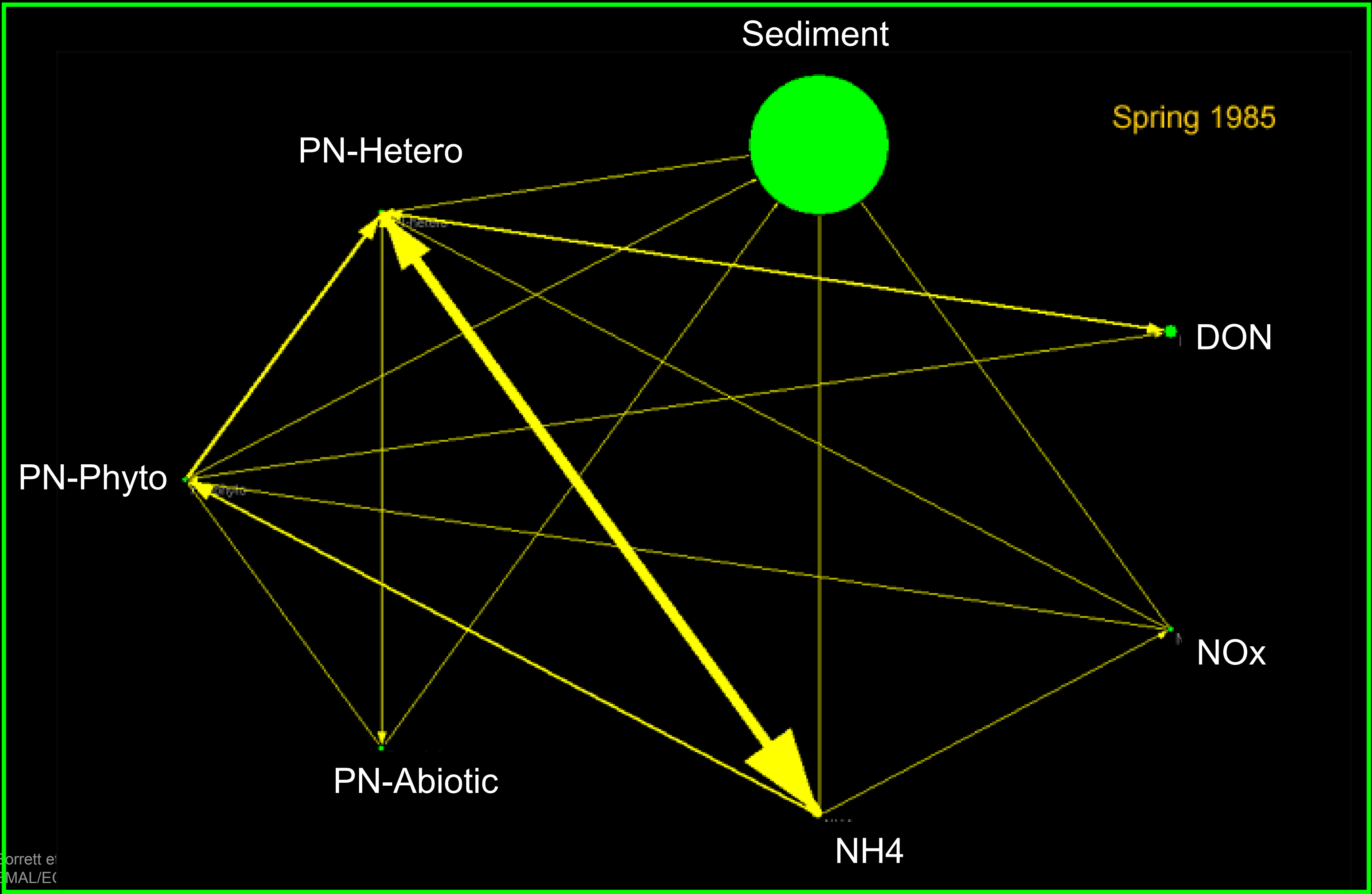
- ISEM

Questions?



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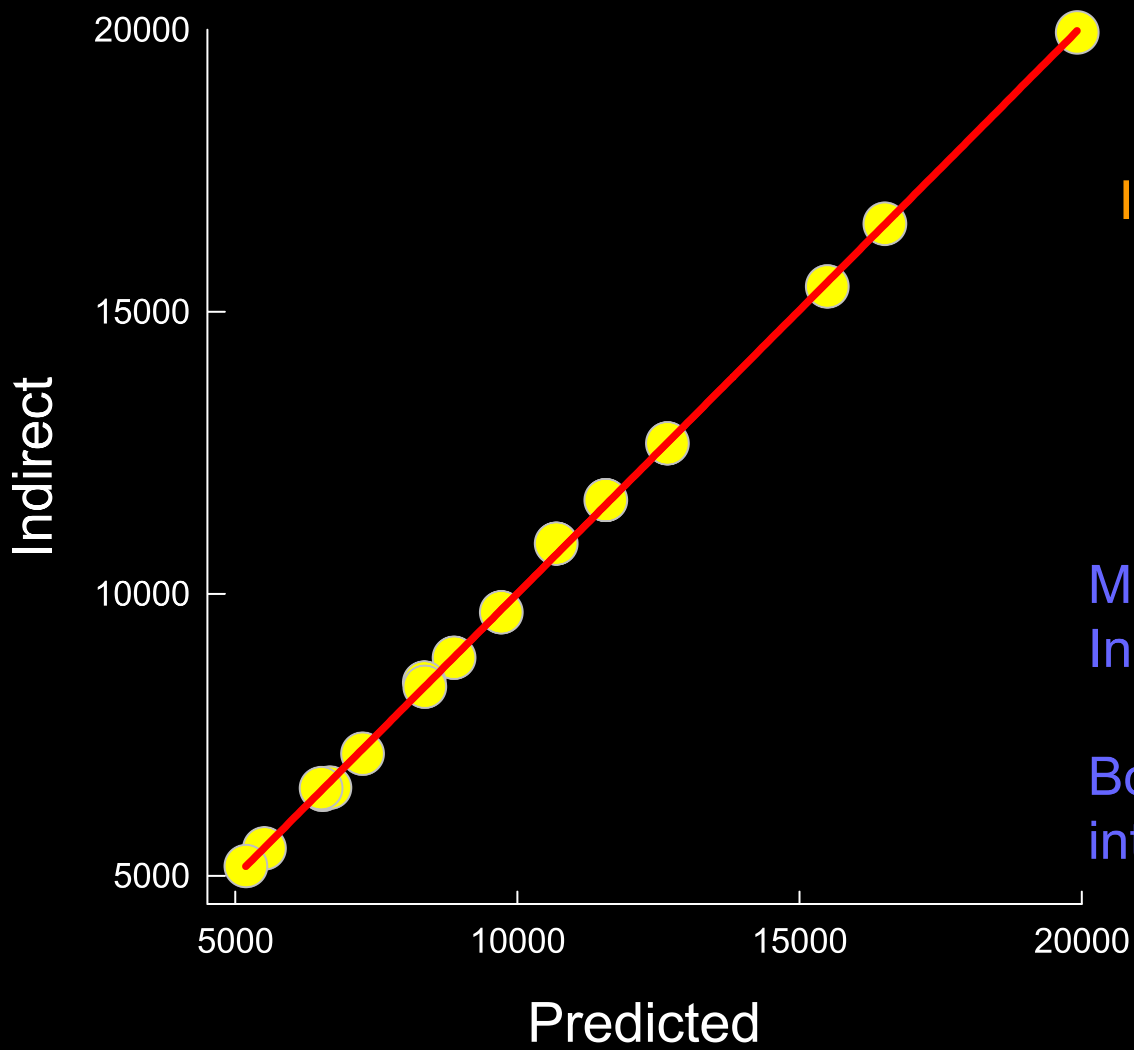
Determinants of Indirect Flow (2)



Indirect = 226.5 + 1.0 (Cycled)
+ 2.1 (Boundary)

R^2 = 0.997, C(p) = 1.25

Multiple linear regression fits and Includes Cycled and Boundary

Boundary ≈ Direct so are nearly interchangeable