Key factors in streams 1

Limnology

Lecture 17

Erosion and Deposition

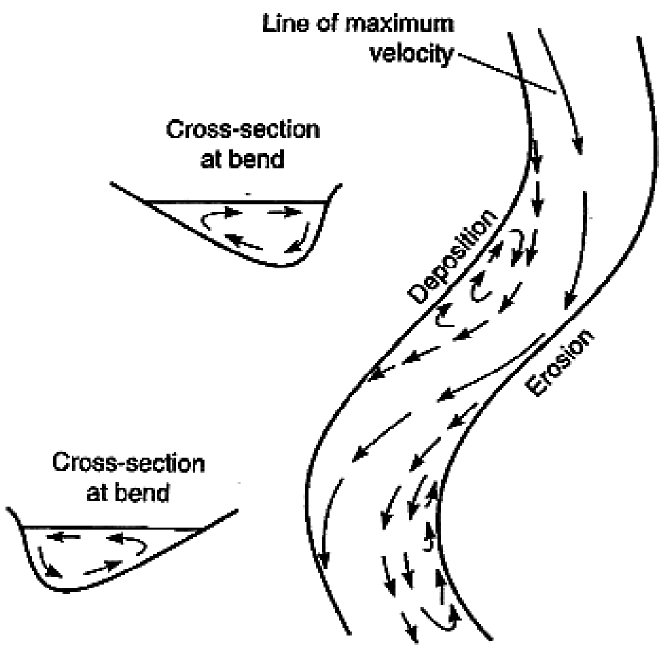
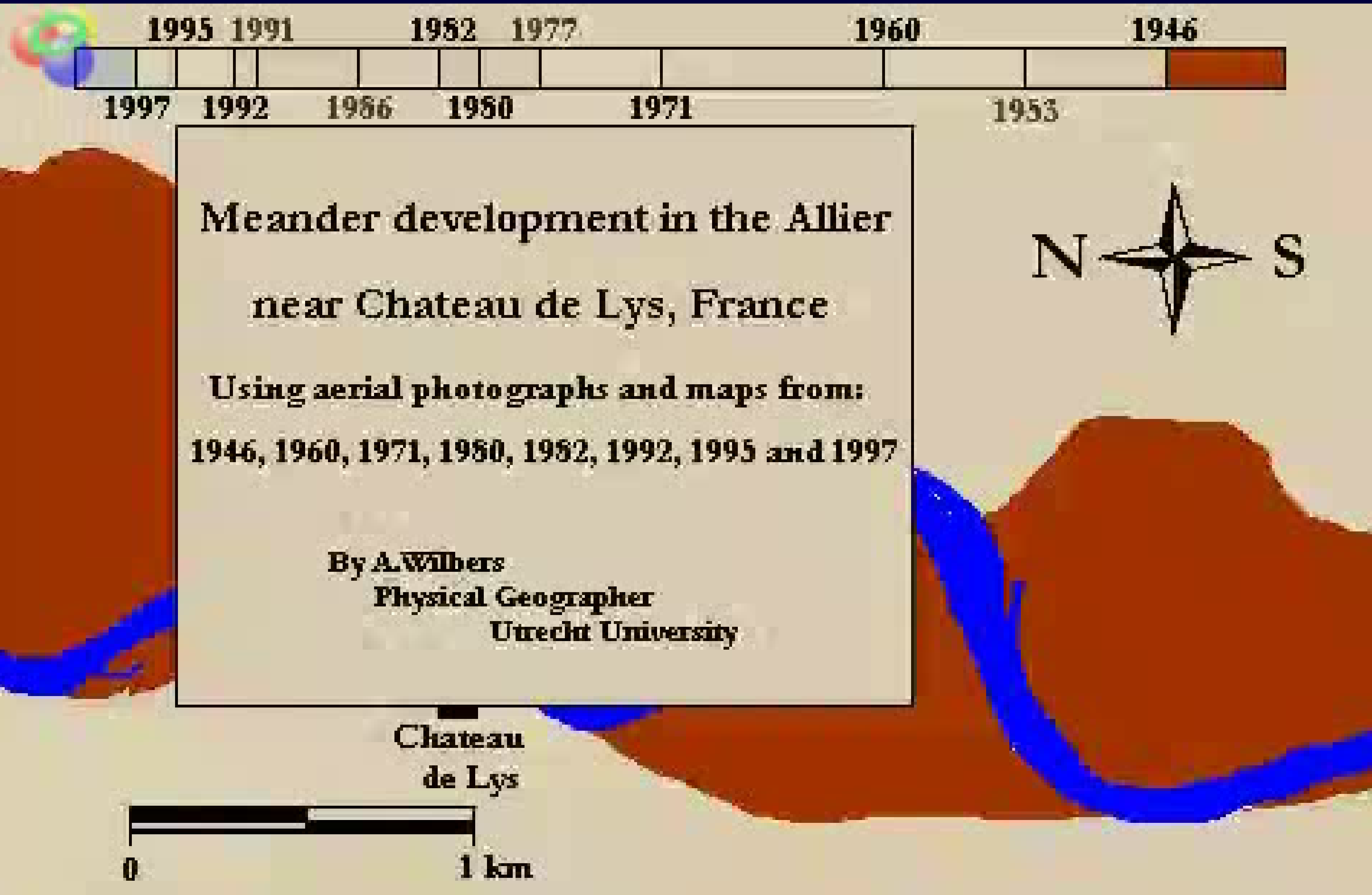


FIGURE 1.10 A meandering reach, showing the line of maximum velocity and the separation of flow that produces areas of deposition and erosion. Cross-sections show the lateral movements of water at the bends. (Redrawn from Morisawa, 1968.)


1995 1991 1982 1977 1960 1946
1997 1992 1986 1980 1971 1953
Meander development in the Allier
near Chateau de Lys, France
Using aerial photographs and maps from:
1946, 1960, 1971, 1980, 1982, 1992, 1995 and 1997
By A.Wilbers
Physical Geographer
Utrecht University
N
S
Chateau
de Lys
0
1 km


6

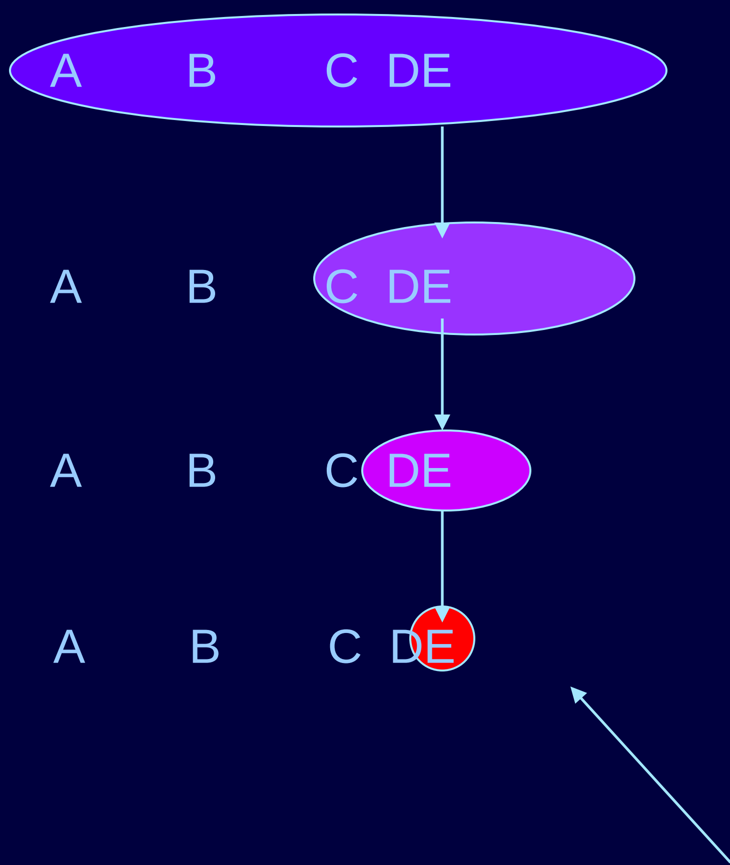
Abiotic frame = habitat templet

- Physical and chemical characteristics of an environment
- Varies in space and time
- Species differ in their abilities to live & reproduce in different abiotic environments

  “niche”

Landscape filters

Traits



Regional species pool

Dispersal

Abiotic

Biotic interactions

Poff, N. L. 1997. Landscape filters and species traits: towards mechanistic understanding and prediction in stream ecology. *JNABS*. 16(2): 391-409.

Key Factors in Lakes

- Light
- Permanence
- Temperature
- Chemistry
- Water Density

Organizing principle:
Depth gradients

→

Ecological
patterns
(e.g. the niche)

Key Factors in ~~Lakes~~ Rivers

Flow

Substrate

- ~~Light~~
- Permanence
- Temperature
- Chemistry
- ~~Water Density~~

Organizing principle:
~~Depth gradients~~

Directional flow

→ Ecological patterns (e.g. the niche)

Physical Factors: Flow

Water velocity tied to

- Substrate
- Food, nutrient and oxygen availability
- Waste product removal
- Physical force

Recall the Reynold's Number

$$Re = \frac{\text{inertial forces}}{\text{viscous forces}}$$

$$= \frac{UD}{v}$$

U = m s-1 = relative speed

D = Channel depth

v = kinematic viscosity

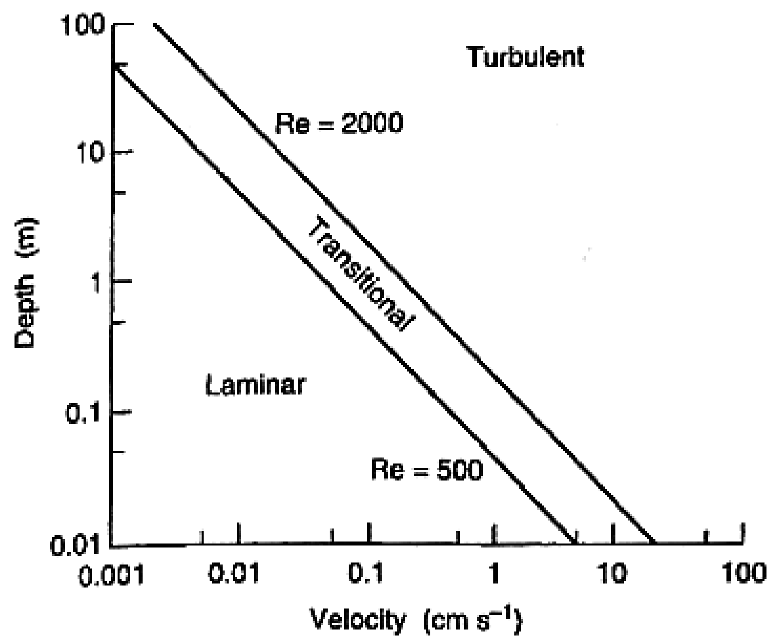


FIGURE 3.3 Reynolds number conditions for the occurrence of laminar, transitional and turbulent flow in stream channels. Note that turbulent conditions are the norm. (Redrawn from Davis and Barmuta (1989), after Smith (1975).)

From Allan 2001

Froude number

$$Fr = \frac{\text{inertial forces}}{\text{Gravitational forces}} = \frac{V}{\sqrt{gd}}$$

V = average velocity

g = gravitational acceleration

d = water depth

Measures potential for turbulent stream flow

Fr < 1 subcritical, slow and tranquil

Fr > 1 supercritical, fast, turbulent

~ water moves faster than wave

Boundary layer

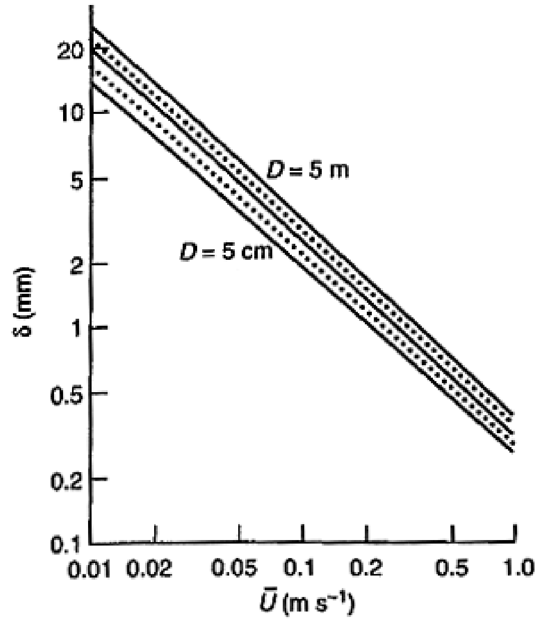


FIGURE 3.4 Depth of viscous sublayer (δ) in turbulent flow over a smooth surface. The central continuous line is for a water depth of 50 cm and the dashed lines correspond to 15 cm and 1.5 m. (From Silvester and Sleigh, 1985.)

= Viscous sublayer of low flow

Effect of friction on localized flow

Dead zones behind sediment

Boundary layer

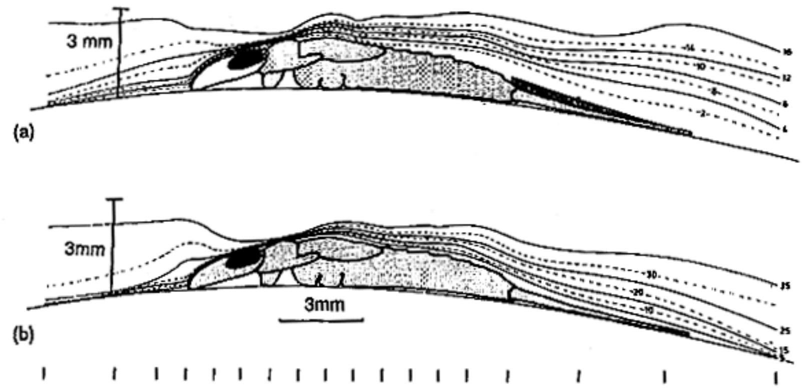
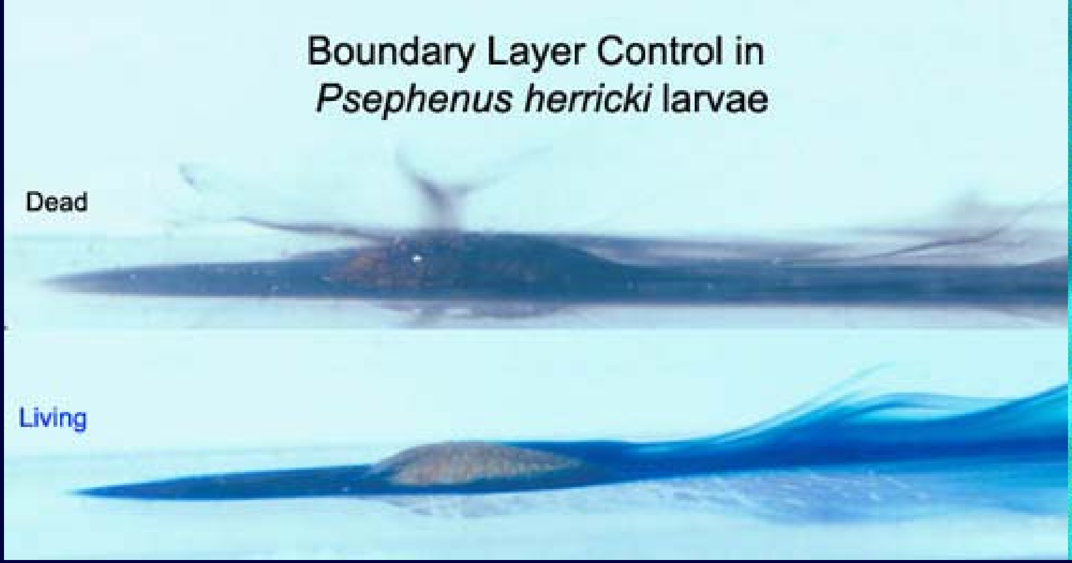
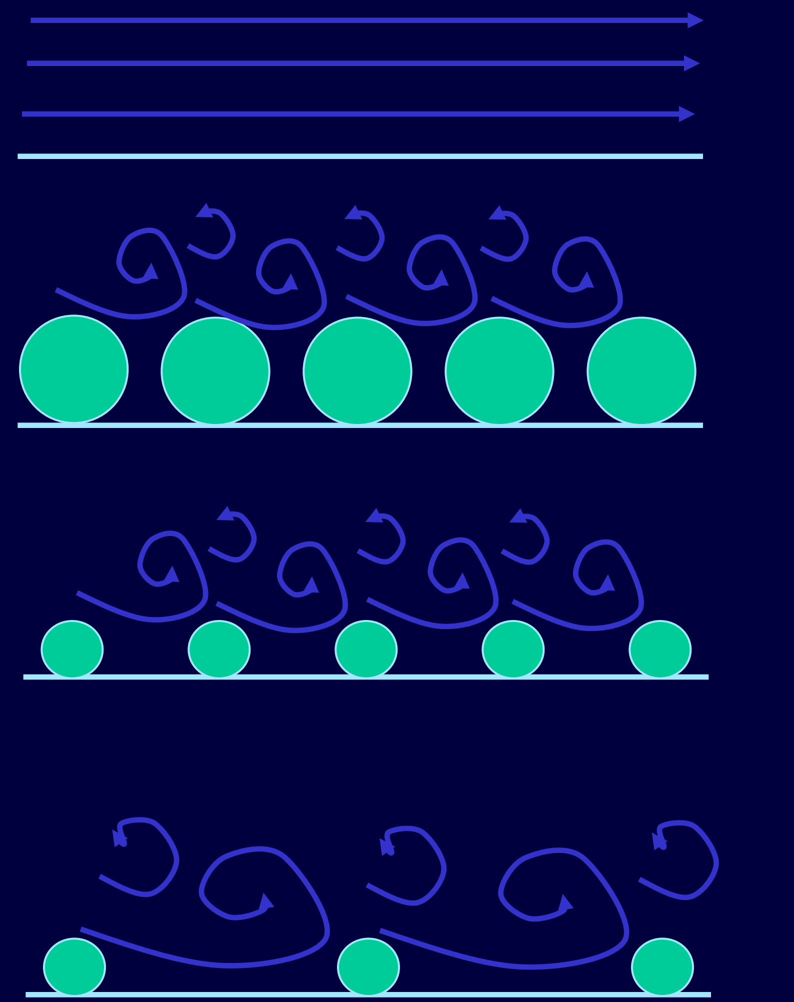


FIGURE 3.5 Lines of equal flow (iso-vels) around a dead mayfly nymph glued to a surface in a laboratory flume, measured using a flow visualization technique. Note that all iso-vels are compressed over the mayfly's dorsal surface. (a) Maximum velocity 16 cm s^{-1}, (b) 32 cm s^{-1}. (After Statzner and Holm, 1982.)



Substrate also affects turbulence

(and vice-versa)



1. Size of particles

2. Spacing of particles

Adaptations to flow

Sculpin

Bluegill

Salmon

Adaptations to flow

Black fly larvae

Zebra mussel

Stonefly

Adaptations to flow

Periphyton = attached algae

Not much phytoplankton

Rooted macrophytes

Human effects on flow

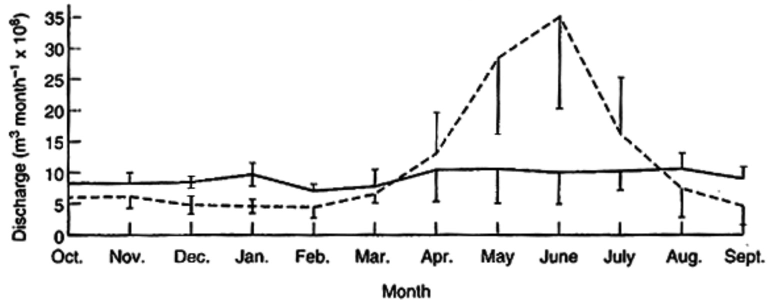


FIGURE 14.2 Monthly means and ranges of discharge in the Colorado River at Lees Ferry before (1944–1962; ----) and after (1963–1977; ——) impoundment of Lake Powell. (From Paulson and Baker, 1981.)

Glen Canyon Dam

Lake effect on streams

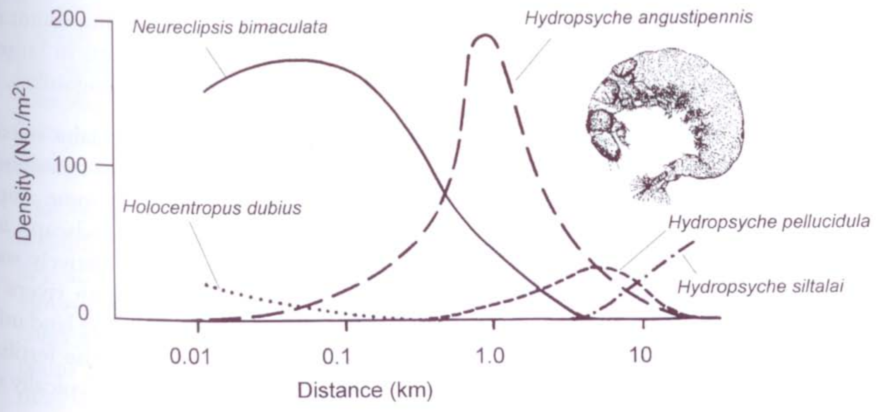
Changes in suspended particles

Rapid change in community composition

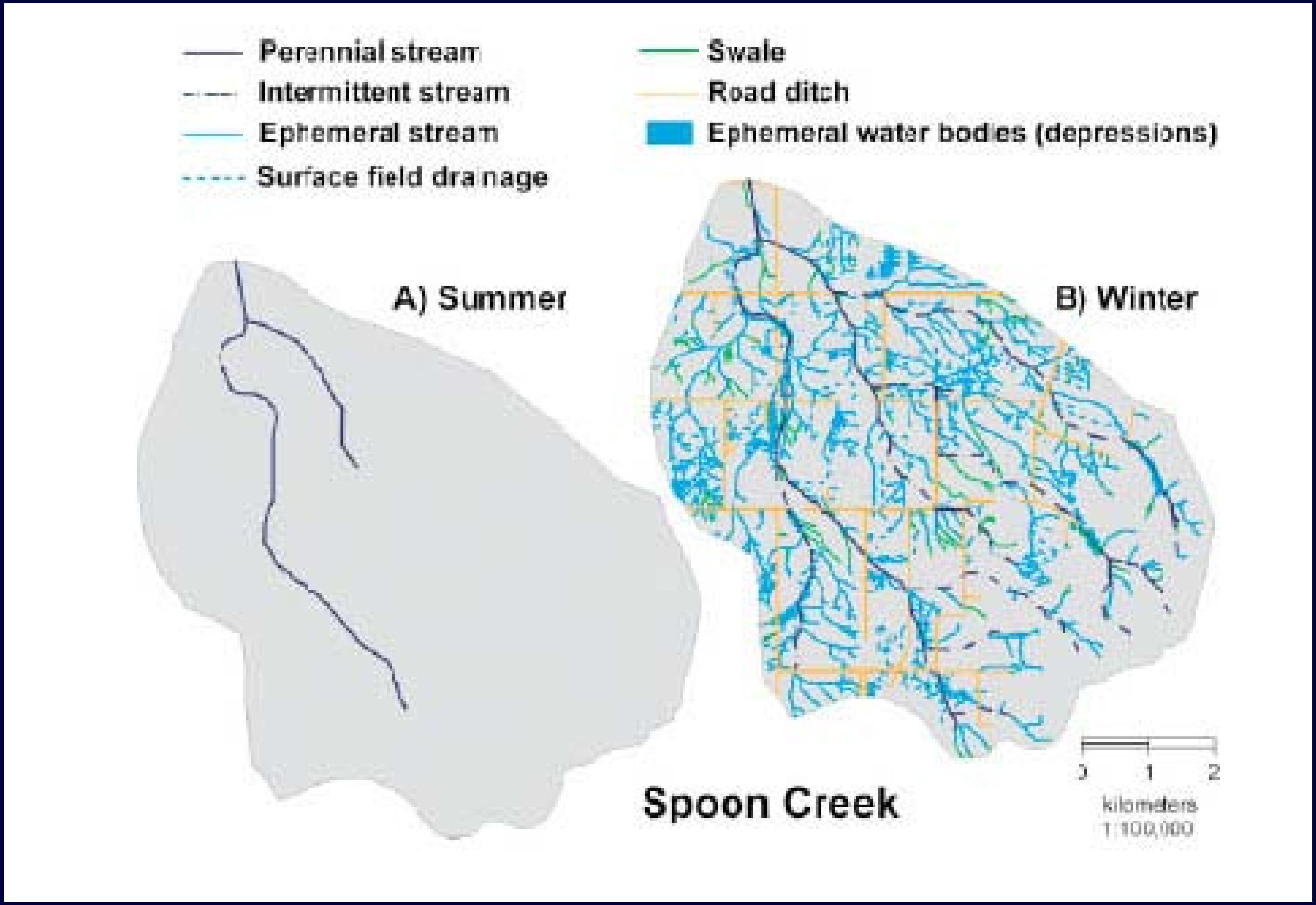
Near-lake communities:

- high biomass
- high competition

Fig. 2.4 Downstream succession of five species of net-spinning caddis larvae in a Swedish lake-outlet stream. (Redrawn from Brönmark and Malmqvist, 1984.)



Permanence: perennial vs. intermittent



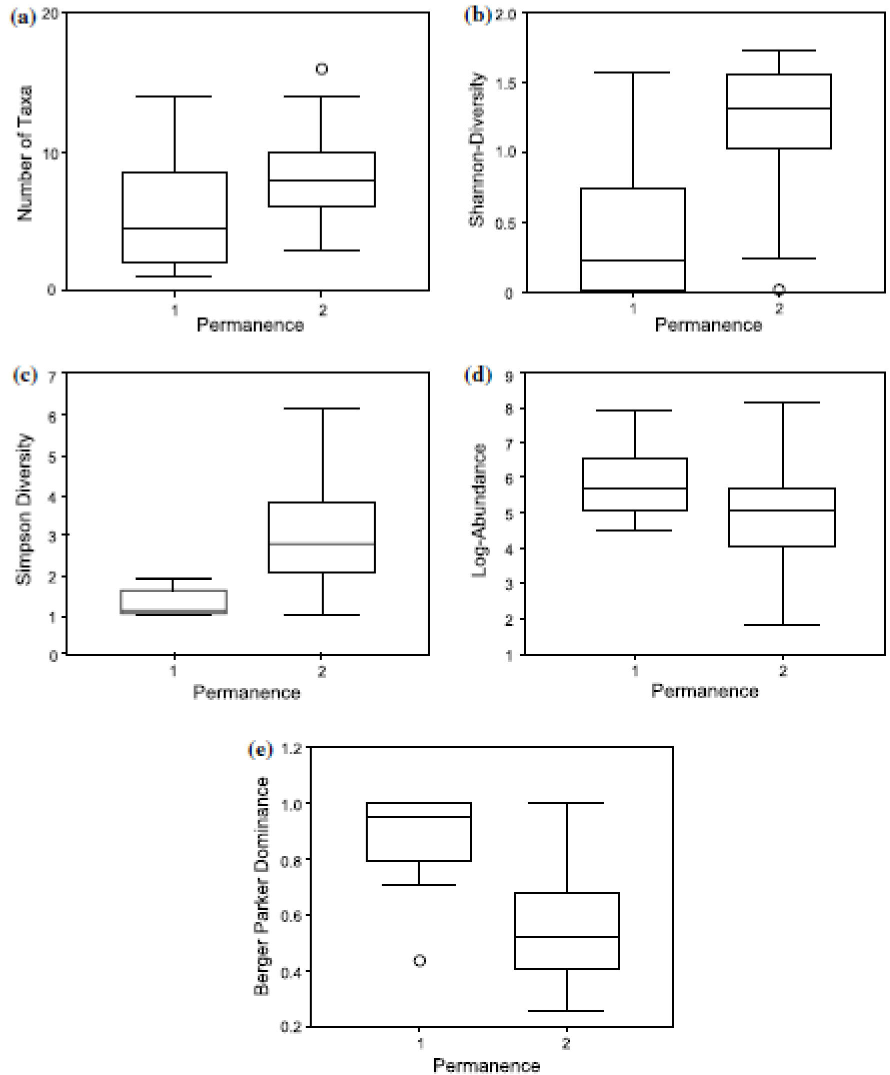
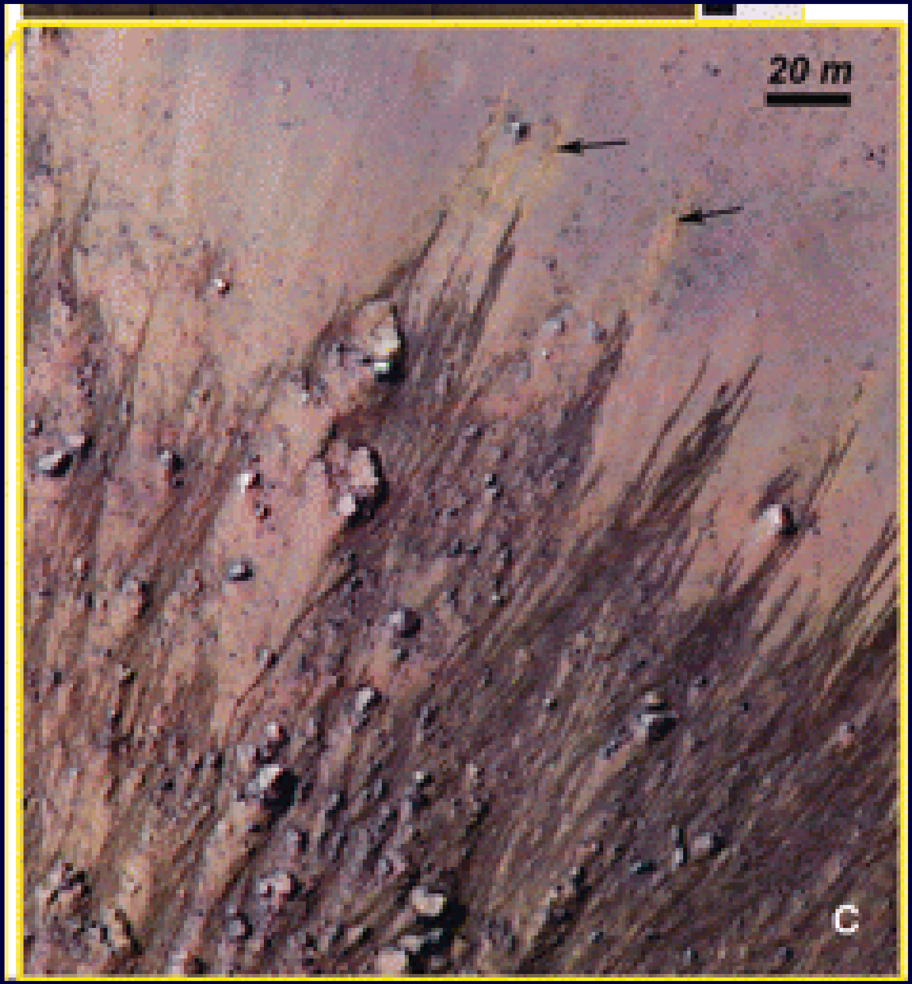
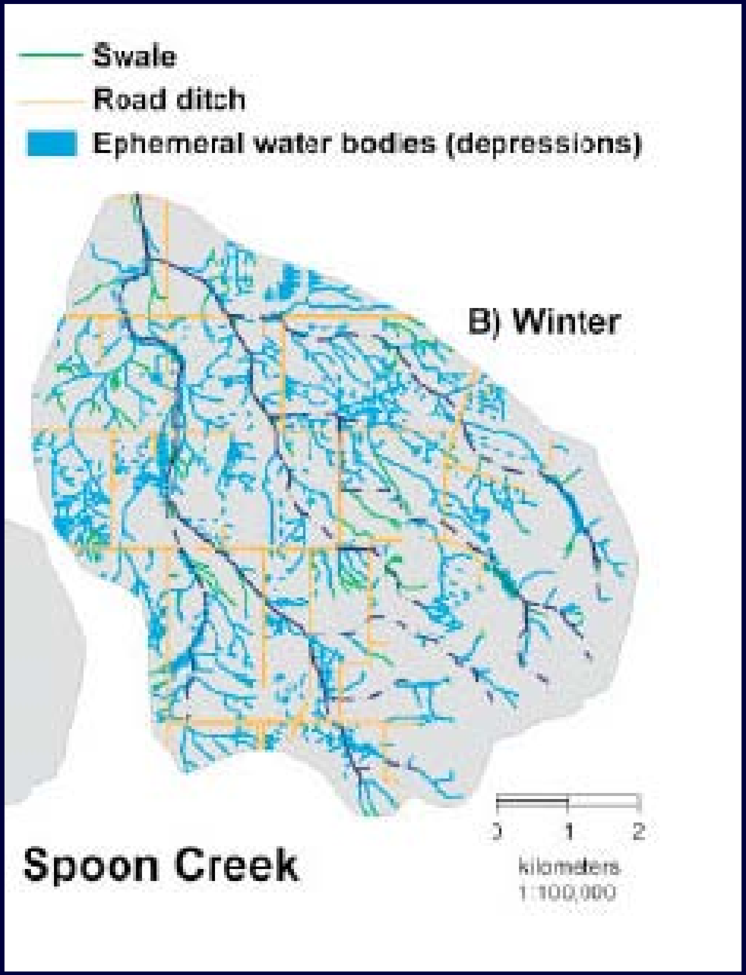


Figure 3. Box-plots of significantly different invertebrate community indices for intermittent and perennial springs ($n = 42$) from the White Peak at intermediate discharge: (a) number of taxa; (b) Shannon diversity index; (c) Simpson diversity index; (d) Log-abundance; and (e) Berger– Parker dominance index. 1 = intermittent springs; 2 = perennial springs; and O = outliers.

Wood et al. 2005


20 m
C


Swale
Road ditch
Ephemeral water bodies (depressions)
B) Winter
Spoon Creek
0 1 2
kilometers
1:100,000

Key Factors in Rivers

- Flow
- Permanence
- Substrate
- Temperature
- Chemistry

Organizing principle:
Directional flow

→

Ecological
patterns
(e.g. the niche)

Substrate

Size distribution determines

Resilience to flow
disturbance freq.

Flow characteristics
e.g., riffle vs. run

Habitat
directly
indirectly thru chem.

Organic substrate

Large woody debris
Coarse particulate organic material (CPOM) > 1 mm
Fine particulate organic matter (FPOM)
Dissolved organic matter (DOM)

Creating dam and scour pools

Providing habitat

Substrate

Mean substrate decreases as you move downstream

Why ?