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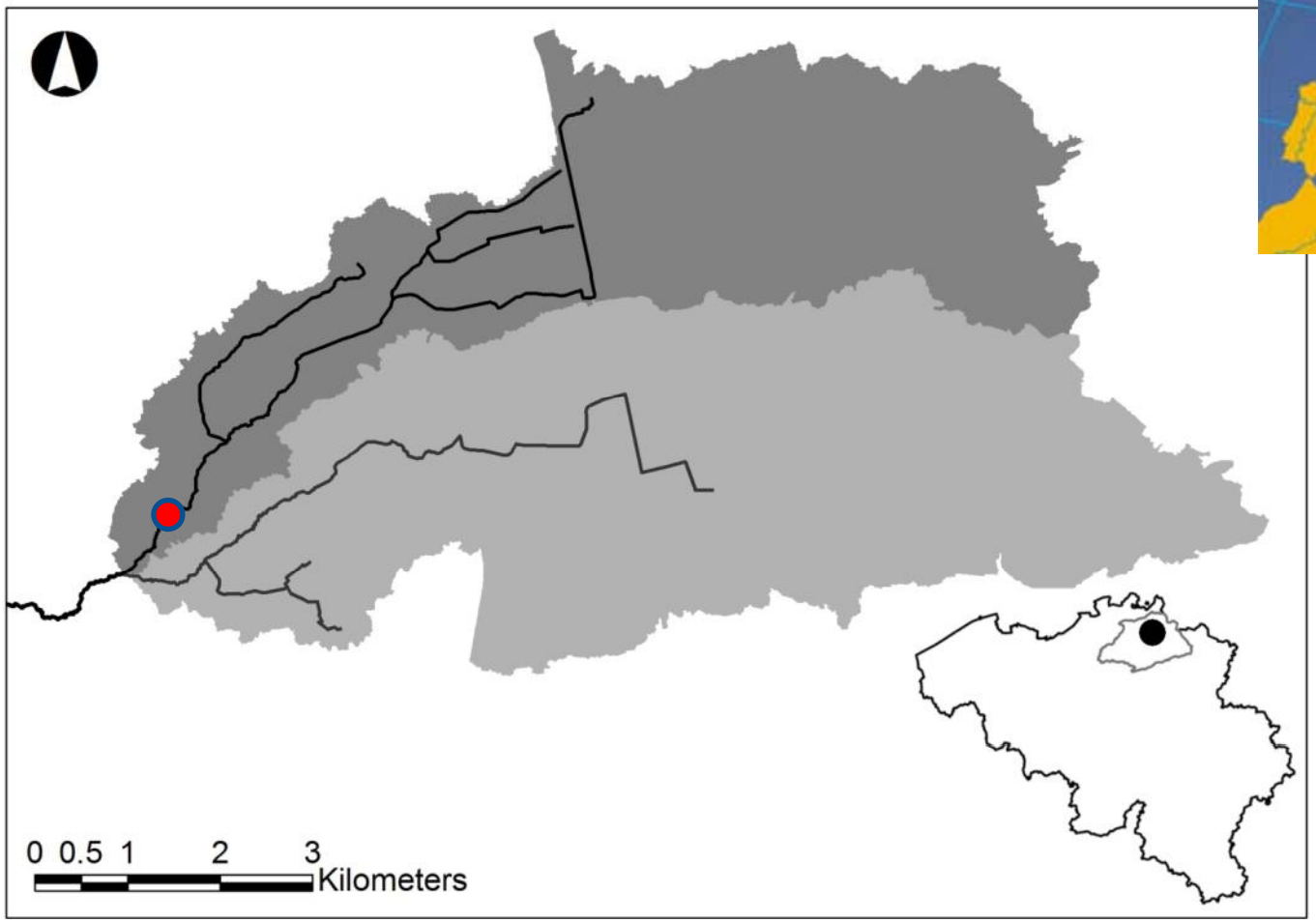
Self-organisation and scale-dependent feedbacks in freshwater vegetation

Schoelynck J, De Groote T, Bal K, Vandenbruwaene W, Meire P, Temmerman S. Self-organised patchiness and scale-dependent bio-geomorphic feedbacks in aquatic river vegetation. Submitted

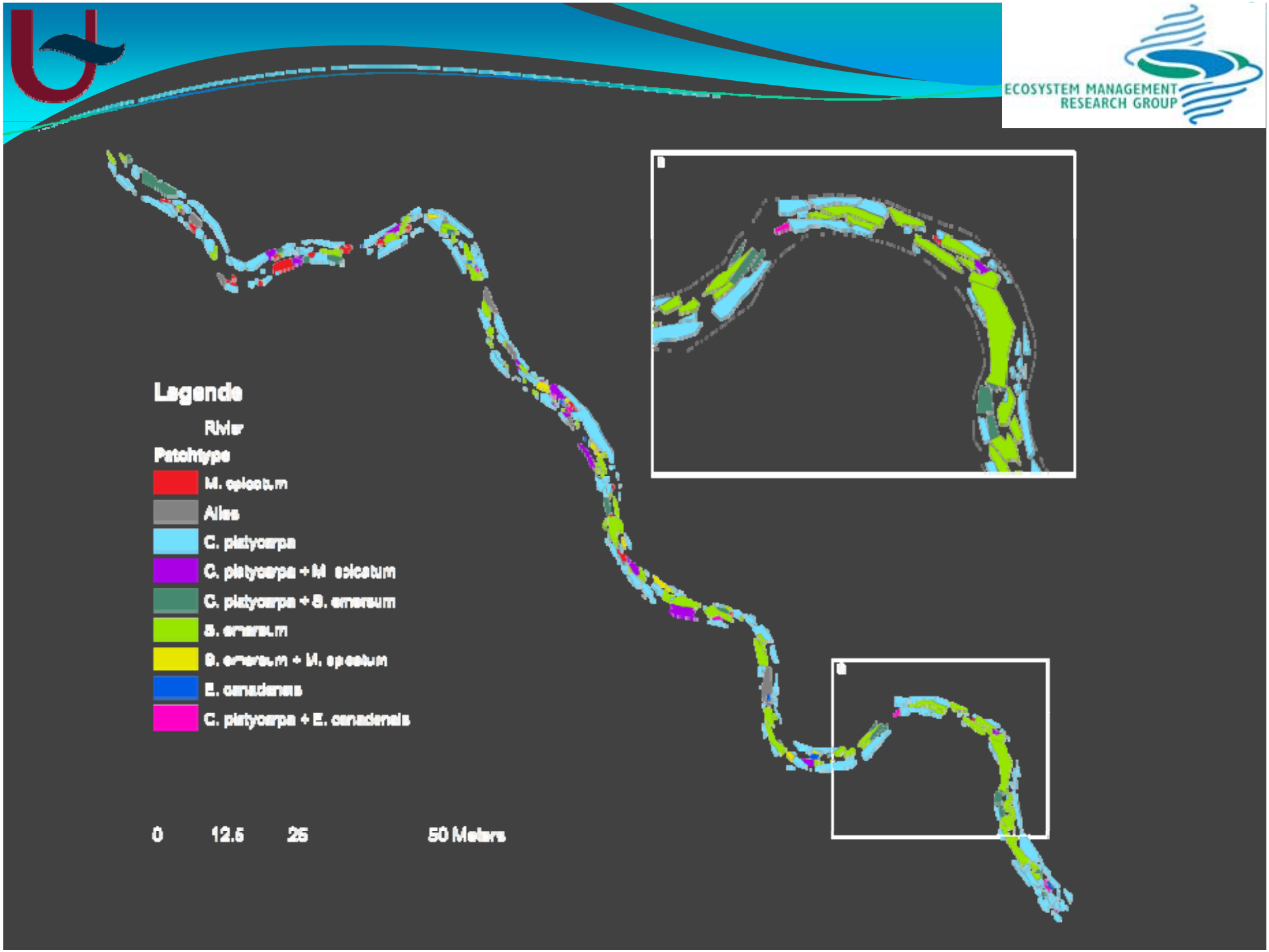
Universiteit Antwerpen



Study site: Zwarte Nete in Flanders (Belgium)

Field measurements with total station

Field measurements with total station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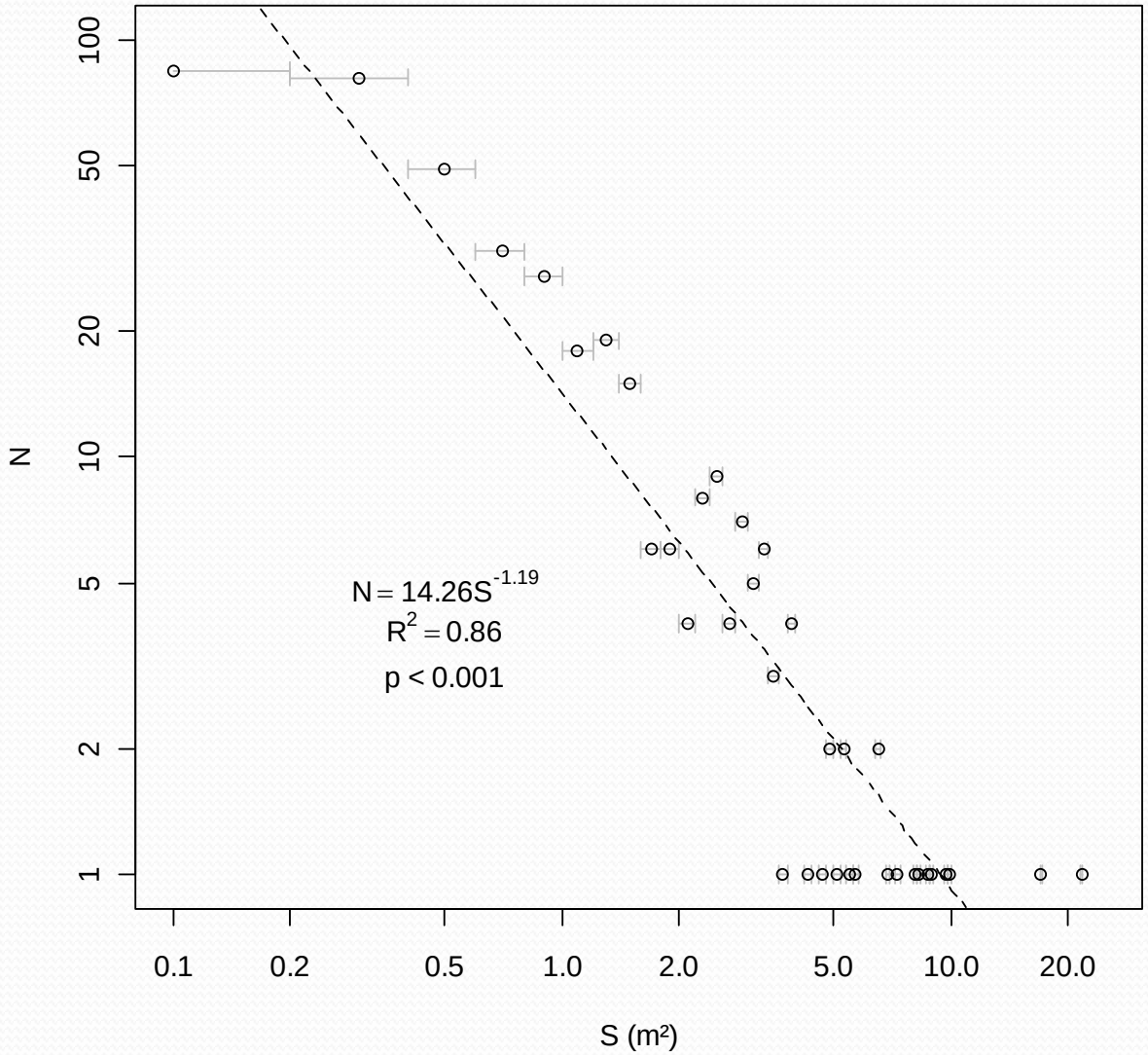
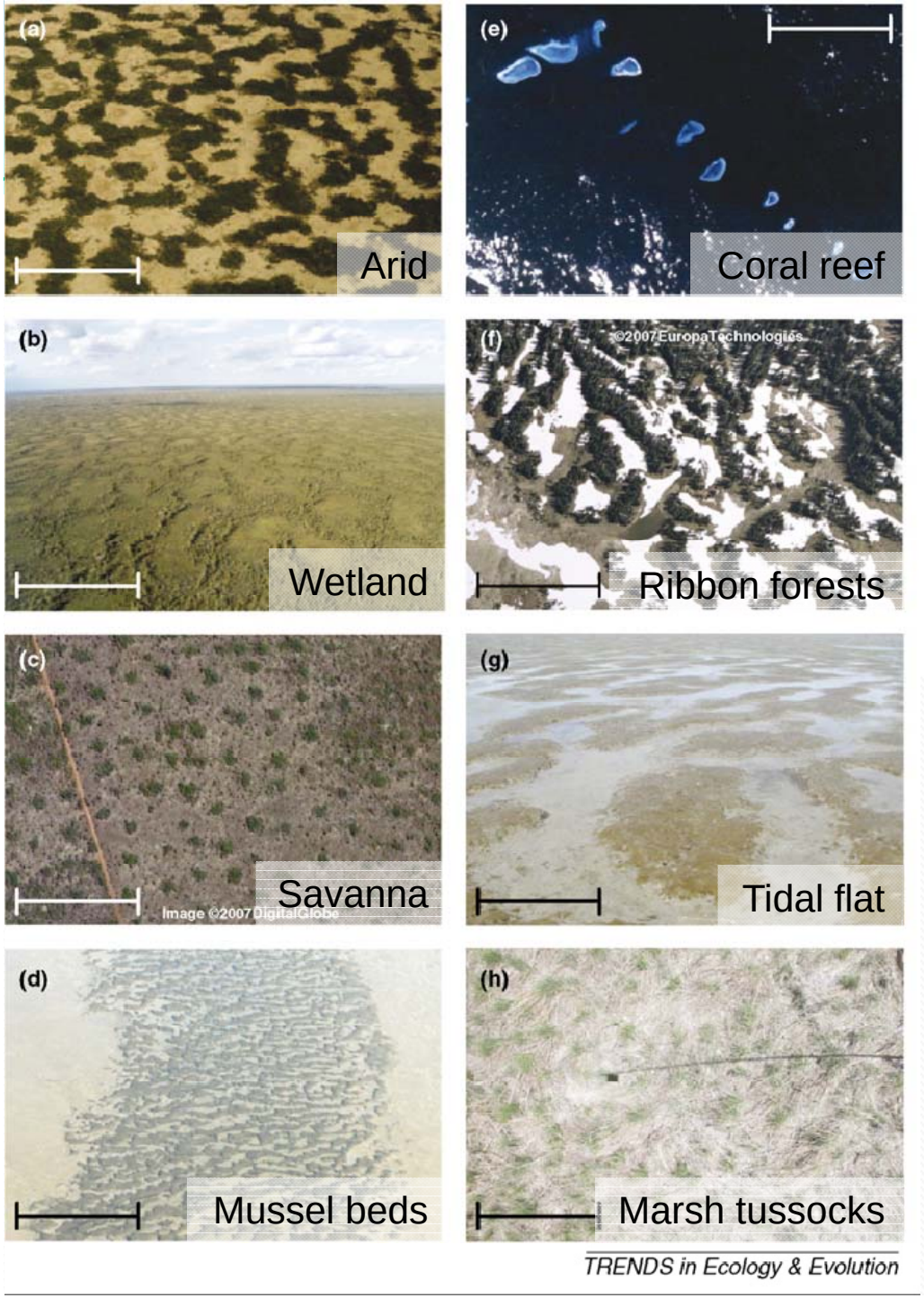
Legende
River
Patchtype
M. spicatum
Alles
C. platycarpa
C. platycarpa + M. spicatum
C. platycarpa + S. emersum
S. emersum
S. emersum + M. spicatum
E. canadensis
C. platycarpa + E. canadensis
0
12.5
25
50 Meters

Power-law distribution: $N = a.S^b$

field



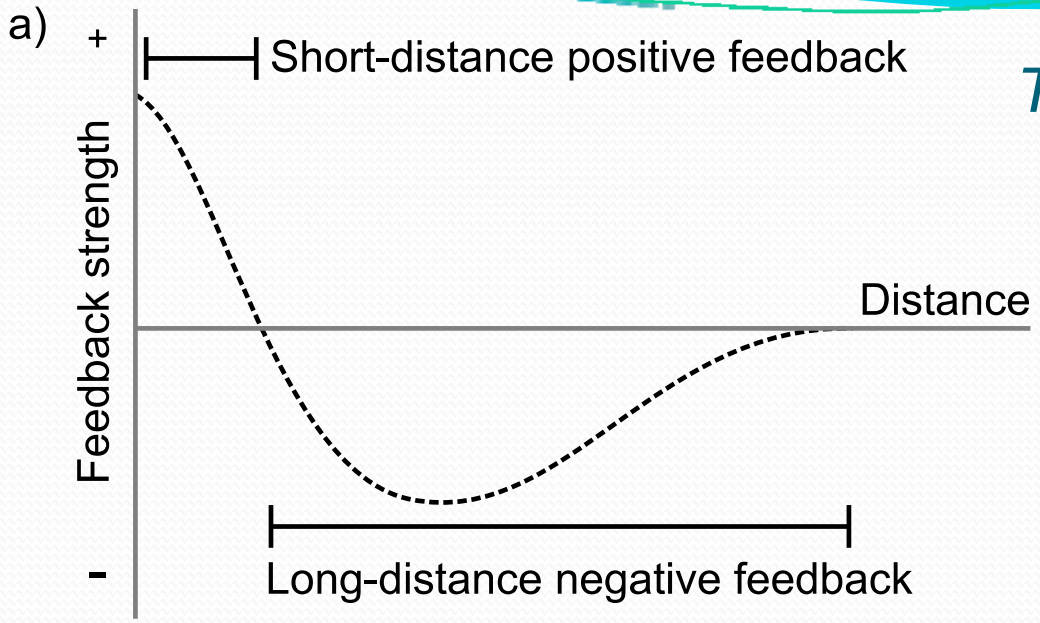
Examples



"Regular pattern formation is a general phenomenon rather than a peculiarity."

(Rietkerk & van de Koppel, 2008)

Theory



Scale-dependent feedbacks between organisms and their environment are considered as a necessary condition for self-organised patchiness to form .

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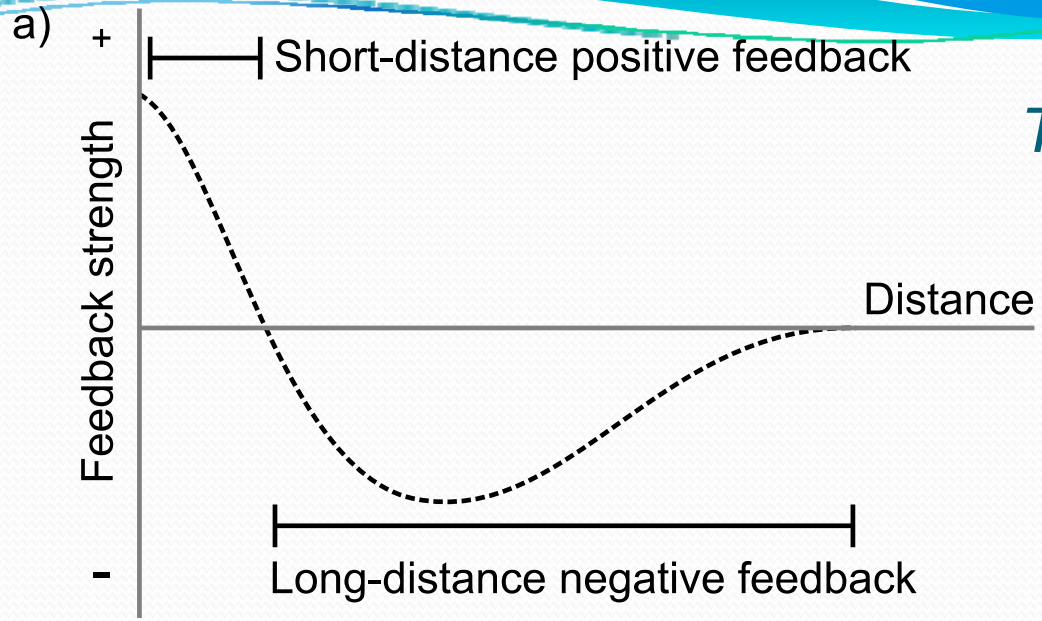
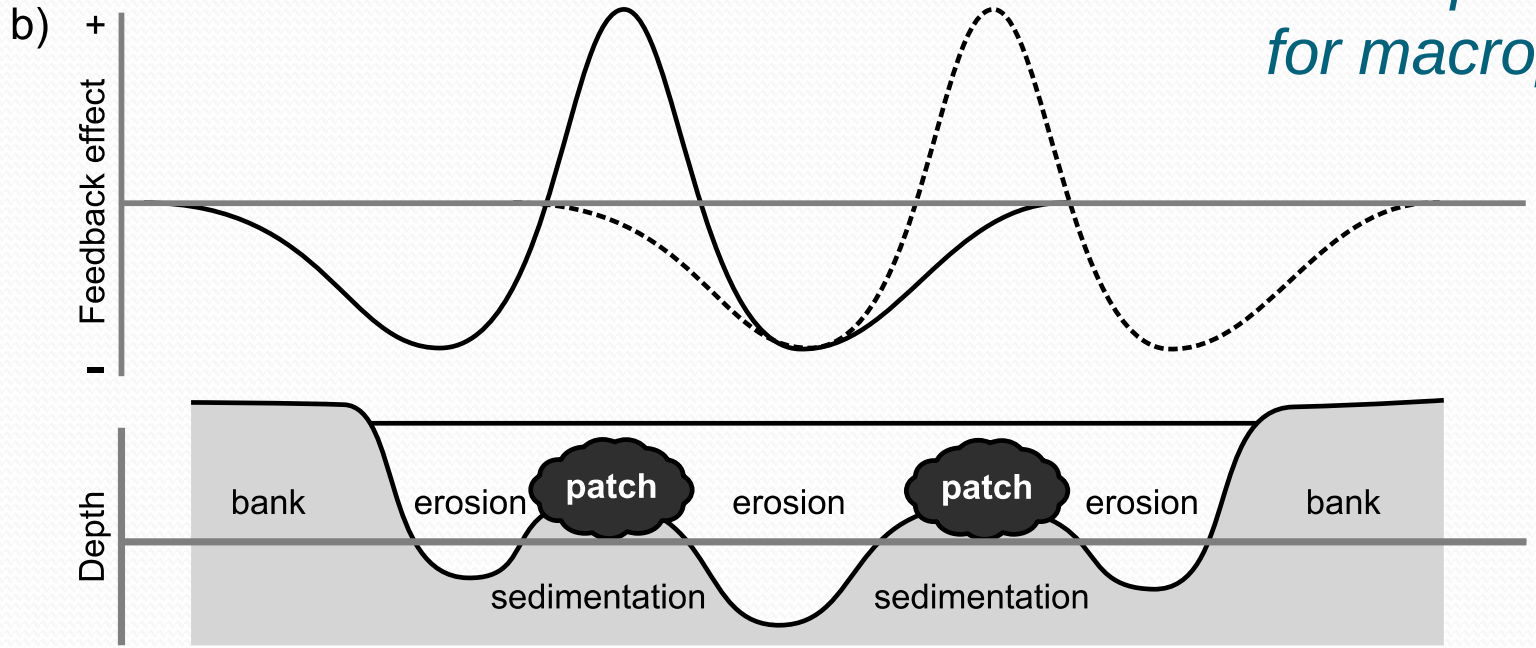
Theory



Conceptual idea for macrophytes



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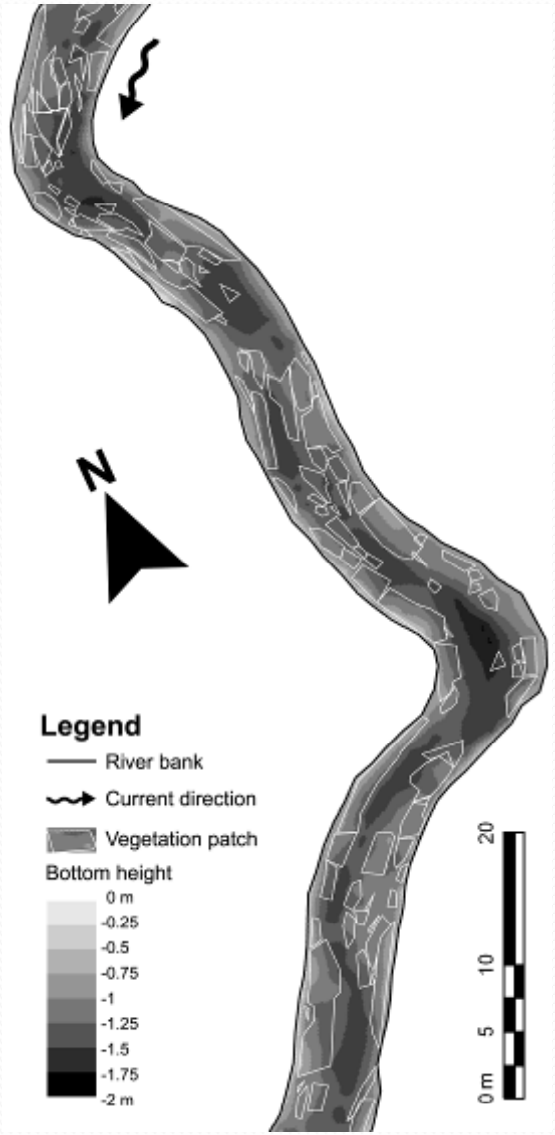
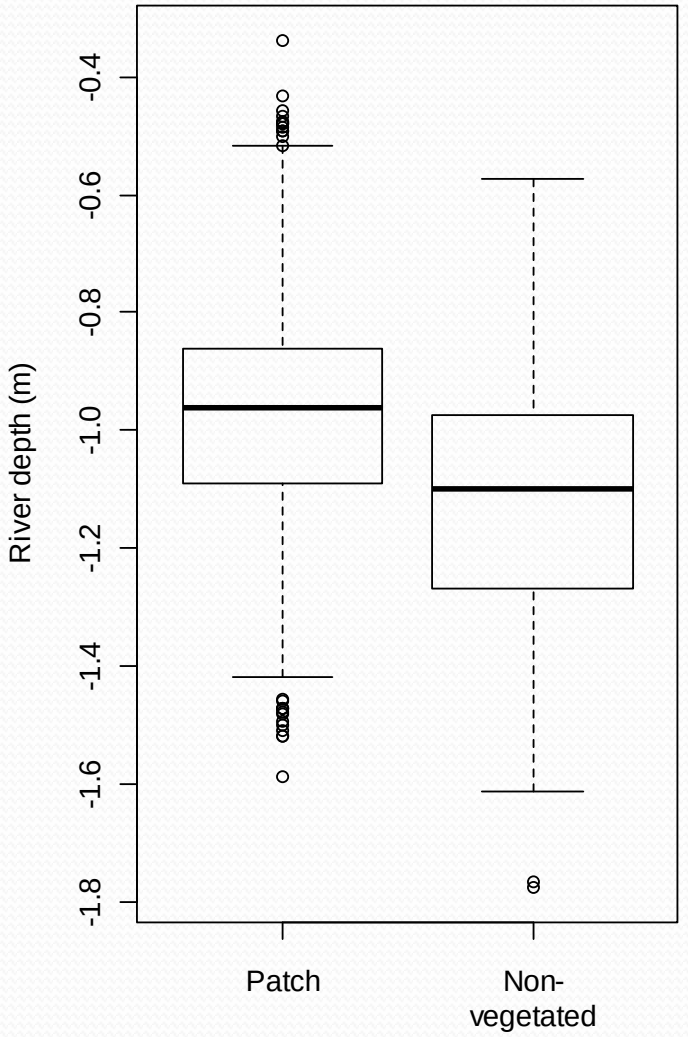
Hypothesis

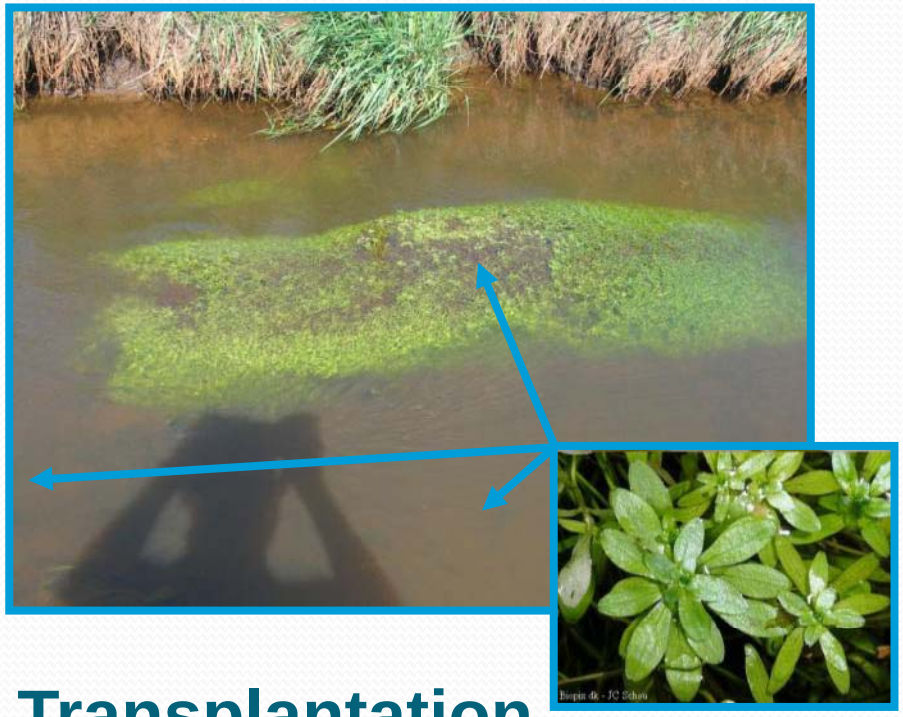
Short-range positive feedbacks and long-range negative feedbacks occur between macrophyte growth and environmental conditions (water flow, sedimentation, erosion) influencing each other.





field

d = 15 ± 18 cm (t-test, p<0.001)



Transplantation experiment

Mimics experiment

Fast current (+30%) → reduced sedimentation

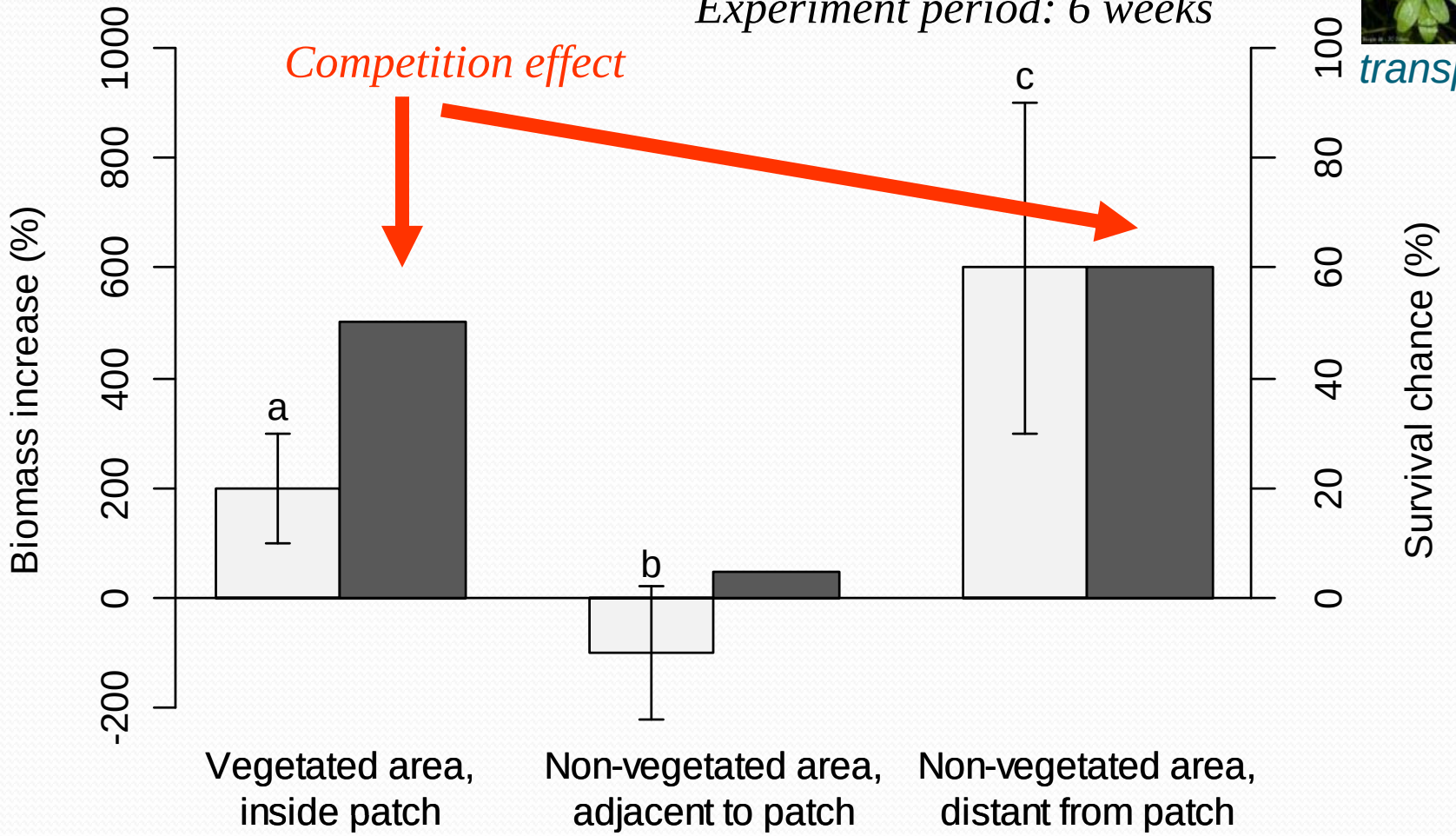
mimic

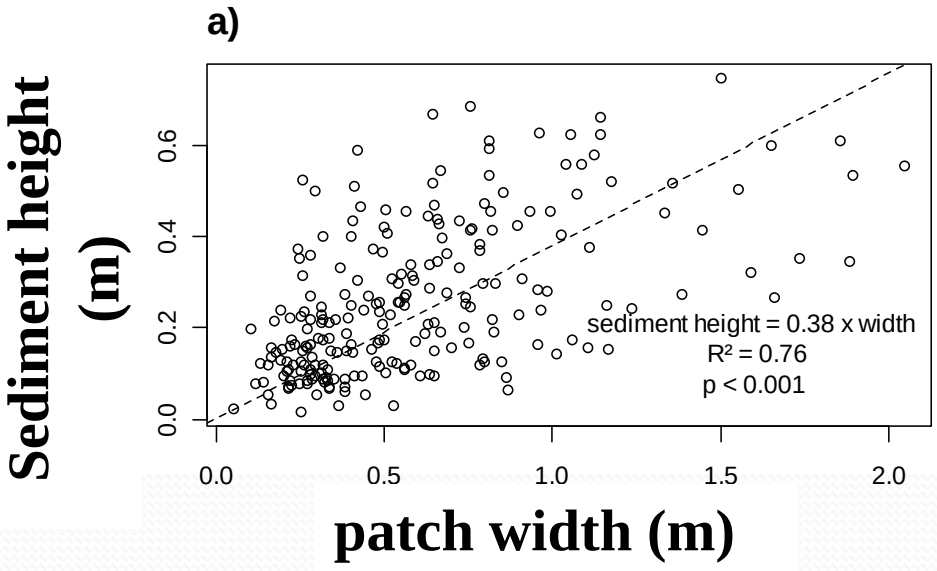
Slow current (up to -100%) → increased sedimentation

Initial mass: 100 g

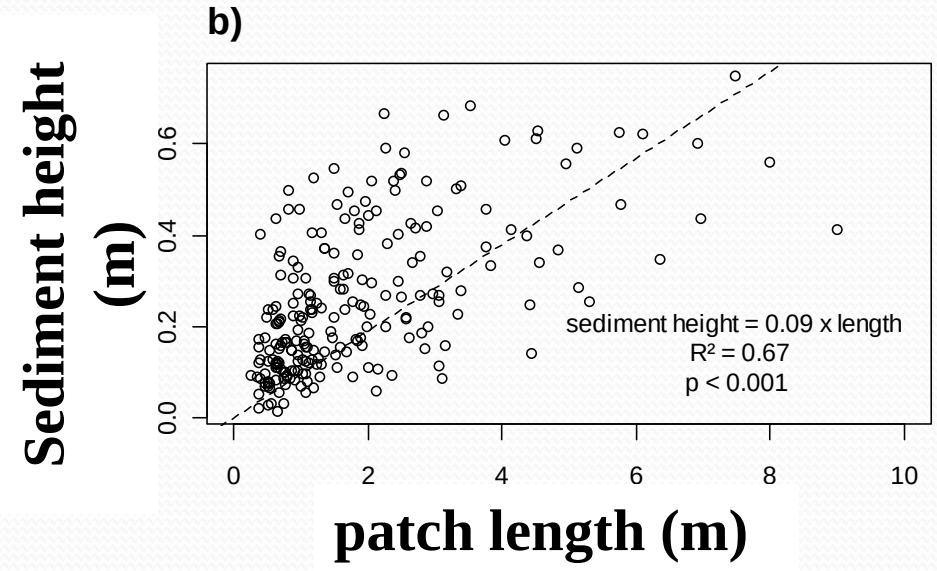
Experiment period: 6 weeks

transplant





field



Sediment height: difference between heightest point in patch and lowest point in vicinity of patch

Scale-dependent feedbacks are likely to be size-dependent

Discussion

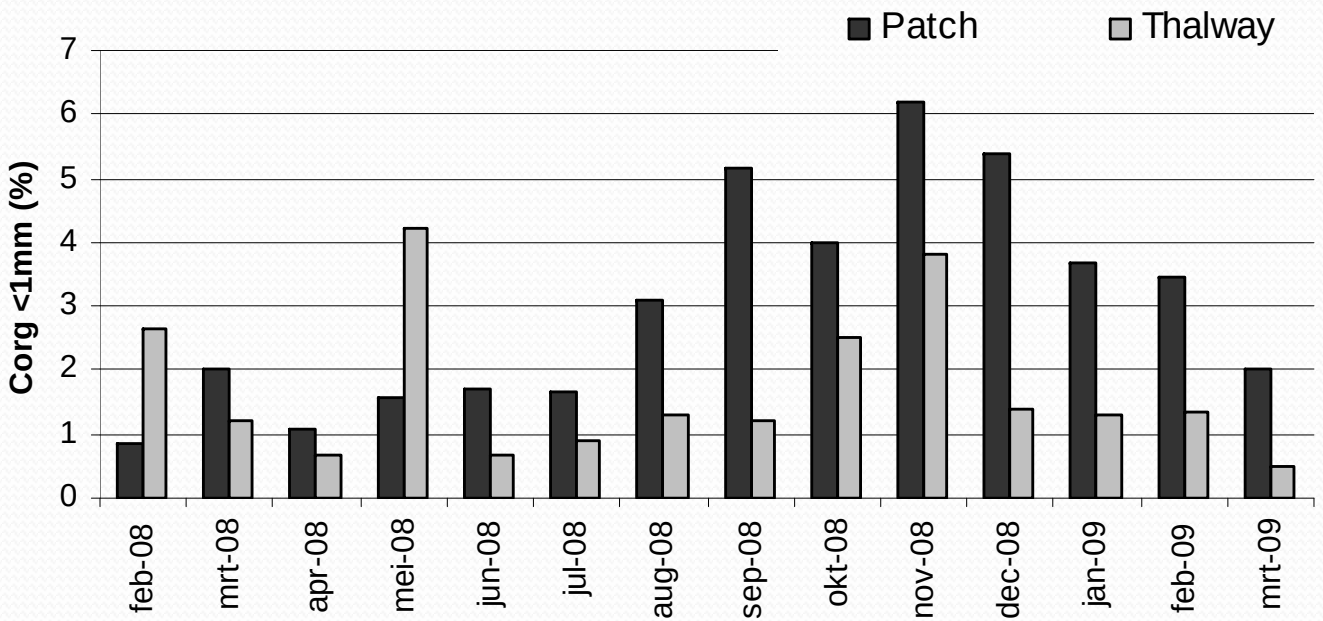
- *power-law relation indicates spatial distribution to be self-organising*

- *scale-dependent feedback processes hold true in freshwater river ecosystems and govern self-organising*
  - *in patch: v*↓ + *sedimentation*↑ = plant survival ↑ ↑
  - *adjacent: v*↑ + sedimentation↓ = plant survival ↓ ↓

- *scale-dependent feedbacks are likely to be size-dependent*

Discussion

- *The presence of self-organised patchiness has important implications for ecosystem functioning* (Rietkerk & van de Koppel, 2008)
  - *PRODUCTIVITY: Patches are "island of fertility" by organic matter accumulation*

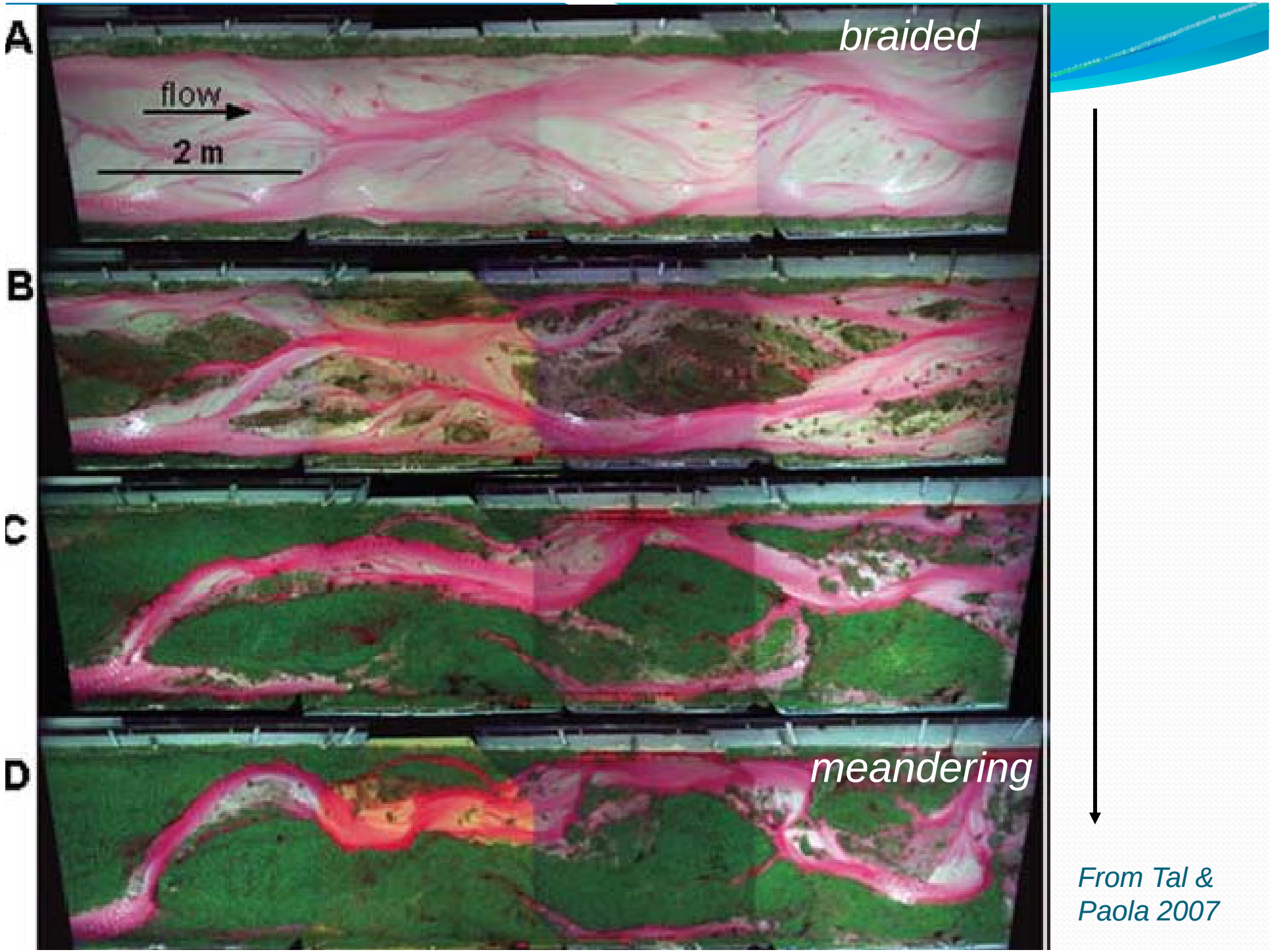


Discussion

- *The presence of self-organised patchiness has important implications for ecosystem functioning* (Rietkerk & van de Koppel, 2008)
  - *PRODUCTIVITY: Patches are "island of fertility" by organic matter accumulation*
  - *RESISTANCE: at peak discharges, water is deviated around patches rather than through in case of uniform biomass*


RESISTANCE
Fast current → bank/bed erosion
Slow current → sedimentation


1987:
channel
1990:
meandering

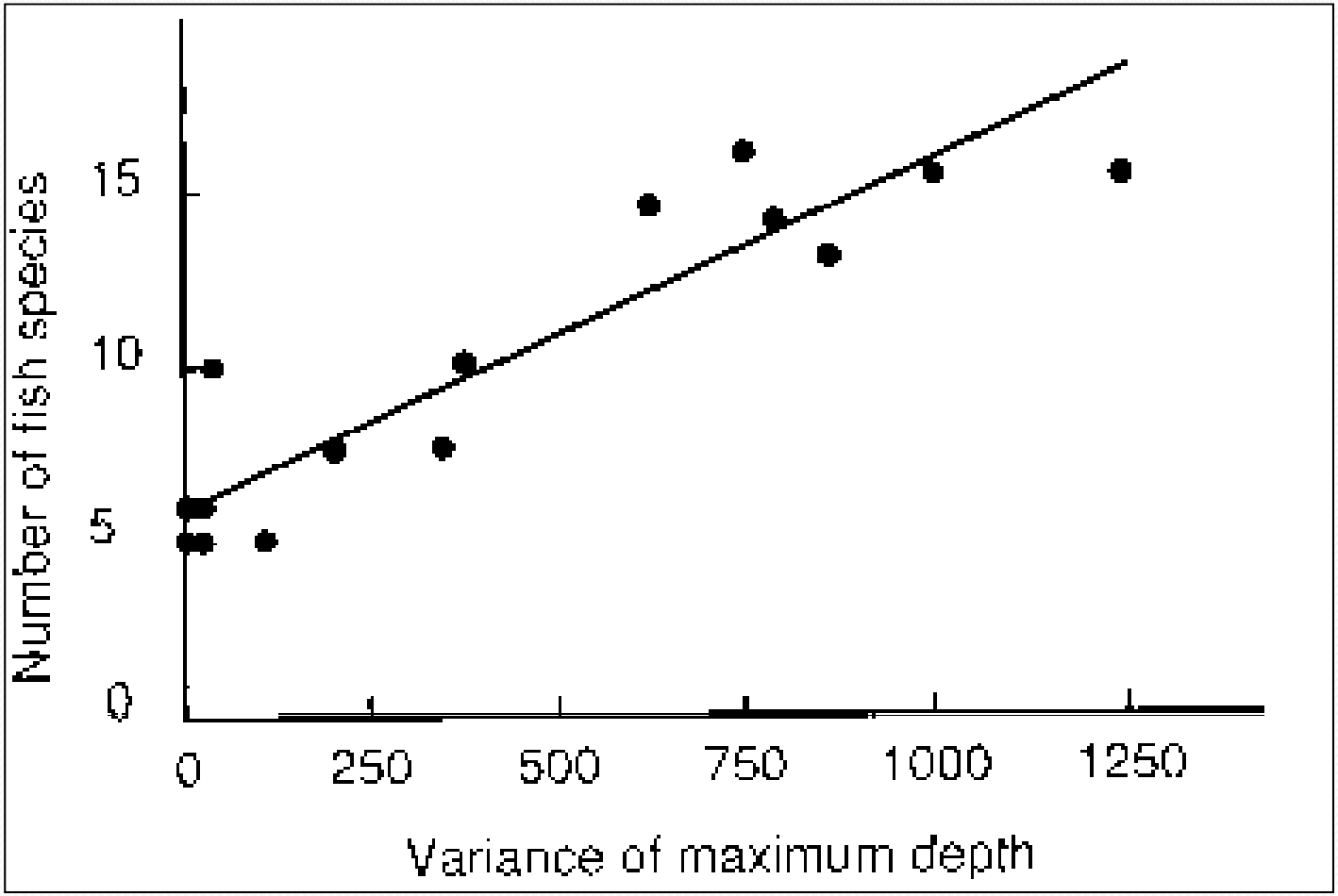


From Tal & Paola 2007

Discussion

- *The presence of self-organised patchiness has important implications for ecosystem functioning* (Rietkerk & van de Koppel, 2008)
  - *PRODUCTIVITY: Patches are "island of fertility" by organic matter accumulation*
  - *RESISTANCE: at peak discharges, water is deviated around patches rather than through in case of uniform biomass*
  - *RESILIENCE: biodiversity increase*

Consequences for fish diversity



Uit Cowx & Welcomme 1998

Thank you

- **Cited references**

Rietkerk, M. & Van De Koppel, J. (2008) Regular pattern formation in real ecosystems. Trends in Ecology & Evolution, 23, 169-175.

Tal, M. & Paola, C. (2007) Dynamic single-thread channels maintained by the interaction of flow and vegetation. Geology, 35, 347-350.

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(picture by Willem Kolvoort)

PRODUCTIVITY