

Vybrané kapitoly z říční ekologie

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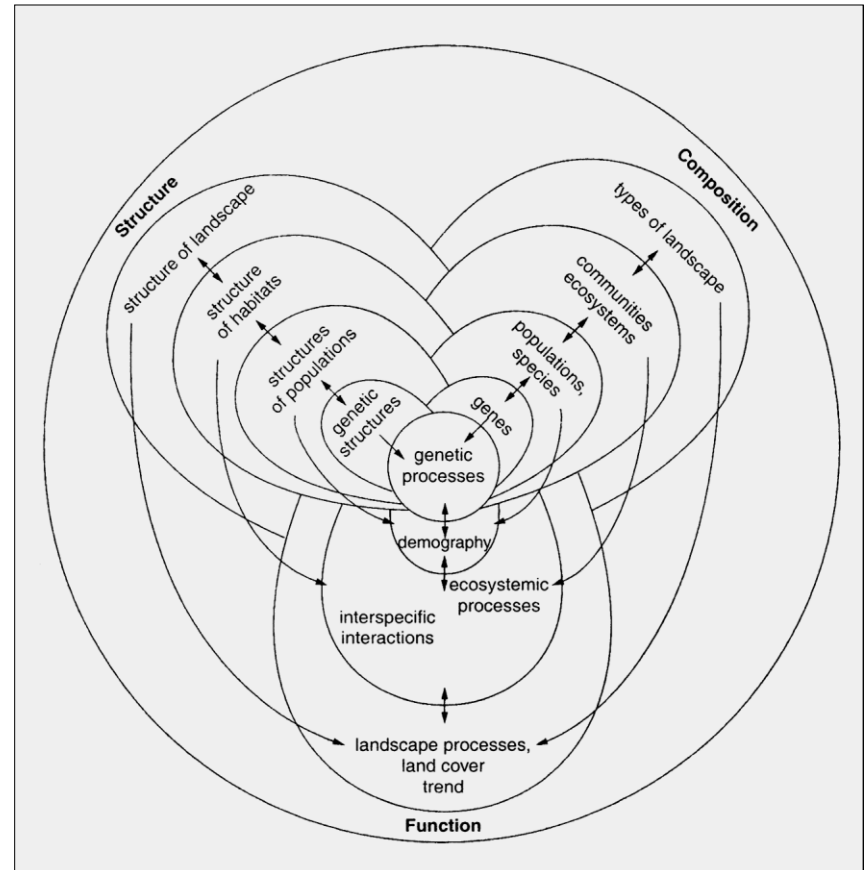
Náplň kurzu - Helešic

- Teorie a hypotézy popisující říční systémy
- Tropické toky
- Velké řeky – ekologie a biologie

Biodiverzita

- Obecně lze diverzitu popsat jako „počet rozdílných prvků a jejich relativní frekvenci“.
- „Biologická diverzita informuje o variantách a variabilitě mezi živými organismy a ekologickými komplexy, ve kterých je možno ji nalézt. Pro biodiverzitu tedy platí, že jednotlivé prvky, o nichž je řeč, jsou organizovány na mnoha úrovních, počínaje komplexními ekosystémy a konče chemickými strukturami, které tvoří molekulární bázi dědičnosti. (Definice dle Úřadu Kongresu USA pro technologický výzkum, 1987)

Vztah mezi strukturou, hierarchickým uspořádáním a funkcí v daném ekologickém systému. Podle Noss (1990), převzato z Burel and Baundry (2003).



Říční ekosystémy a jejich klasifikace

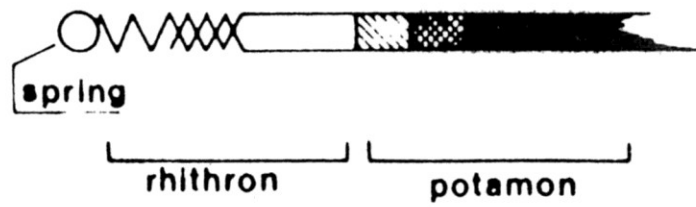
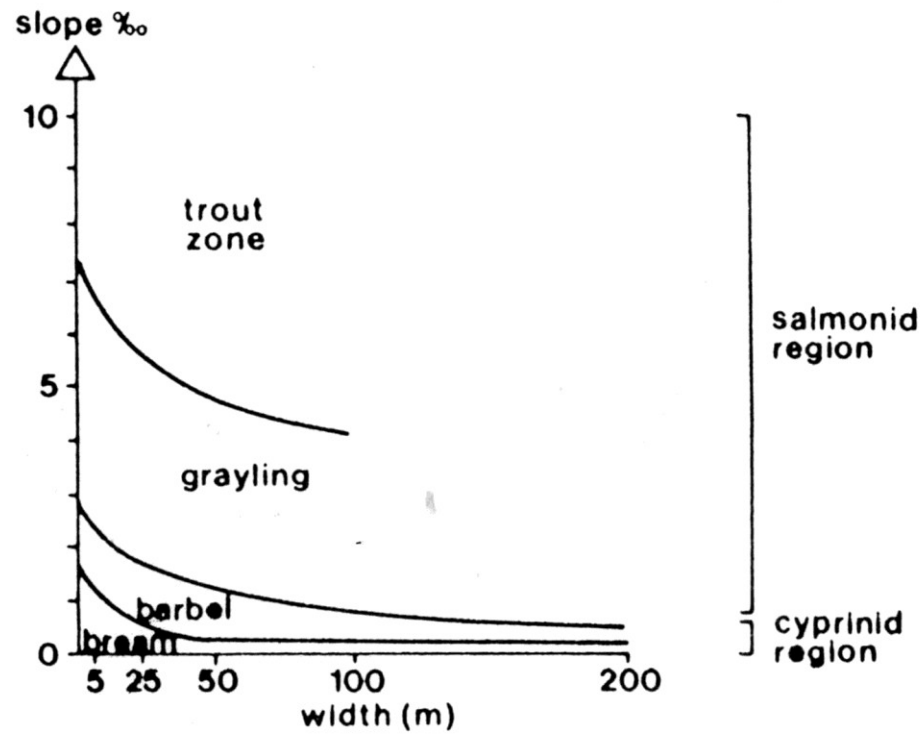
- **Zonačně-prostorový koncept**
- **Prostorově klinální koncept**
- **Časový koncept**
- **Časově prostorový koncept**

- **Zonační teorie (Zonation Concept)**
- **Teorie říčního kontinua (River Continuum Concept (RCC))**
- **Stream hydraulic concept**
- **“Spirální” teorie (Resource Spiralling Concept) (RSC)**
- **Serial Discontinuity Concept (RDC)**
- **Teorie povodňového pulsu (Flood Puls Concept) (FPC)**
- **Riverine Productivity Model (RPM)**
- **Teorie povodí (Catchment Concept)**

Zonačně-prostorový koncept

- Zonační schéma
 - Rybí pásma
 - Frič (1872), Hawkes (1975)
 - Organismy
 - Thienemann (1921) dle pakomárů
 - Zelinka (1953) dle jepic
 - Organismy a podmínky
 - Ilies (1961), Ilies & Botosaneanu (1963)

	ILLIES a BOTOSANEANU 1963	FRIČ 1872 (doplňeno)	Zóny jepic (ZELINKA 1953)	Fyziografické členění	Průměrný spád v promile	Maximální teploty vody ve °C
KRENON	Eukrenon	Pramen	-	Pramen	-	-
	Hypokrenon	Pramenná stružka	Ameletová	Stružka	nad 3 (ale i méně)	do 14
RHITHRON	Epirhithron	Pstruhový potok	Rhithrogenová	Bystřina	nad 3 (blíže k pra- mení i méně)	do 16
	Metarhithron	Pstruhová říčka	Ecdyonurová	Potok	do 3	do 18 (20)
	Hyporhitron	Lipanové pásmo	Ecdyonurová	Říčka	1,5 - 3,0	do 20 (22)
POTAMON	Epipotamon	Parmové pásmo	Oligoneuriello- vá	Řeka	0,8 - 1,5	do 25 (27)
	Metapotamon	Cejnové pásmo	Ephoronová	Veletok	do 0,8	až 28
	Hypopotamon	Pásmo vody brakické	-	-	-	-



Prostorově – klinální koncept

- Struktura společenstva
 - Objektivní klasifikace a ordinace (Townsend 1983)
 - Po proudový vývoj související s teplotou vody, hydraulikou atd. (Vannote & Sweeney 1980; Statzner & Higl 1986

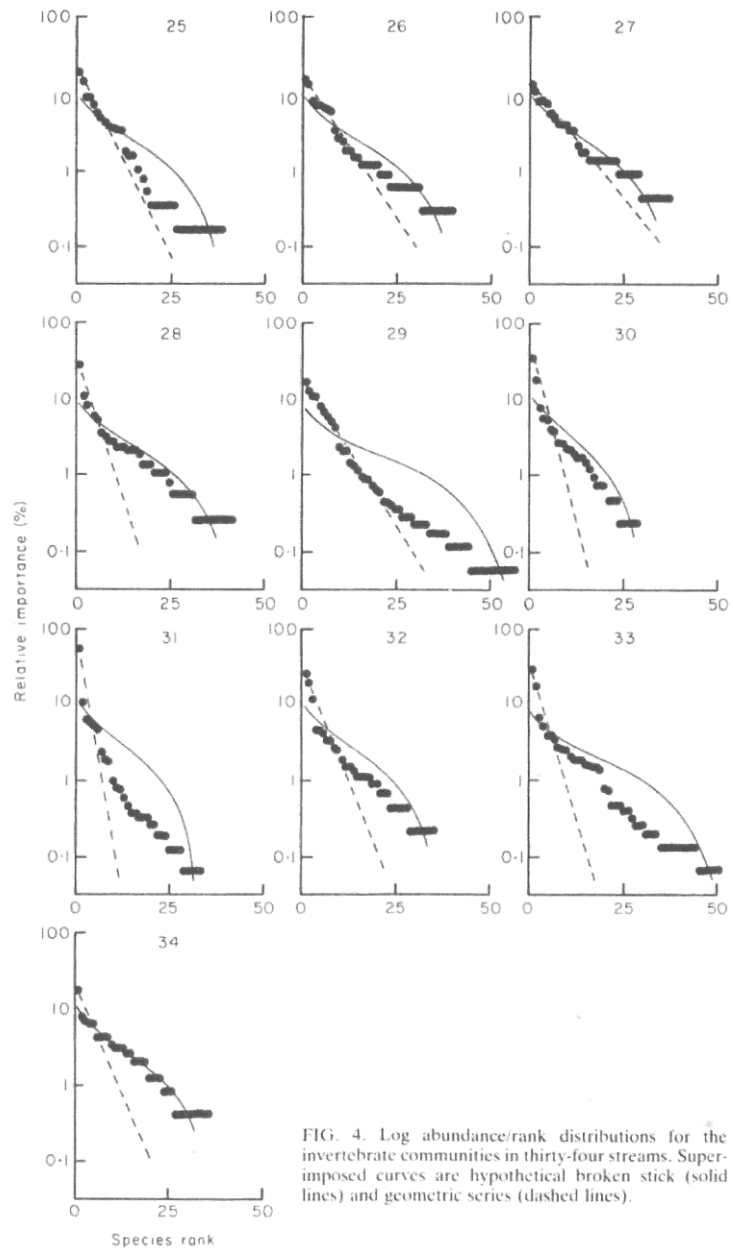


FIG. 4. Log abundance/rank distributions for the invertebrate communities in thirty-four streams. Superimposed curves are hypothetical broken stick (solid lines) and geometric series (dashed lines).

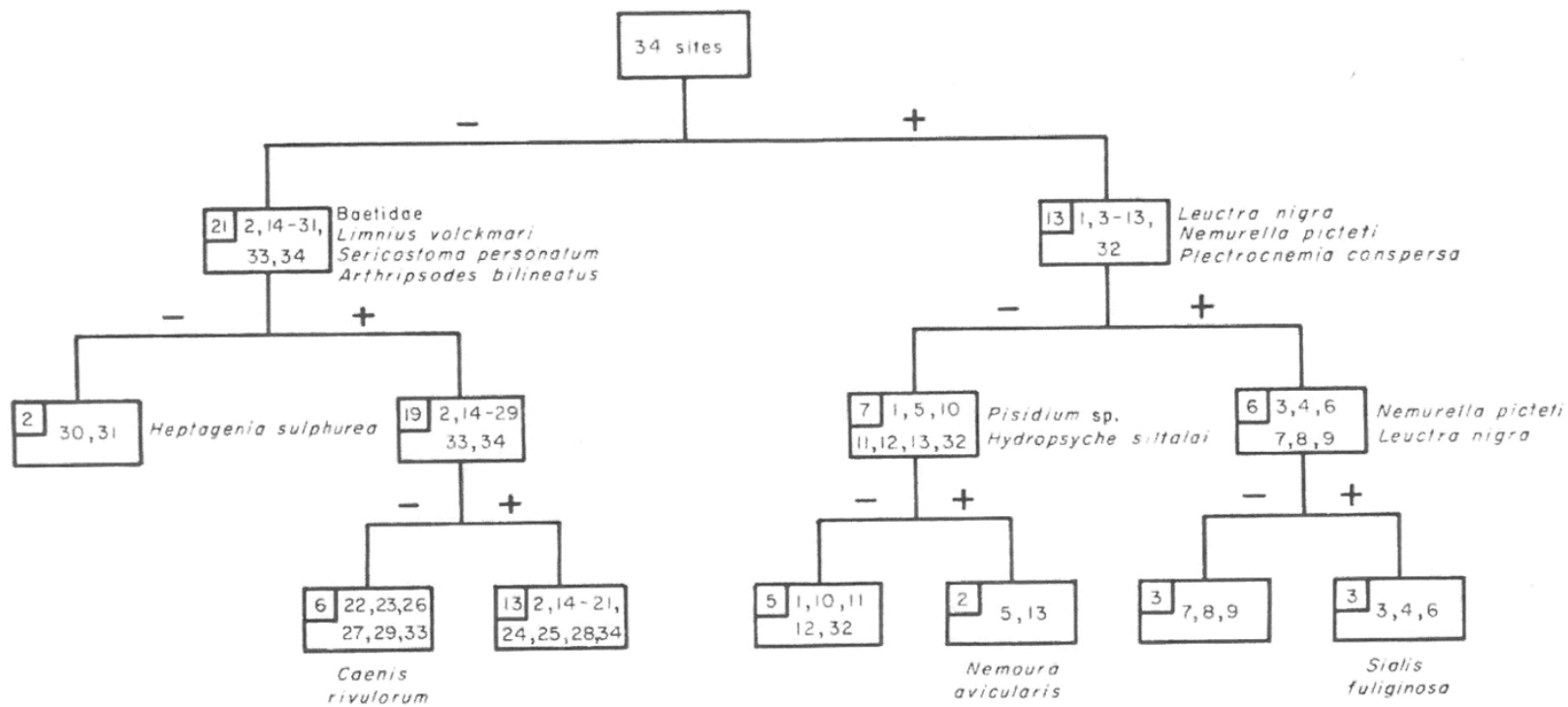
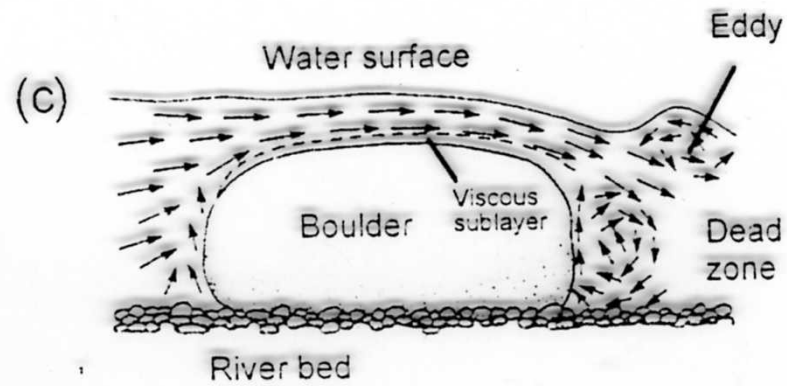
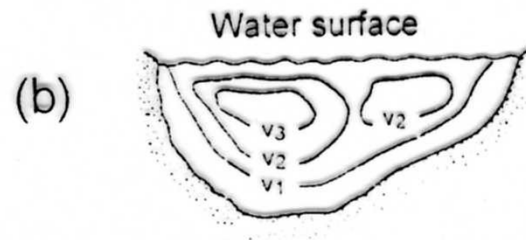
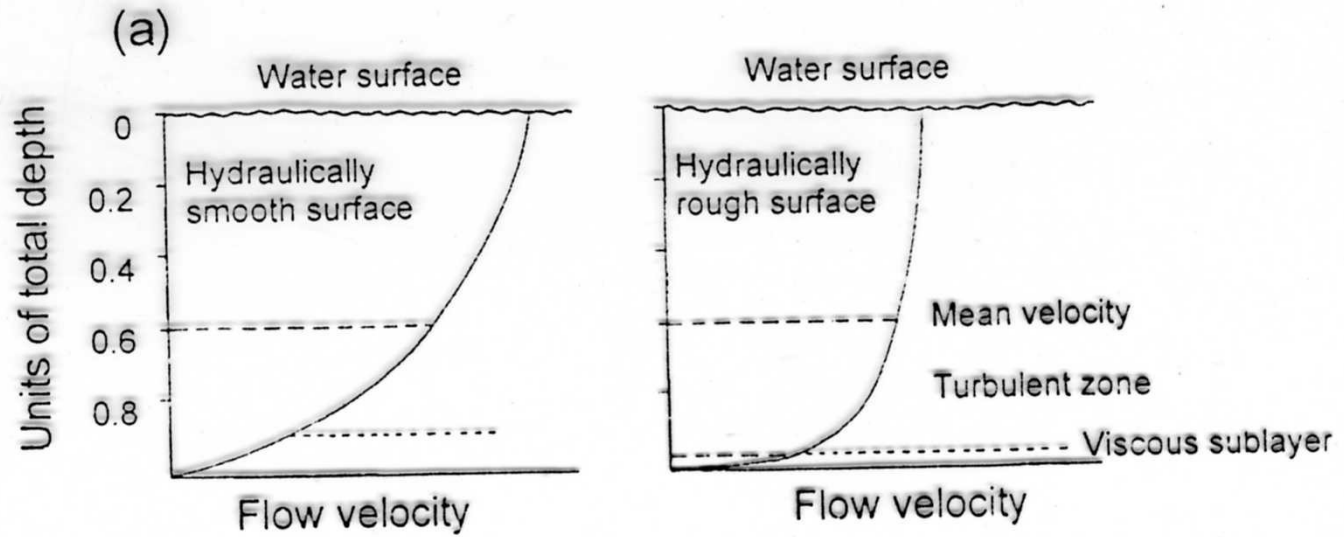


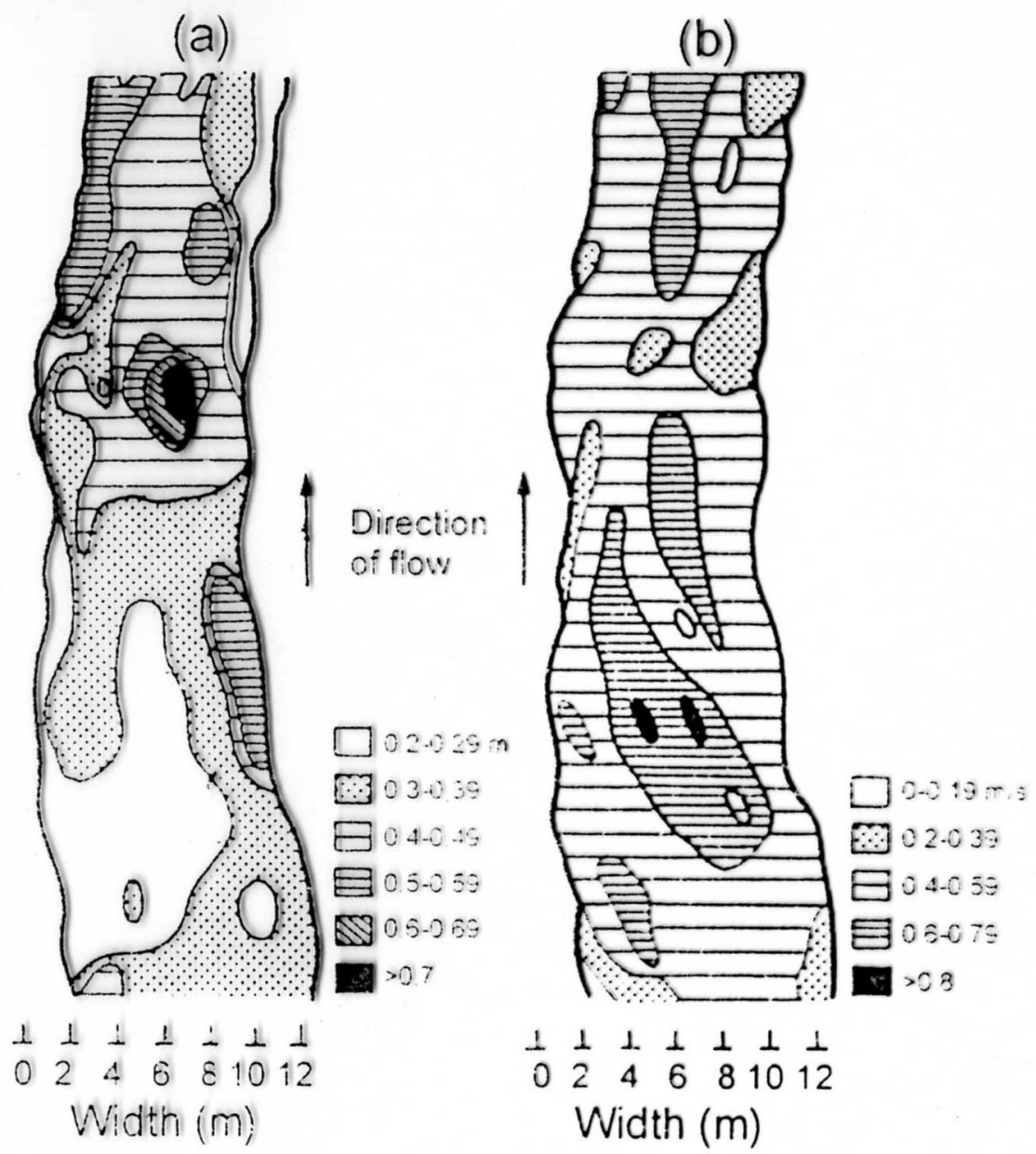
FIG. 6. Classification of thirty-four stream communities as revealed by indicator species analysis. The technique progressively divides the set of communities into smaller sub-sets according to the closeness of similarity in species composition. At each division, 'indicator' species are shown.

Physical factors of importance to the biota

TABLE 3.2 Some terms and equations useful in describing streamflow (Adapted from Davis and Barmuta, 1989; and Carling, 1992)

Terms			
\bar{U}	Mean velocity		Measured at 0.6 depth from surface or from velocity profile
U_*	Shear velocity		Estimated from fine-scale velocity <i>versus</i> log depth profile at nearbed depths
D	Water depth		Total depth, surface to bottom
k	Height of surface roughness elements		Difficult to quantify; methods described in text
ν	Kinematic viscosity		$1.004 \times 10^{-6} \text{ m}^2 \text{ s}^{-1}$ at 20°C
g	Acceleration due to gravity		$9.8 \text{ m}^2 \text{ s}^{-1}$
Equations			
Re	Bulk flow Reynolds number		
	$Re = \bar{U}D/\nu$	$Re < 500$ $500 < Re < 10^3 - 10^4$ $Re > 10^3 - 10^4$	\Rightarrow laminar flow \Rightarrow transitional flow \Rightarrow turbulent flow
Fr	Froude number		
	$Fr = \bar{U}/\sqrt{gD}$	$Fr < 1$ $Fr = 1$ $Fr > 1$	\Rightarrow sub-critical flow \Rightarrow critical flow \Rightarrow super-critical flow
D/k	Relative roughness		Height of roughness elements relative to water depth; influences flow type
Re_*	Roughness Reynolds number		Describes flow near streambed
	$Re_* = U_*k/\nu$	$Re_* < 5$ $5 < Re_* < 70$ $Re_* > 70$	\Rightarrow hydraulically smooth flow \Rightarrow transitional flow \Rightarrow hydraulically rough flow
δ	Thickness of laminar sublayer		Describes region of viscous flow
	$\delta = 11.5\nu/U_*$	$\delta/k < 1$ $\delta/k > 1$	\Rightarrow hydraulically smooth flow \Rightarrow hydraulically rough flow





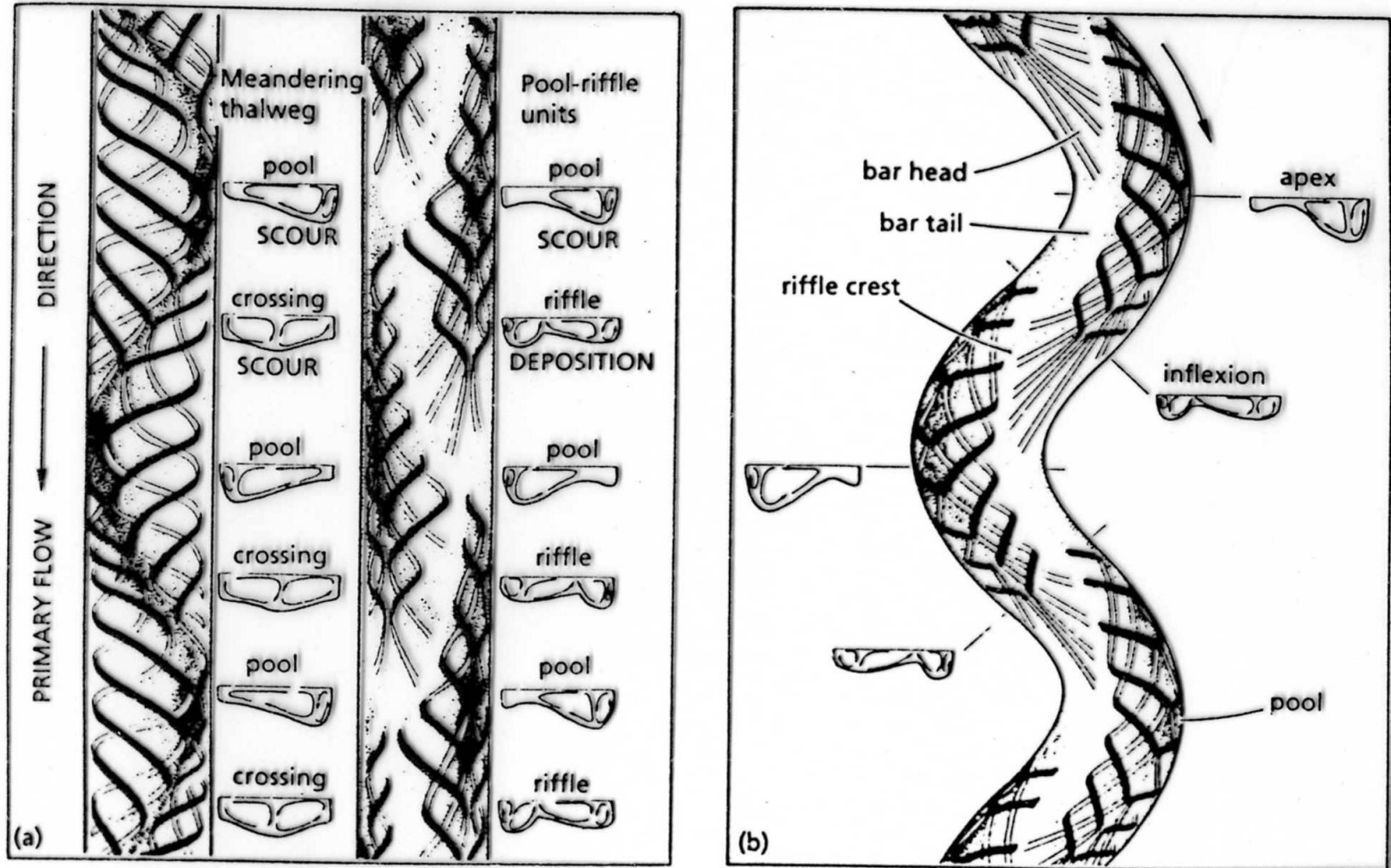
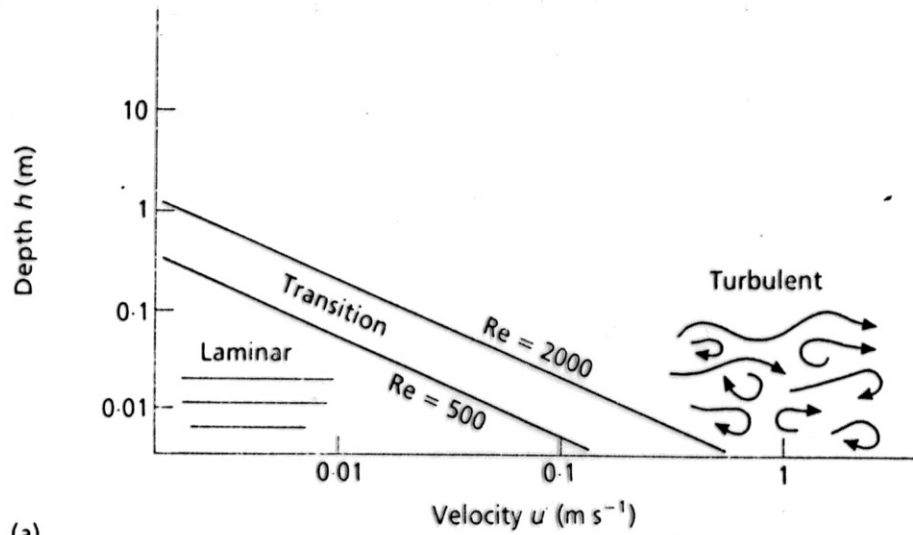
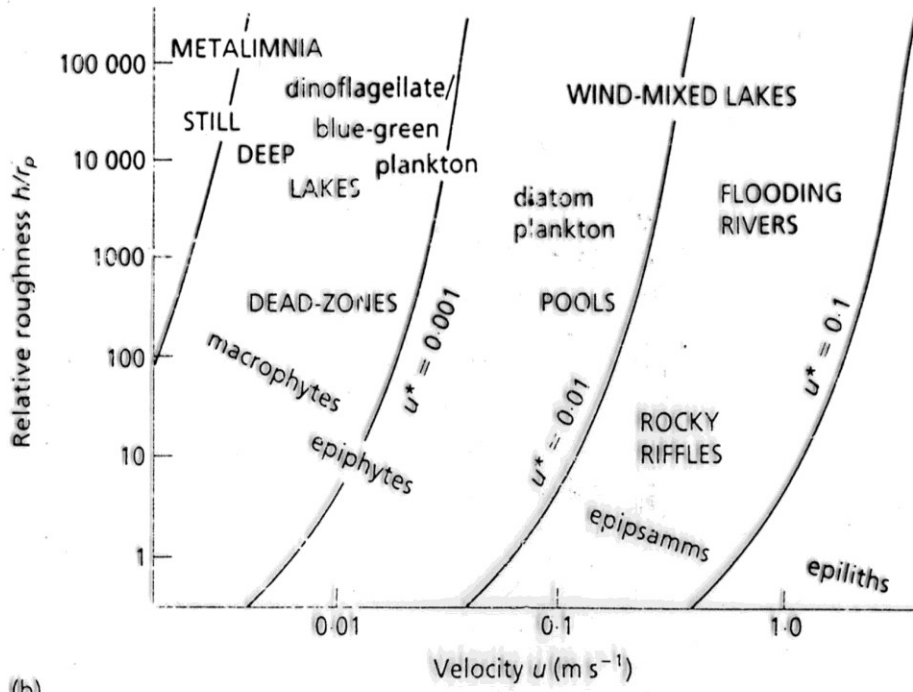


FIGURE 7-5 Models of flow structure in (a) straight and (b) meandering channels. (From Carling, 1992, after Thompson, 1986. Secondary flows and the poolriffle unit: a case study of the processes of meander development. *Earth Surface Processes and Landforms* 11:631-641, © John Wiley & Sons Limited. Reproduced



(a)



(b)

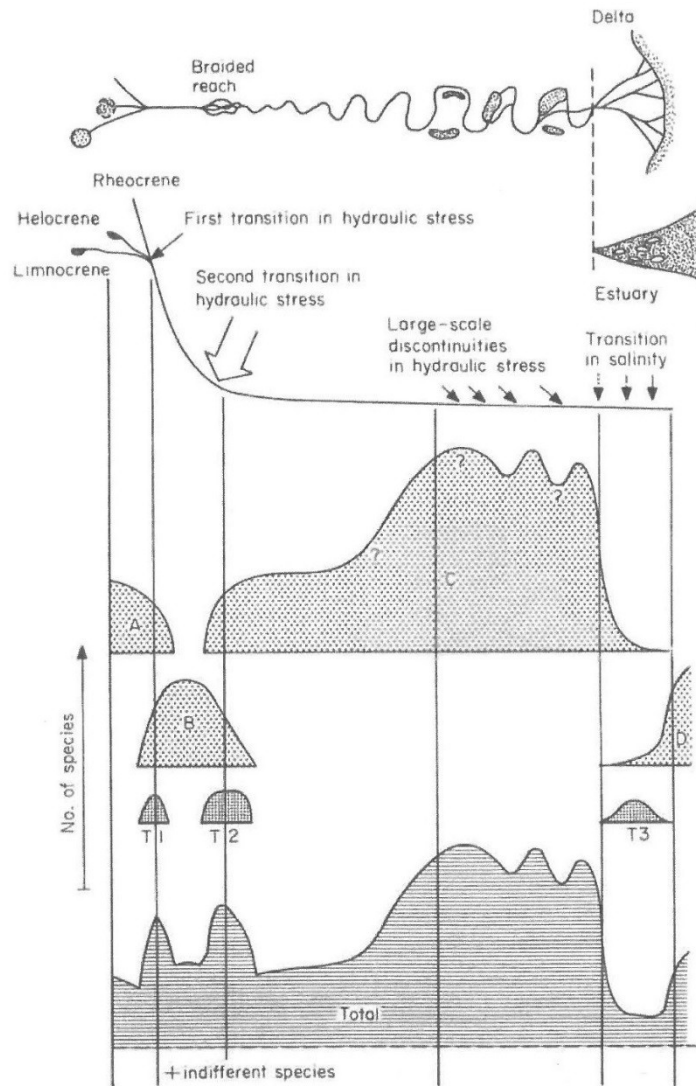
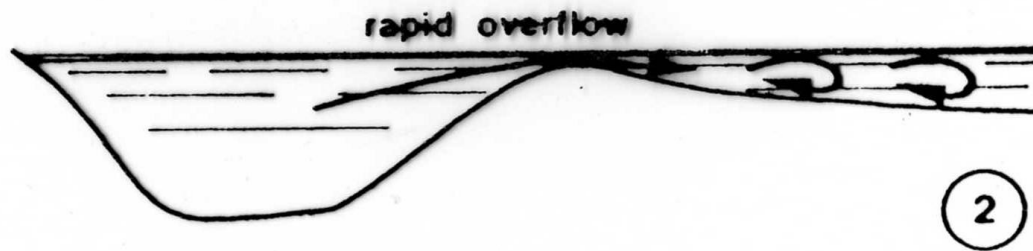
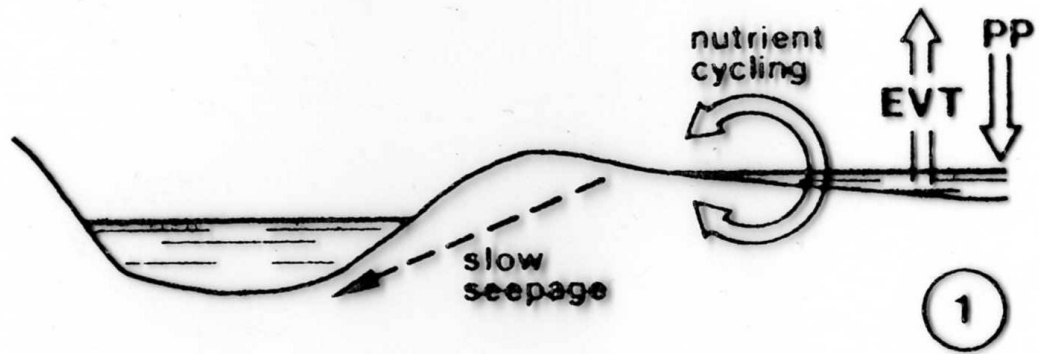
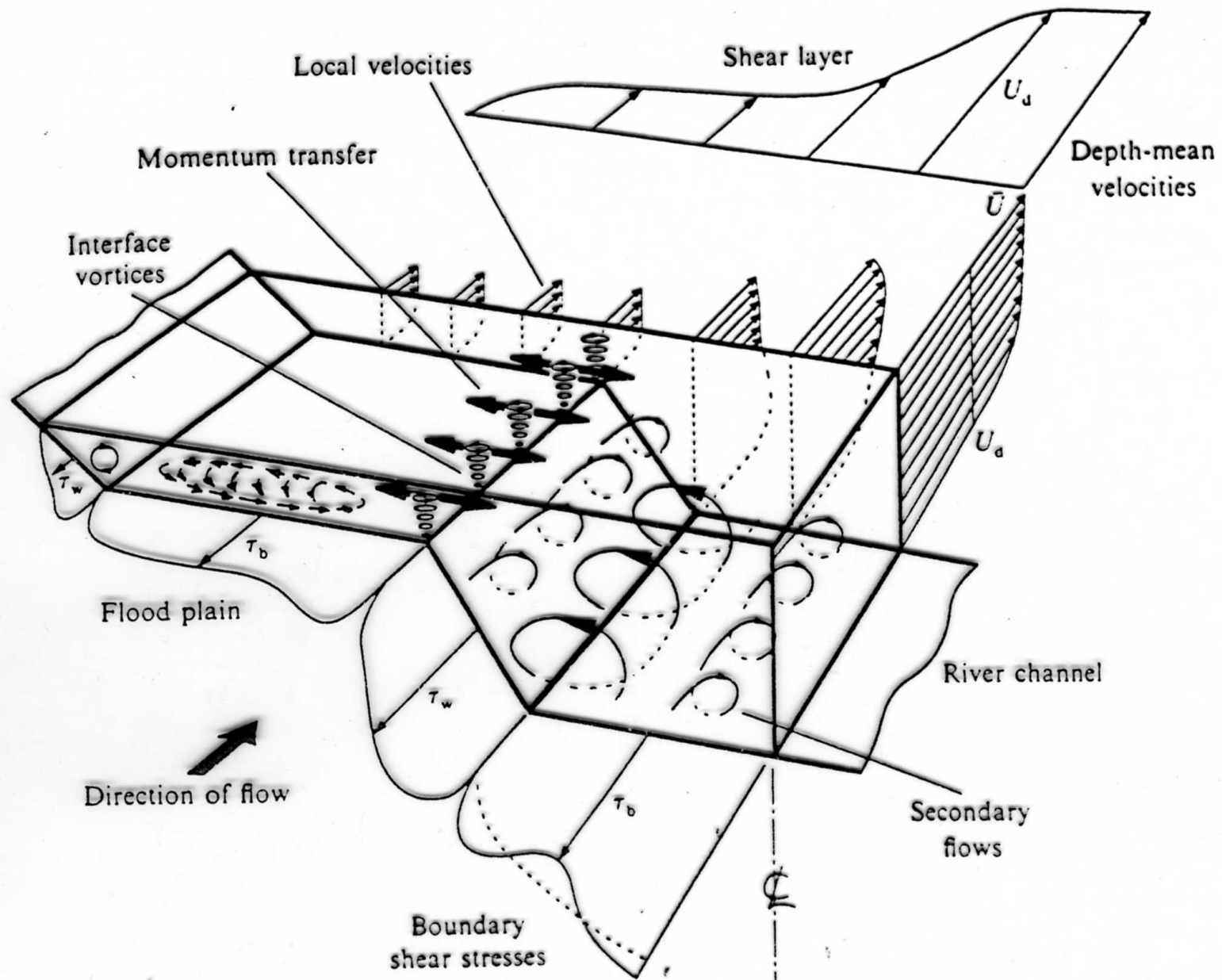


FIG. 8. Proposal for a general faunistic zonation pattern of the benthos in pristine streams (aerial view and slope) with 'standard' flow characteristics. Source types: rheocrene—source discharges directly into a channel; helocrene: source discharges into a marshy pond; limnocrene—source discharges into a pond. Not all of the components shown here can be or must be present in a stream. The species distribution in a running water that starts with a helocrene and ends with an estuary is indicated in our example. Species occurring in the spring (A) and in the reach of high slope (B) overlap at the first transition in hydraulic stress. Species of group B and species occurring in the stream after it has entered the flood-plain (C) overlap at the second transition in hydraulic stress, where pristine streams are frequently braided. Patterns in the large river are rather speculative due to sparse information. In the brackish zone a third overlap is found between species of group C and the marine fauna (D). In all three zones of species overlap few species occur which are solely found in these reaches of transition (T1, T2, T3). Species which do not characterize a zone are omitted.

Prostorově – klinální koncept

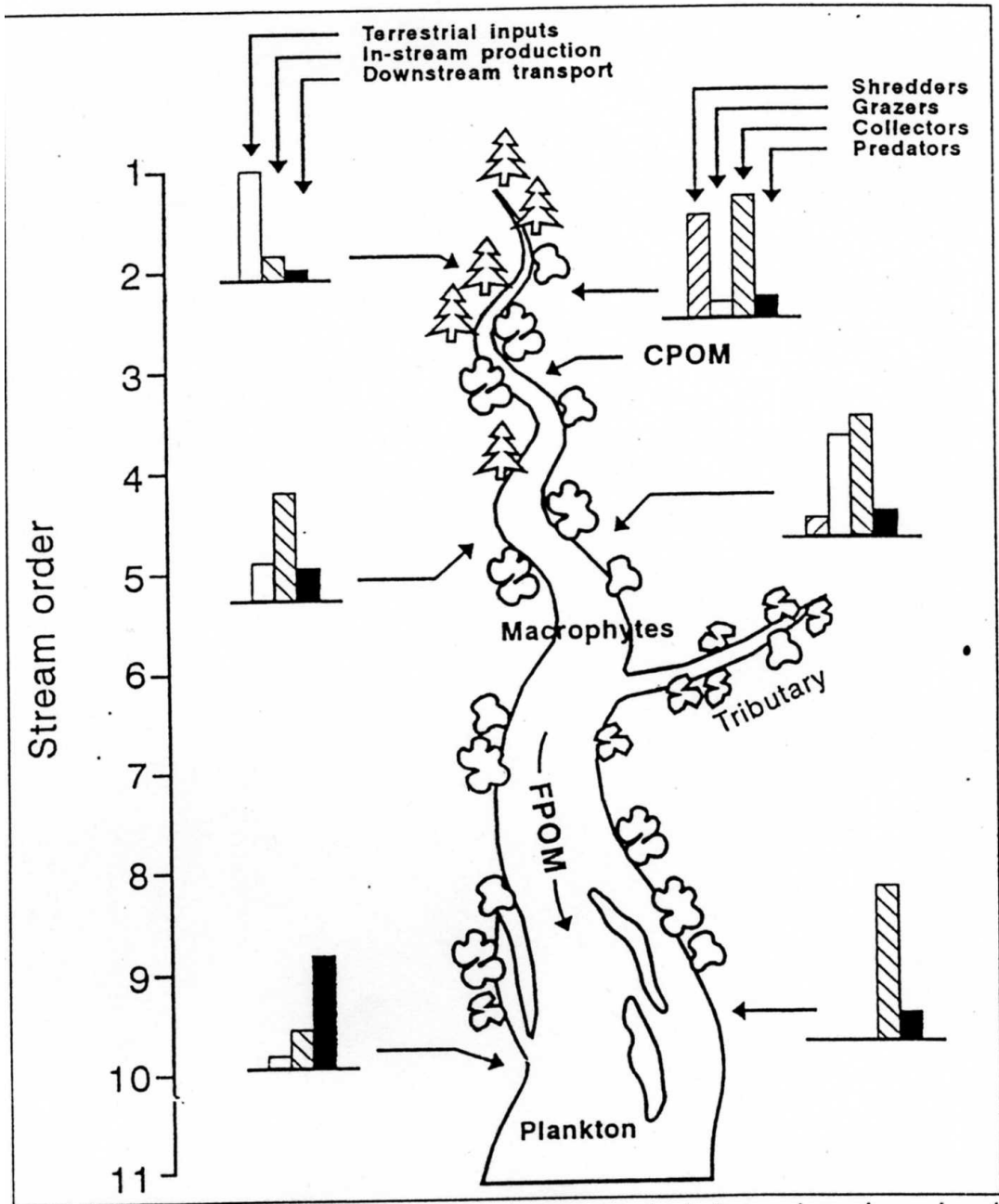
- Laterální (boční) propojení (komunikace)
 - Koloběh materiálu (hmoty) v systému břeh / koryto a záplavové území (niva)/koryto (Sedell et al. 1990; Wetzel & Ward 1992)





Prostorově – klinální koncept

- Podélné propojení (komunikace) toku
 - Proti/poroudový koloběh hmoty a organismů (Vannote et al 1980, Newbold 1992)



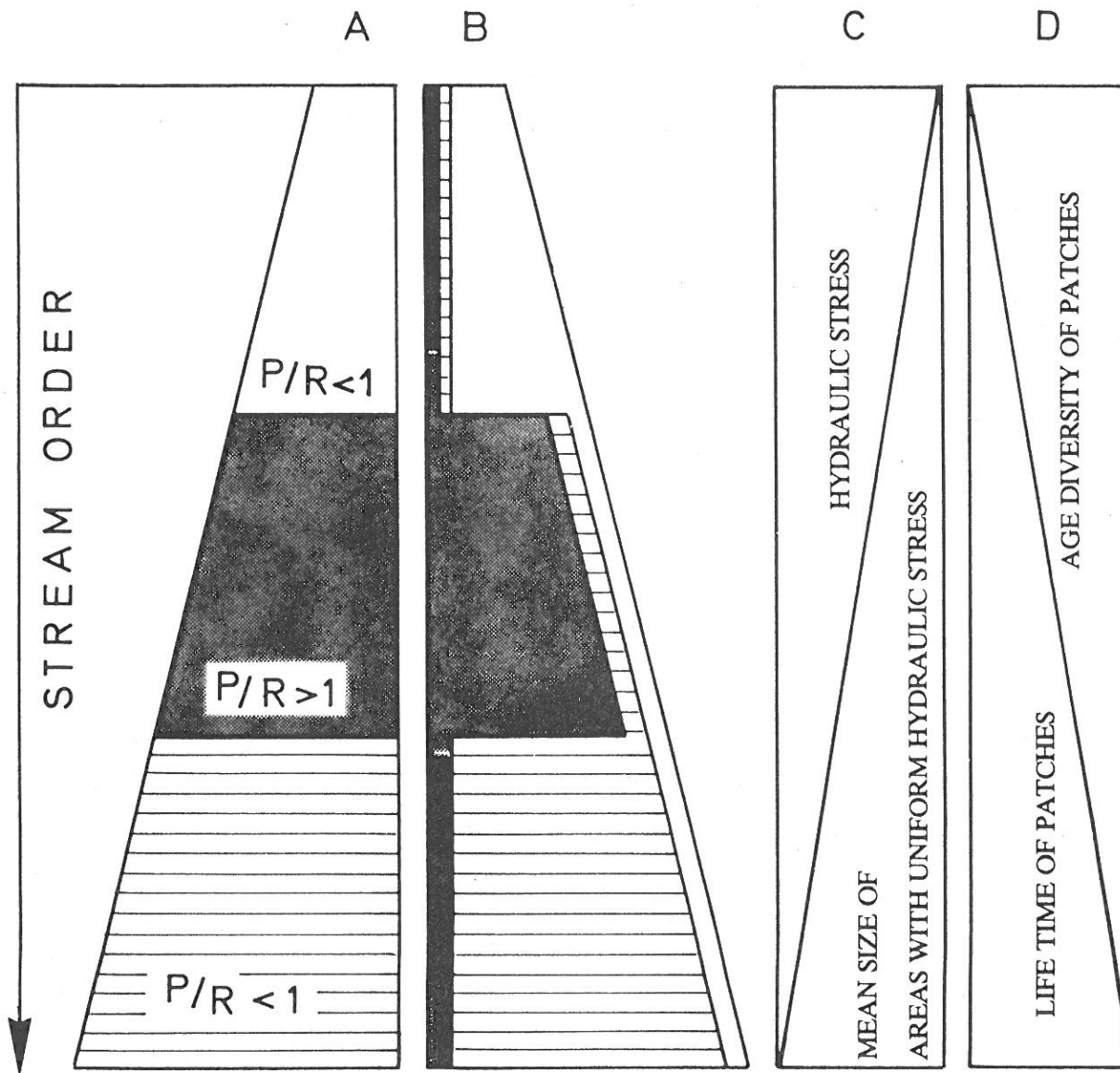
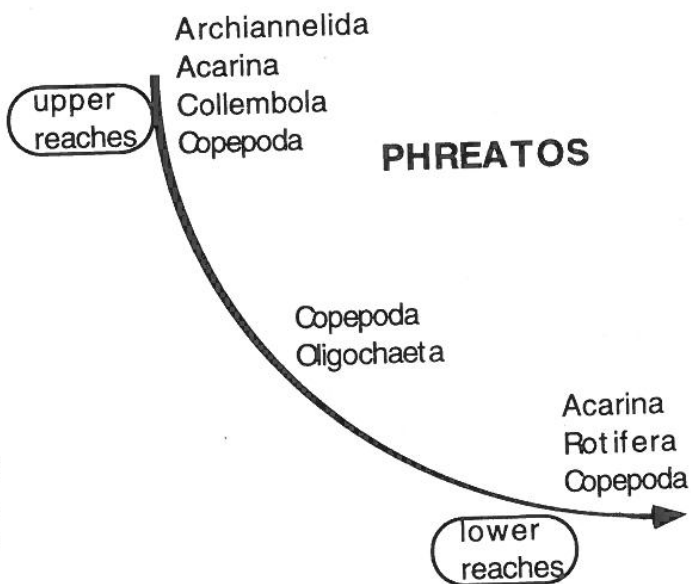
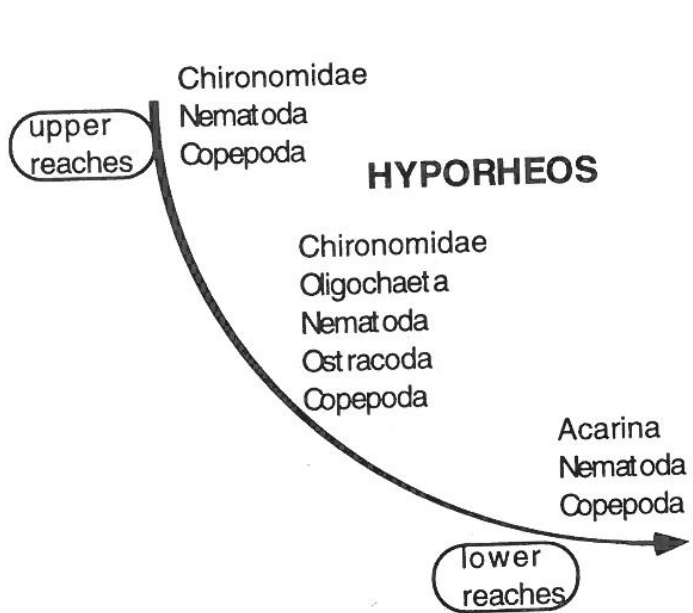
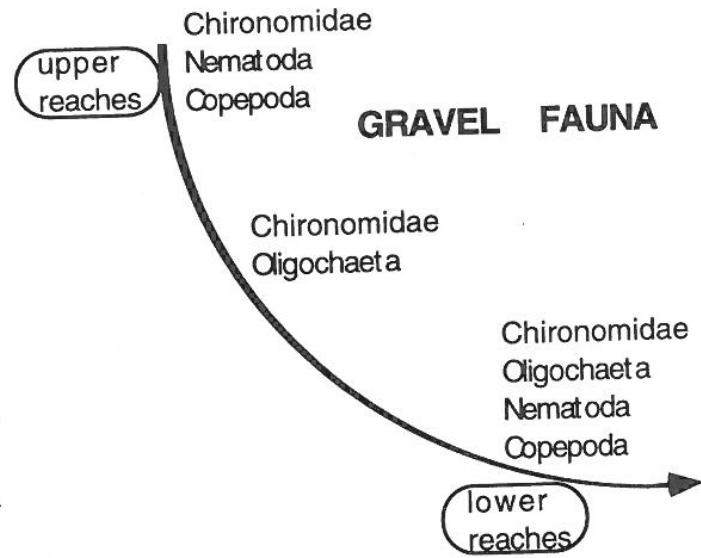
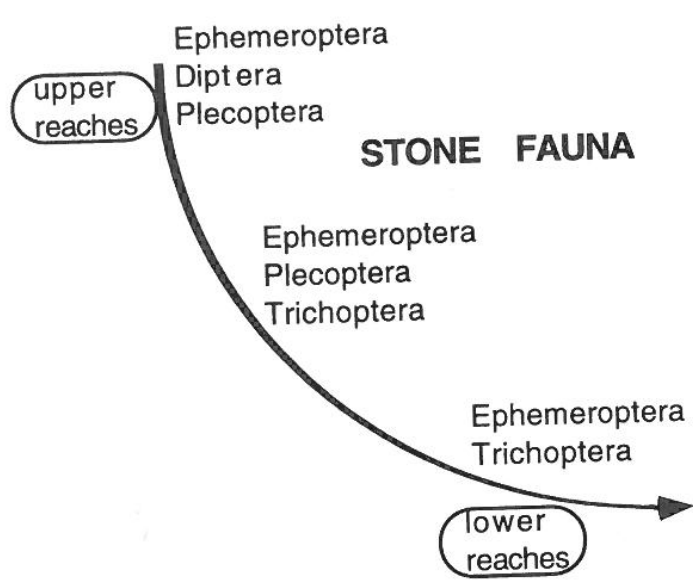
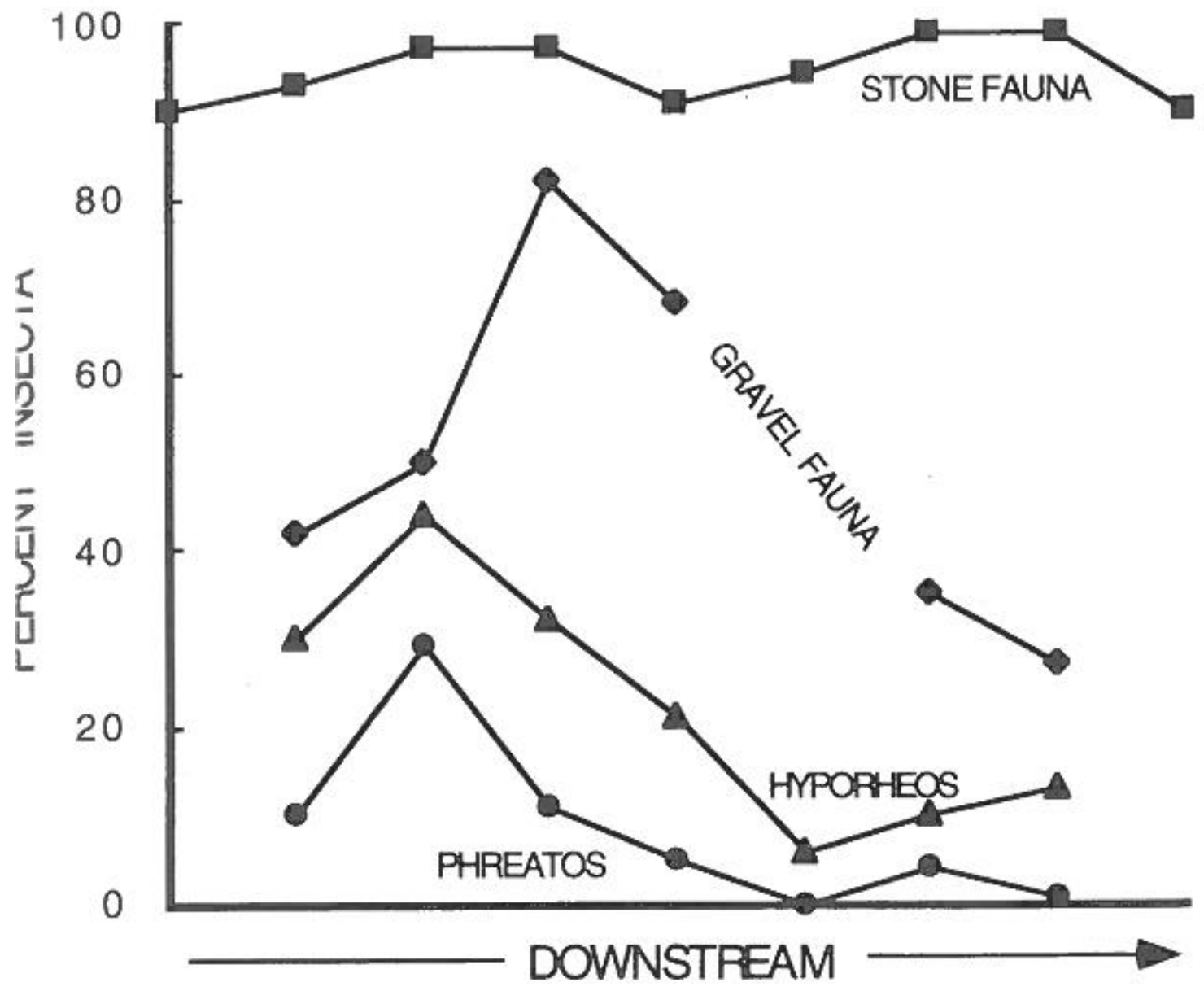


Fig. 2. A: The classical RCC configuration. B: Modification of the classical RCC to include habitat heterogeneity. C: Hydraulic regulation and size of physical habitats. D: Temporal responses to hydraulics and streamsize.

Prostorově – klinální koncept

- Vertikální propojení – koloběh
 - Hyporeal/řečiště, hyporeos/bentos
 - Koloběh organizmů a hmoty (Pennak&Ward 1986; Ward 1989; Triska et al 1996





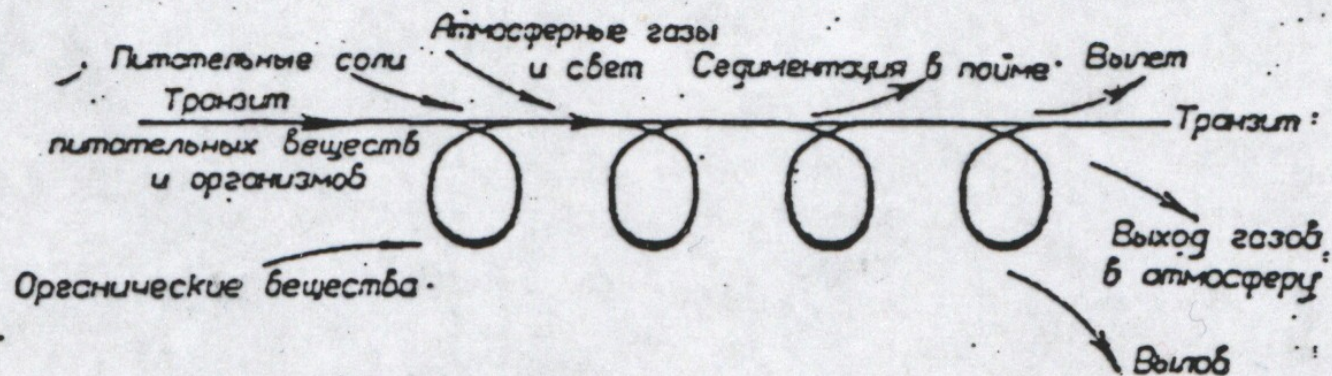
“Spirální” teorie - též Pohyb živin po spirále (Resource Spiralling Concept) (RSC)

- navazuje na RCC. Autoři (Wallace et al. 1977; Newbold et al. 1981, 1982a,b; Elwood et al. 1983; Newbold 1992).

Navazuje na RCC a **přidává** fakt **postupného zpracování materiálu** (ve vodním toku) **z jeho okolí**, což probíhá **ve směru podélného kontinua řeky**. Na **dolním toku přidává** prostorovou **dimenzi (plochu) záplavového území**, kam je materiál v síti ramen a vodních ploch rozprostřen. To vyústí v částečně otevřené cykly, jakýsi **pohyb po spirále – “spiralling”** (Wallace et al. 1977; Newbold et al. 1981, 1982a,b; Elwood et al. 1983; Newbold 1992).

Vzdálenost smyček spirály (S) udává **účinnost zpracování živin** (vztaženo k organickému C, nebo k N). **Spiralling se tak stává jak mírou transportu živin po toku dolů, tak i procesu jejich retence v toku.**

Látková spiralizace v tocích (původní představa podle Žadin 1940)



Фиг. 71. Схема общего хода круговорота веществ в реках.

Diagram of the general circulation of food materials in rivers.

Látková spiralizace v tocích (francouzská úprava podle Décamp 1971)

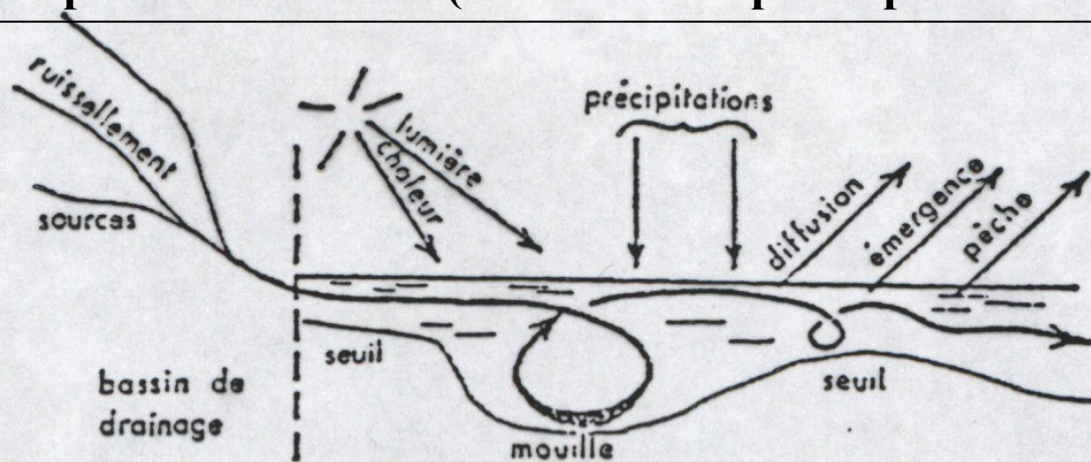


Fig. 5. — Cycle de la matière en eau courante (d'après Zhadin)

Časové modely

- Průběžná redistribuce benthosu
 - Drift a kolonizační dynamika
 - Townsend & Hildrew (1976)
 - Proudová distribuce – časová různorodost v různých podmínkách
 - Vliv nově příchozích populací, interakce a vytěsňování netolerantních druhů
 - Hemphill & Cooper 1983
 - Power & Stewart 1987

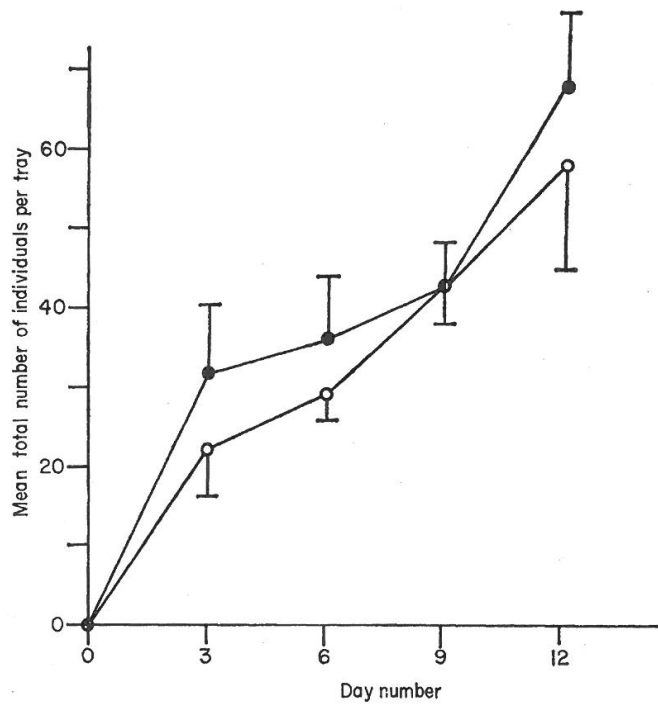


FIG. 1. Relationship between mean numbers of individuals (+ or - standard error) colonizing bottom trays (●) or suspended trays (○) and length of experiment (days).

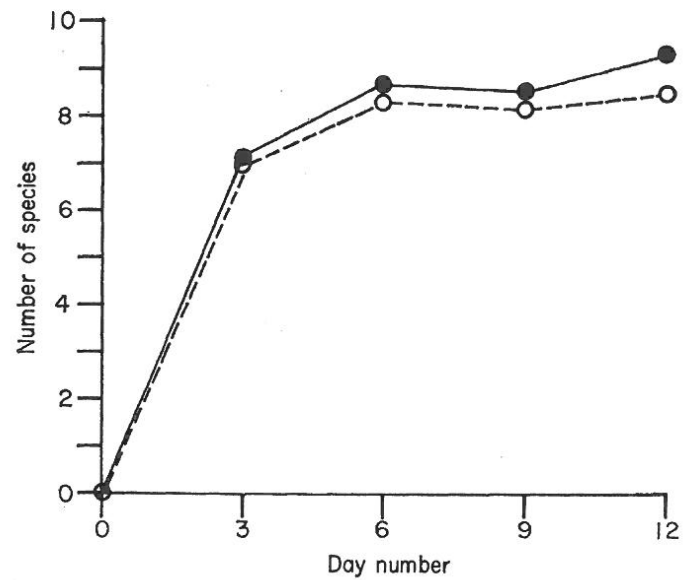


FIG. 2. Species colonization of bottom (●) and suspended trays (○).

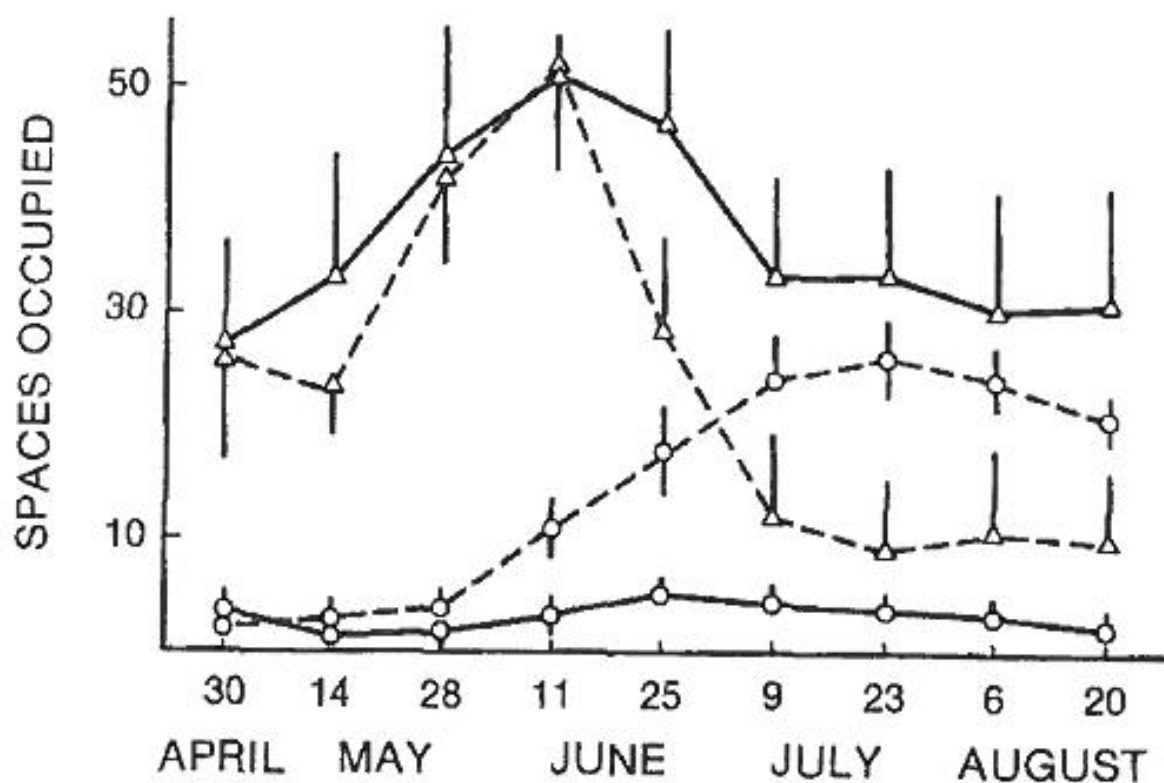


Fig. 2. Temporal changes in the amount of space occupied by *Simulium* (triangles) and *Hydropsyche* (circles) in quadrats which were disturbed every two weeks (solid line) or were left undisturbed (controls, dashed line). Quadrats disturbed every 4 weeks or every 8 weeks occupied intermediate positions between the 2 week and control lines. Bars represent standard errors

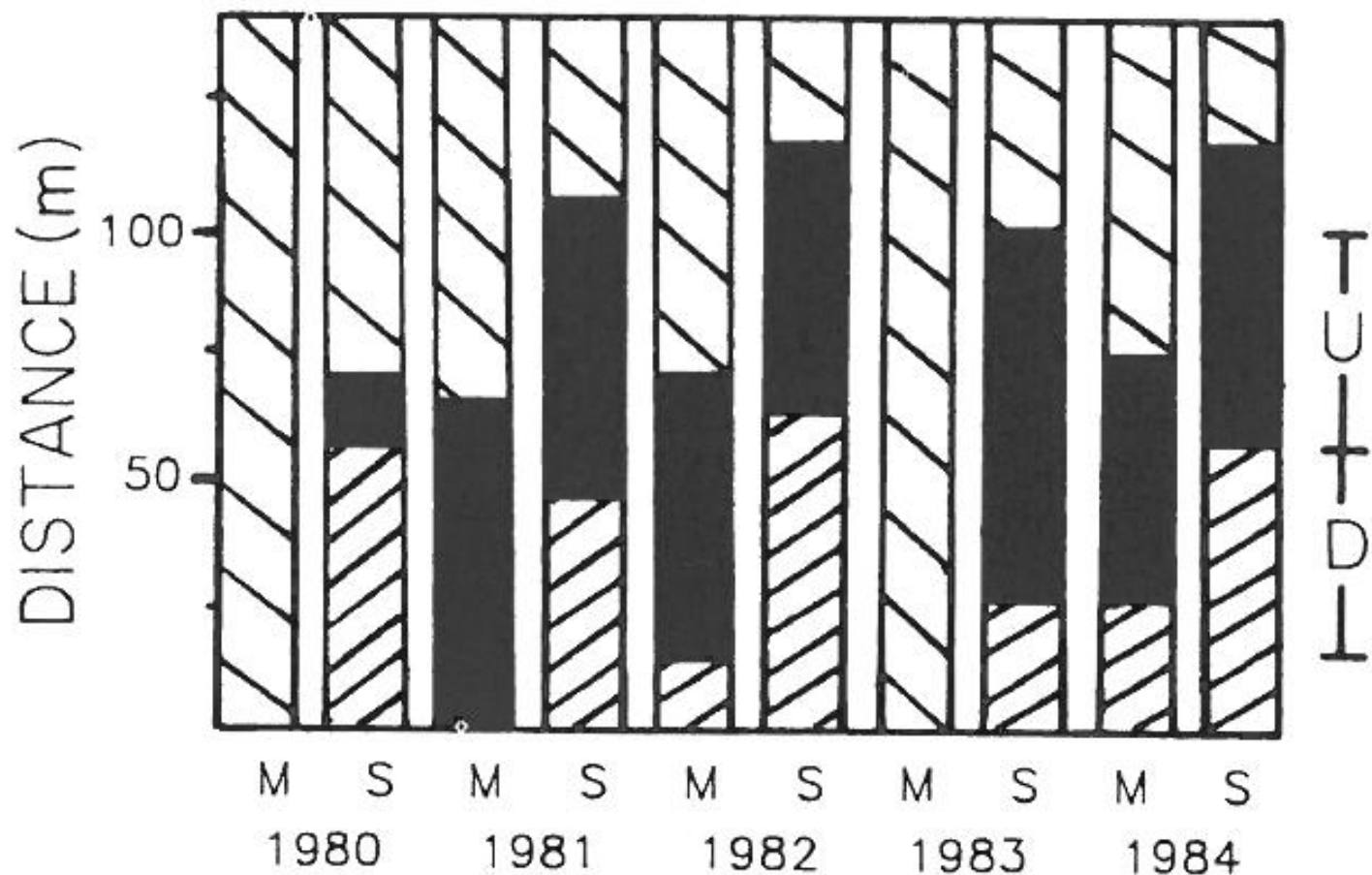
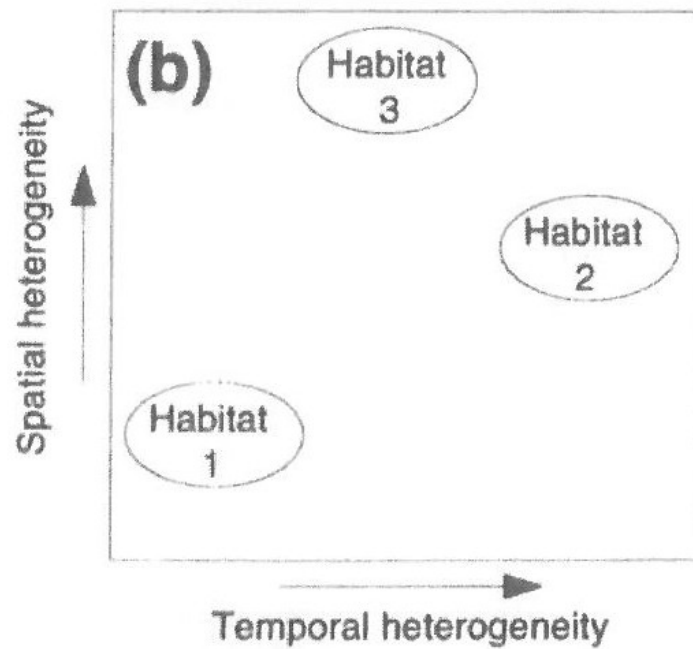
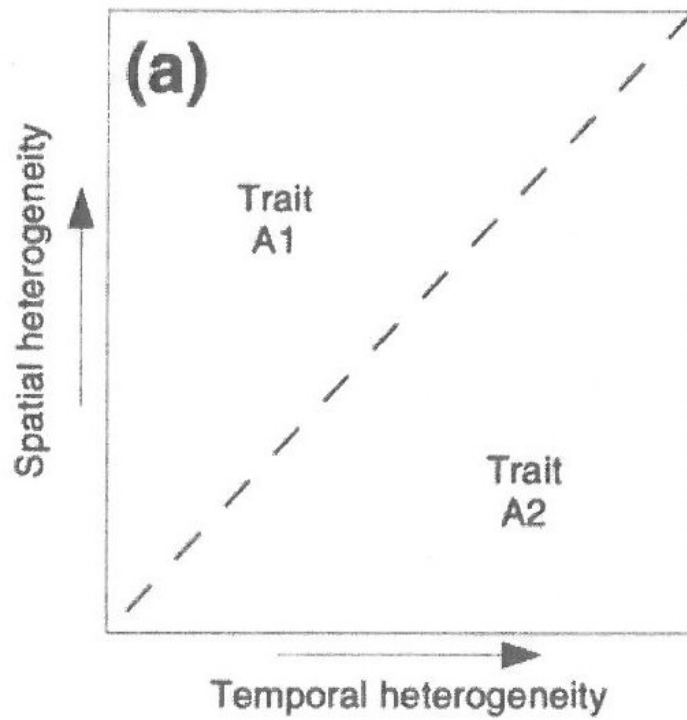


FIG. 3. Year-to-year variation in spatial distribution of *Hydropsyche* \square and *Simulium* \blacksquare in early (May) and late (September) summer in Refugio Creek. The zone of overlap between the two taxa is indicated by \square . The bar to the right indicates the upstream (U) and downstream (D) reaches of the stretch of stream studied in this experiment.

Časově – prostorové modely

- Habitat templet concept
 - Southwood 1977, Townsend & Hildrew 1994, Statzner et al. 1994
- Refugia concept
 - Seddell et al. 1990, Townsend & Hildrew 1994
- Patch-dynamics concept
 - Townsend 1989, 1991



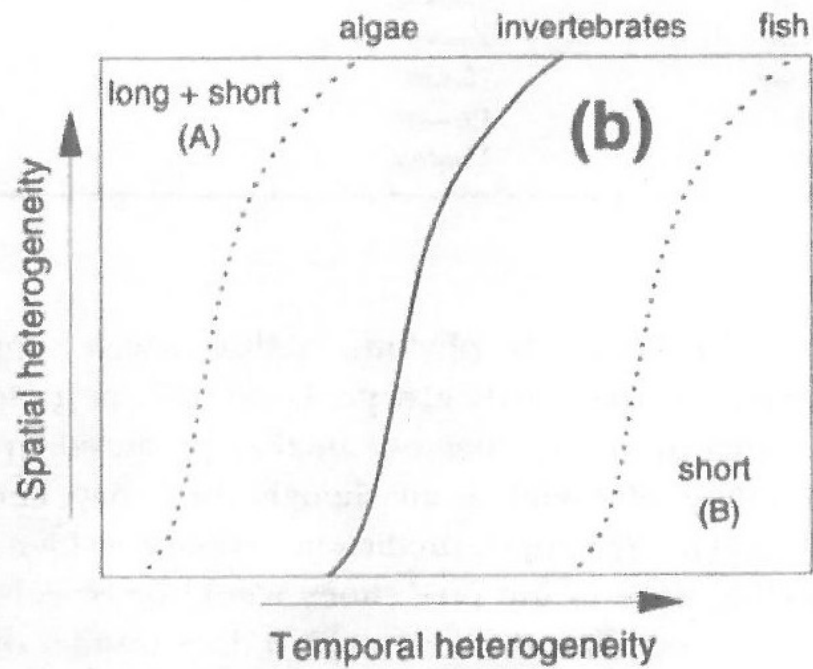
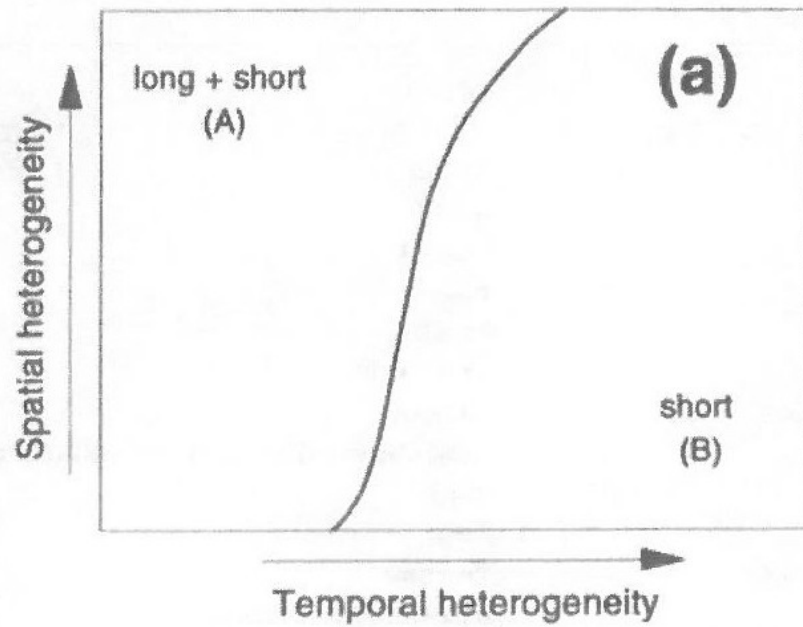


Table 1 Species traits predicted in areas A and B of the habitat templet in Fig. 4

Species trait	Area A	Area B
Minimum age at reproduction	Old–young	Young
Descendants per reproductive cycle	Few–many	Many
Reproductive cycles per year	<1–several	Several
Potential life span	Long–short	Short
Potential size	Large–small	Small
Total reproductive cycles per individual	Many–one	Few–one
Parental care	Present–absent	Absent
Reproductive technique	Diverse	Single individual produces offspring
Annual P/B ratio	Low–high	High
Attachment	None–firm	Firm
Body flexibility	Inflexible–flexible	Flexible
Body form	Diverse	Streamlined–flattened
Inundation tolerance	Absent–present	Present
Desiccation tolerance	Absent–present	Present
Mobility	Immobile–mobile	Mobile
Relatively invulnerable life stages	Absent–present	Present
Potential for regeneration	Absent–present	Present

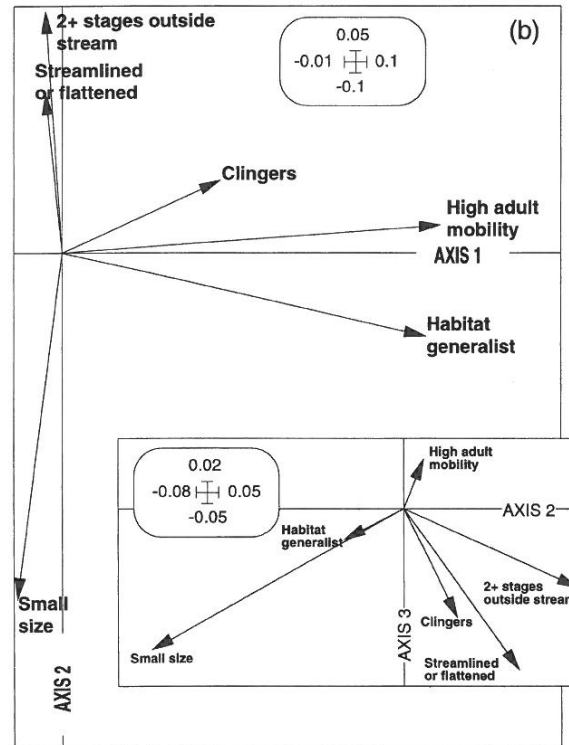
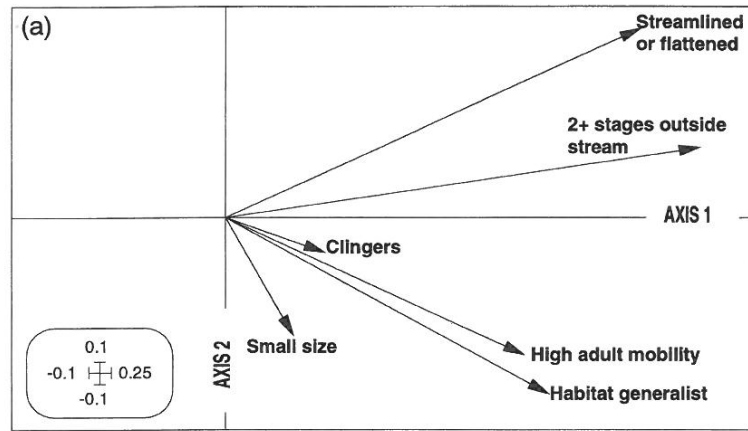


Fig. 3 Typologies of species traits produced using a centred principal components analysis: (a) according to the percentage of individuals per site that possess the traits; (b) according to the percentage of taxa per site that possess the traits (arrangement of traits according to axis 2 *v* 3 is inset).

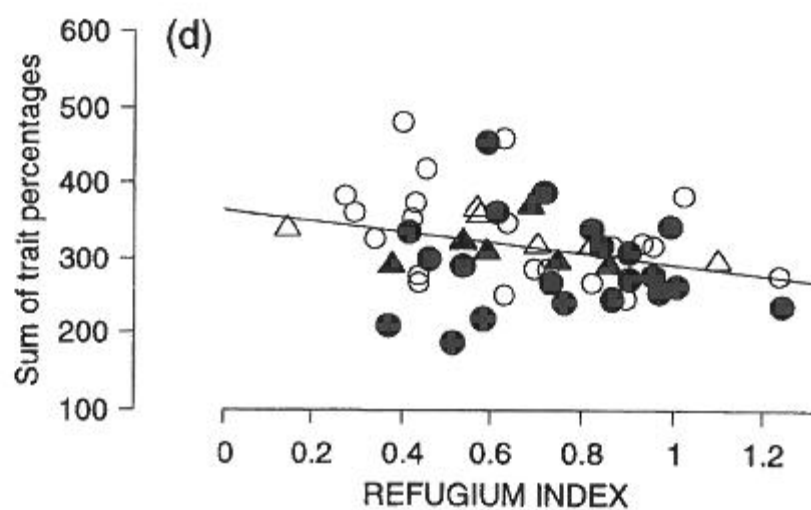
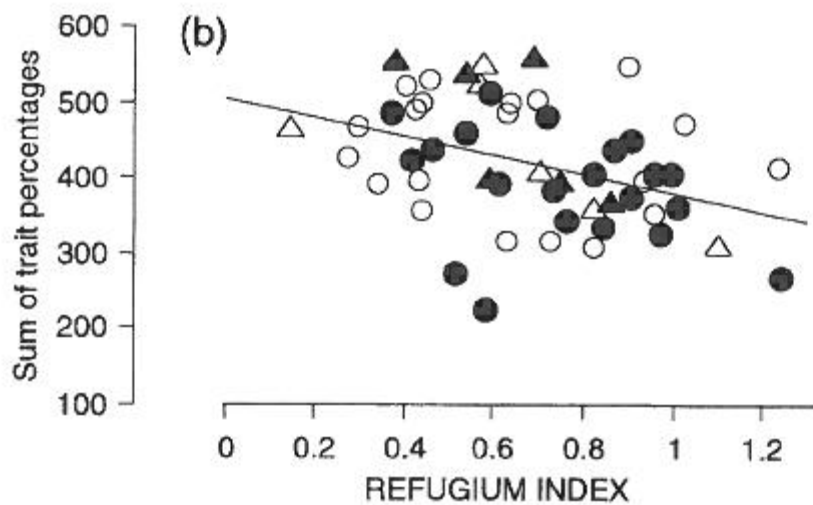
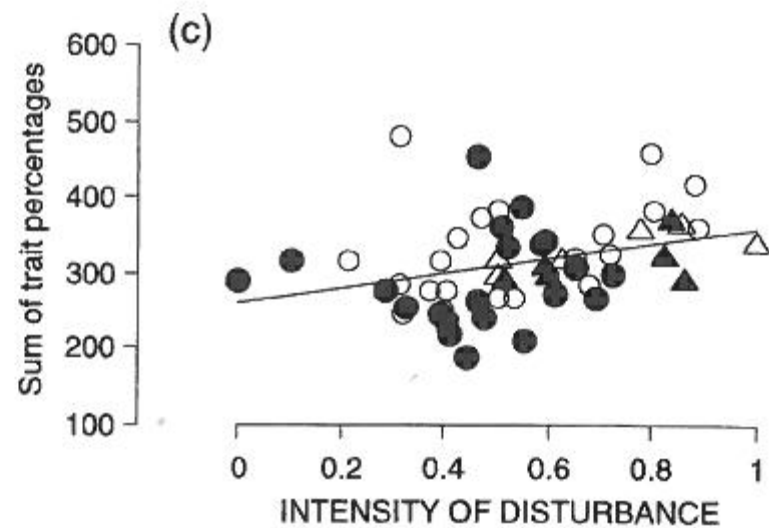
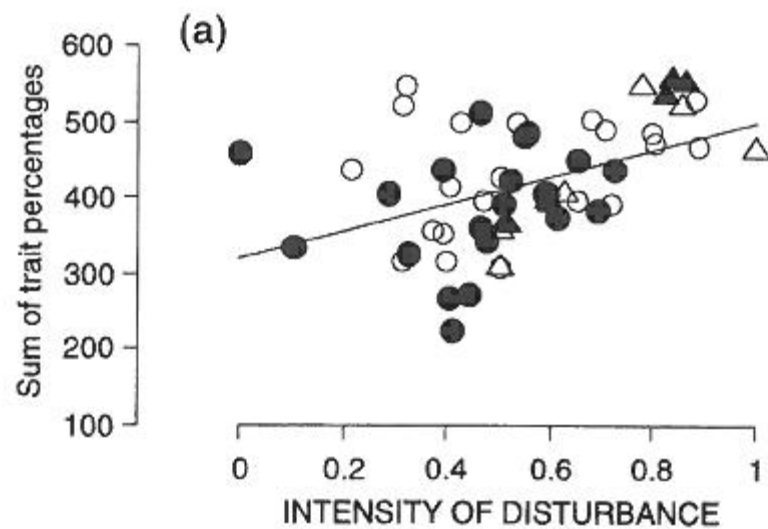
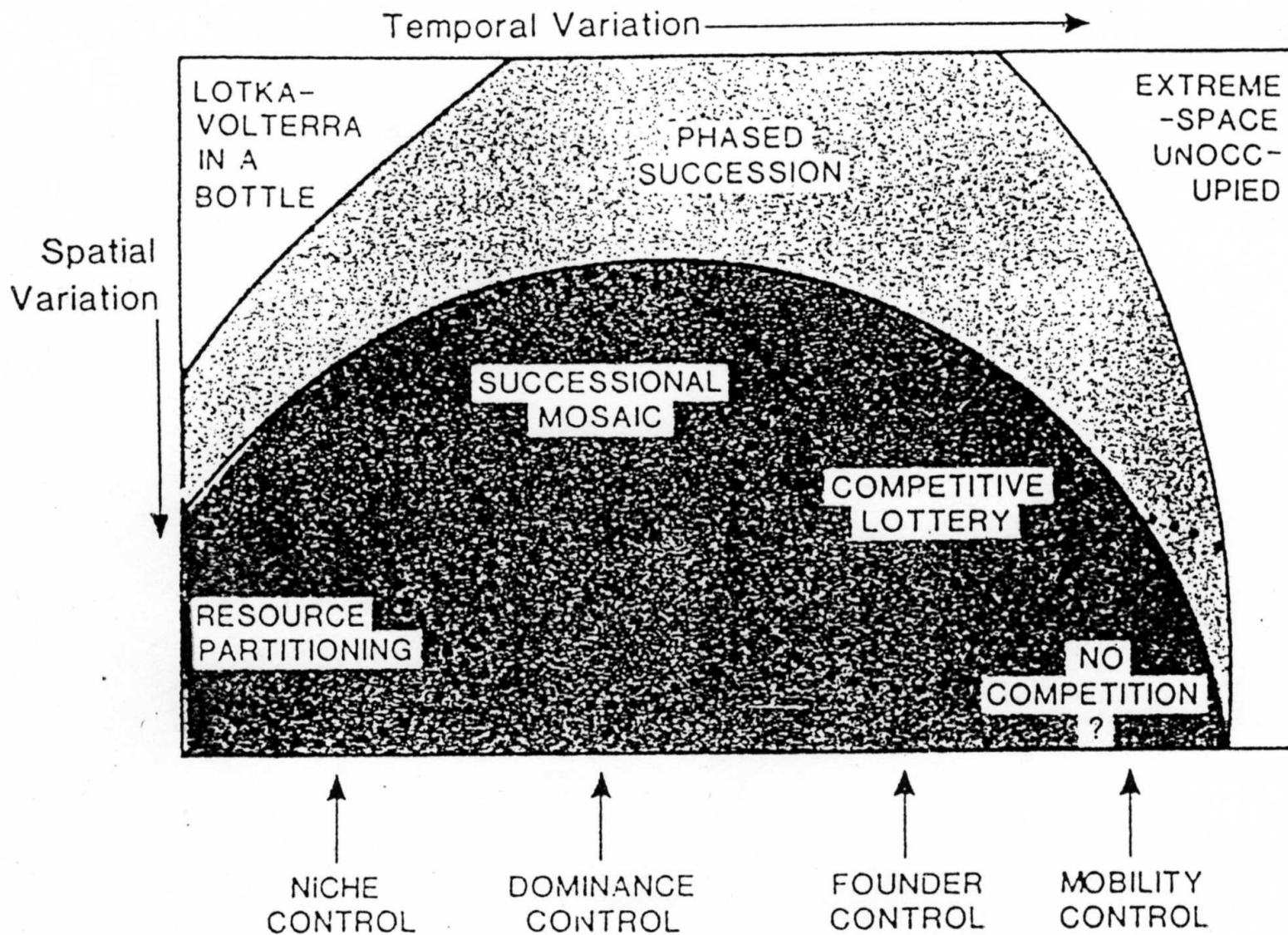


Table 5 Relationships between the percentage of taxa per site that possess each of six traits and intensity of disturbance. R^2 , percentage of variation explained; P , probability that slope of the relationship is different from zero; s , sign of the best fit regression line

Species traits	Intensity of disturbance			Refugia index		
	R^2	P	s	R^2	P	s
Small size	0.044	0.126	+	0.008	0.510	-
High adult mobility	0.078	0.041	+	0.129	0.008	-
Habitat generalist	0.137	0.006	+	0.198	0.001	-
Clingers	0.021	0.300	+	0.006	0.567	+
Streamlined or flattened	0.000	0.954	-	0.011	0.448	+
Two+ stages outside stream	0.000	0.998	+	0.006	0.574	+

C. R. TOWNSEND



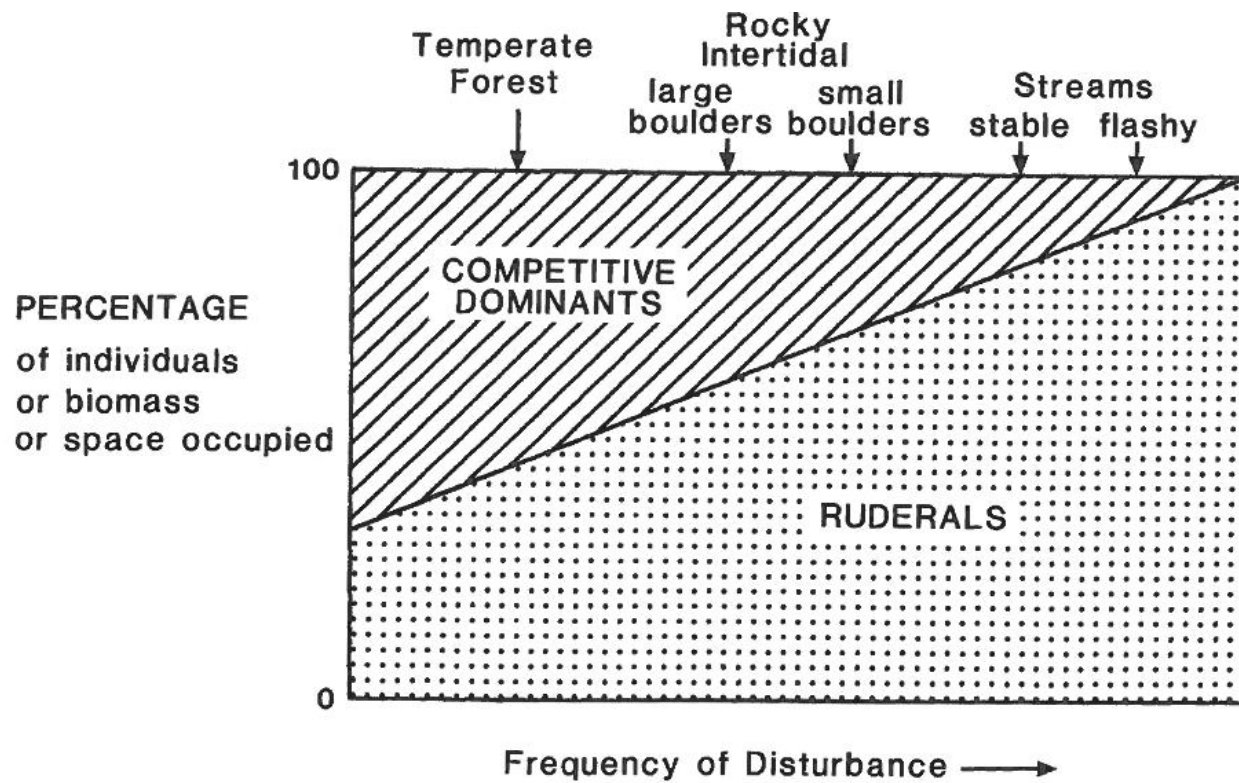
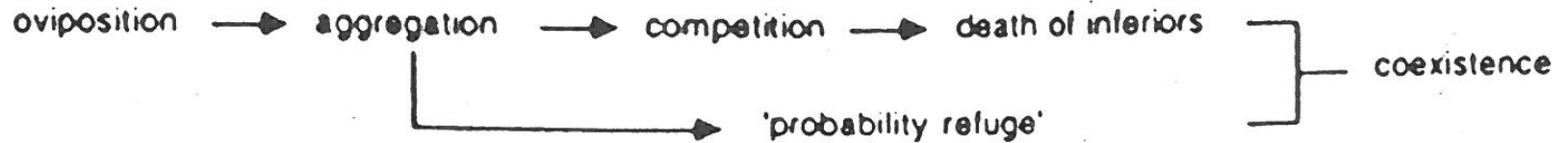


FIG. 5. Hypothetical relationship between frequency of disturbance and the relative representation of species that can be described as competitive dominants or ruderals.

Aggregation model



Stochastic patch dynamics model

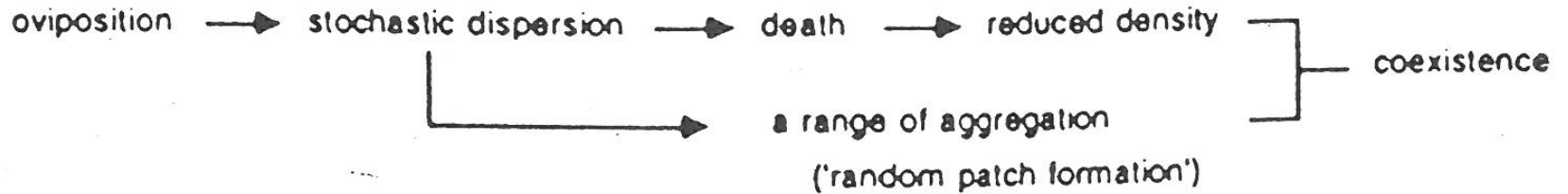


Fig. 6. Components of the "aggregation" model and the "stochastic patch dynamics" model for coexistence of species (see the text for details). (After TOKESHI 1995)

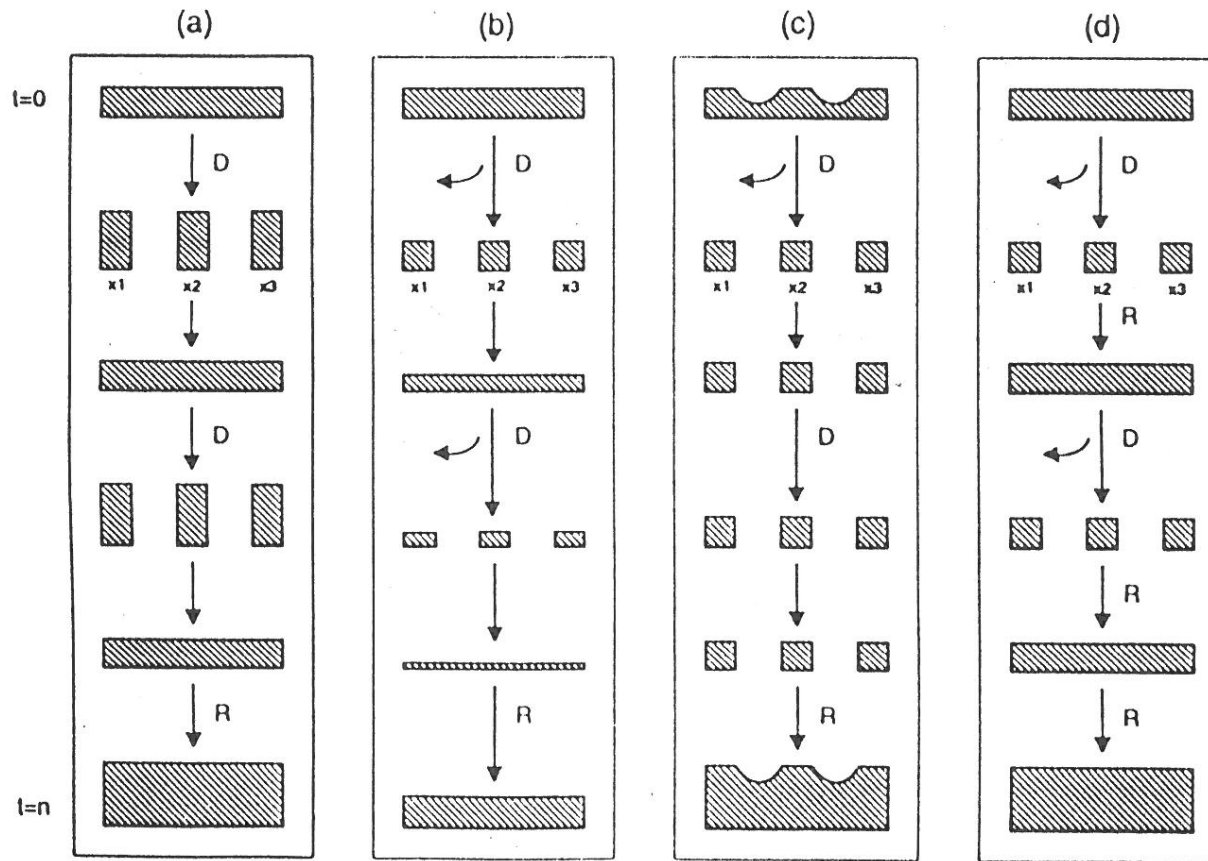


Fig. 4. Sequences of events through time $t = 0$ to $t = n$, in different models of "refugia" (a) – (d). At each stage of a sequence, the total block area (cross-hatched) represents population size while the arrangement of blocks represents spatial distribution. Disturbance events "D" are brief and punctuate longer periods of benign conditions. Horizontal arrows indicate when population numbers are reduced by disturbance. Recruitment "R" occurs only at $t = n$ in models (a) – (c), but is frequent in model (d). (a) "catastrophe avoided", entire population is concentrated into refugia ($x_1, x_2, x_3 \dots$) during disturbance events and redisperses subsequently to occupy the entire habitat when conditions are benign; (b) "incomplete catastrophe", population suffers high mortality from disturbance except for the fraction already in refugia ($x_1, x_2, x_3 \dots$): this fraction subsequently disperses throughout the habitat, after the disturbance; (c) "refugia equals habitat", only that fraction of the population already in refugia survives disturbance and no dispersal occurs between events, except that some individuals may temporarily move into intervening habitat patches, particularly when the population is high and the conditions benign. In models (a) – (c) there are several to many disturbances per generation, recruitment occurs only at the end of a disturbance sequence ($t = n$). In model (d) there is "incomplete catastrophe" as in model (b), but recruitment is frequent. (Redrawn from ROBERTSON et al. 1995).

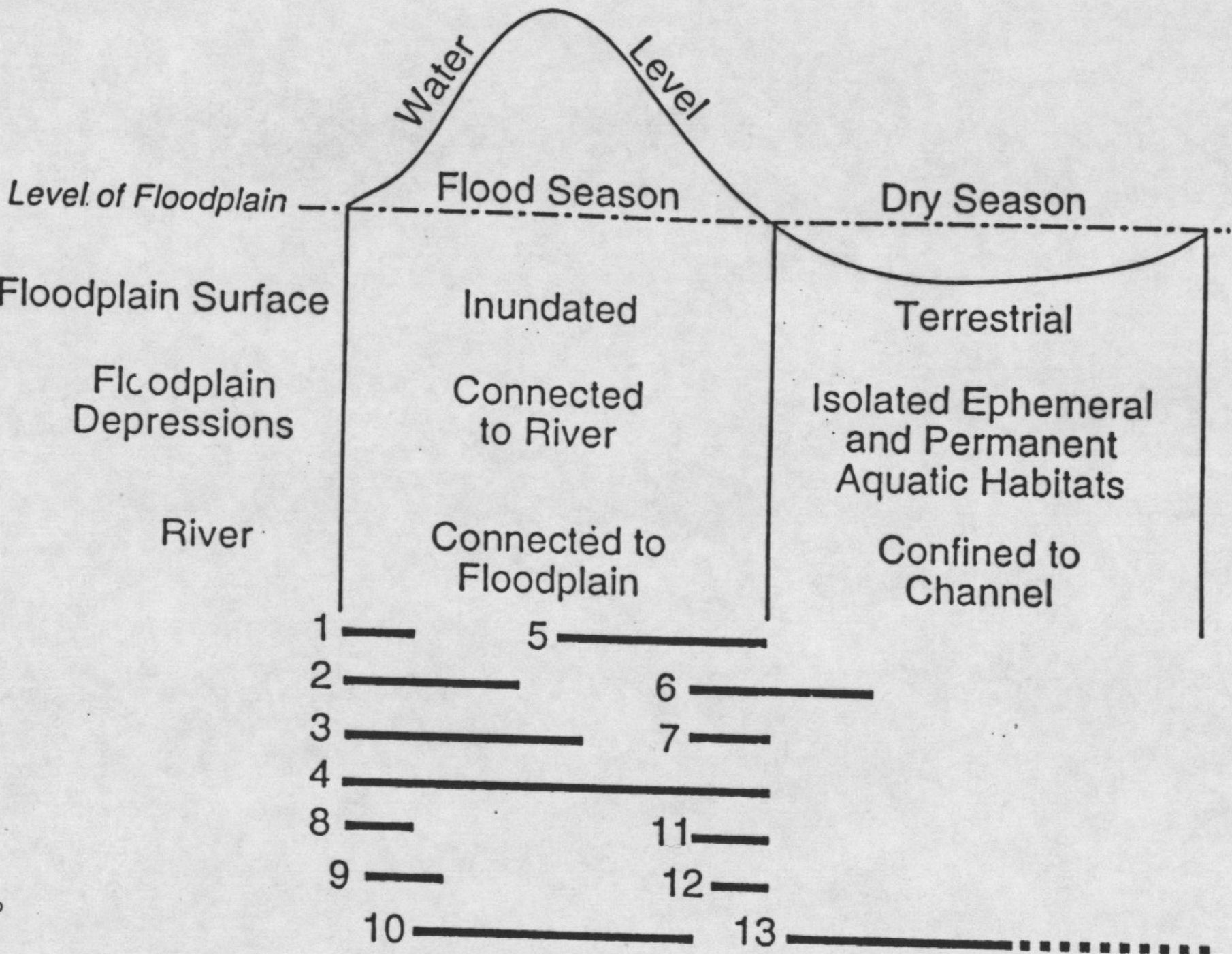
Teorie povodňového pulsu (Flood Puls Concept) (FPC)

Výměna organického C mezi záplavovým územím a hlavním korytem bude záviset na **třech faktorech**:

- přítomnost **mechanismů ukládání**, jež “drží” C v záplavové pláni (zejm. sedimentace a ukládání C v organické podobě: tj. retence pomocí vodních makrofyt a terestrickou vegetací a v živočiších —> uvolňování a hromadění živin v záplavovém území závisí na **potravinové síti a vegetačním pokryvu**

- **trvání povodně**

- „**proplachování**“ záplavové pláně za povodně (růstový cyklus vegetace v záplavové pláni (nakolik je zvodněna, v jakém období roku -v podmínkách mírného pásma tedy i na **vegetačních cyklech**)



Teorie povodí (Catchment Concept)

- Řada autorů obhájí význam výzkumu prováděného z pozice celého povodí:

Frissel et al. (1986) předložili hierarchický rámec pro klasifikaci vodních stanovišť (biotopů), jenž zdůrazňuje **vztah toku ke svému povodí**, skrze **rámec prostorového a časového měřítka** (od celé sítě koryt, k tůním, proudům a mikrostanovištím).

- **Townsend (1996)** ve svém výzkumu (studujícím hierarchické vztahy v rámci povodí) argumentuje ve prospěch **integrace říčních teorií s teorií dynamiky plošek** (Patch Dynamics Concept (White and Pickett 1985; Pringle et al. 1988, tj. existující stanoviště = plošky vznikají a mizí v čase).

➤ Co je to říční krajina?

Je komplexní ekosystém: strukturální a funkční celek, složený z řeky a všech zbývajících strukturálních složek krajiny, které byly touto řekou vytvořeny, nebo které jsou řekou alespoň podmíněny; a dále z veškerého oživení (bioty) všech neživých (tj. abiotických) složek tohoto ekosystému sensu lato (Štěrba a kol. 1999).

Prostorové vymezení říční krajiny je určeno většinou sedimenty současné řeky (aluvium), tyto sedimenty většinou kopíruje říční niva.

➤ Co je to teorie ekologického kontinua?

Je to stav prostorové, časové a funkční spojitosti všech částí říční krajiny.

Pozn.: Prostorové kontinuum má svou podélnou - příčnou - vertikální dimenzi. Rozlišuje se vymezení v podélném směru (např. členění na horský, střední, nížinný úsek), z podstaty definice však vyplývá důležitost vymezení i ve směru příčném (mezi svými říčními terasami) a rovněž ve směru vertikálním („do hloubky“).

Z hlediska časového je říční krajina vymezena obdobím postglaciálním (tj. posledních cca 10 000 let, kdy získala postupně svůj dnešní vzhled i složení biocenóz (tj. živých společenstev).

Funkční vymezení je dáno řadou funkcí, které tato krajina naplňuje.

➤ Antropogenní činitel kontra biodiverzita říční krajiny

Faktor ovlivňující jak běžné fungování, tak nevratné změny tohoto biologického systému, a tedy i vývoj krajiny. Antropogenní vliv snižuje ekologickou kontinuitu ř.k., což ve svých důsledcích ovlivní i její biodiverzitu.

Říční krajina sensu lato

kontinent

pohoří



pobřeží

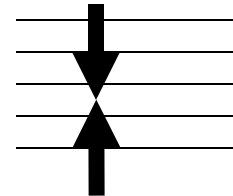


nížina

terasa



terasa

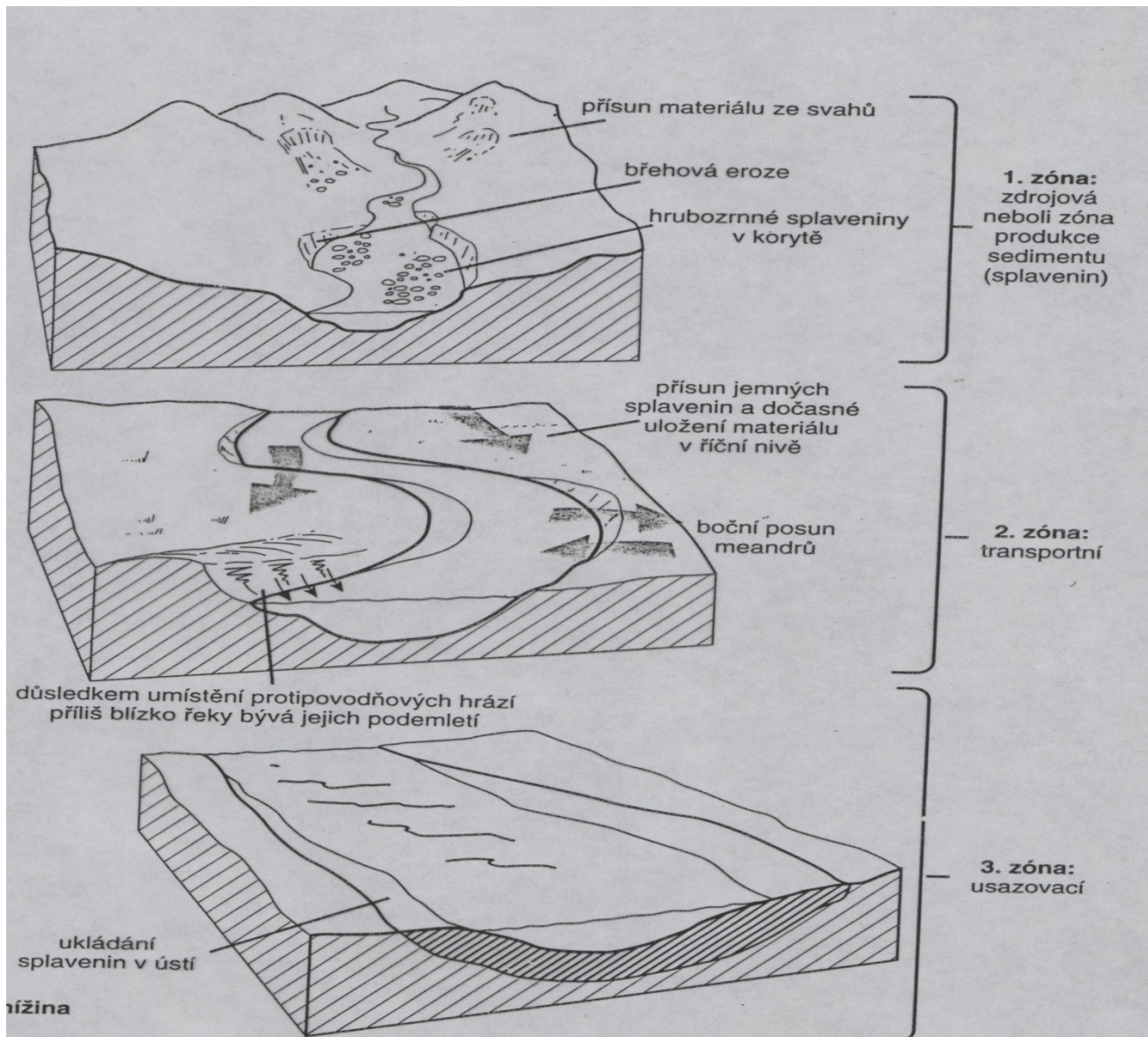


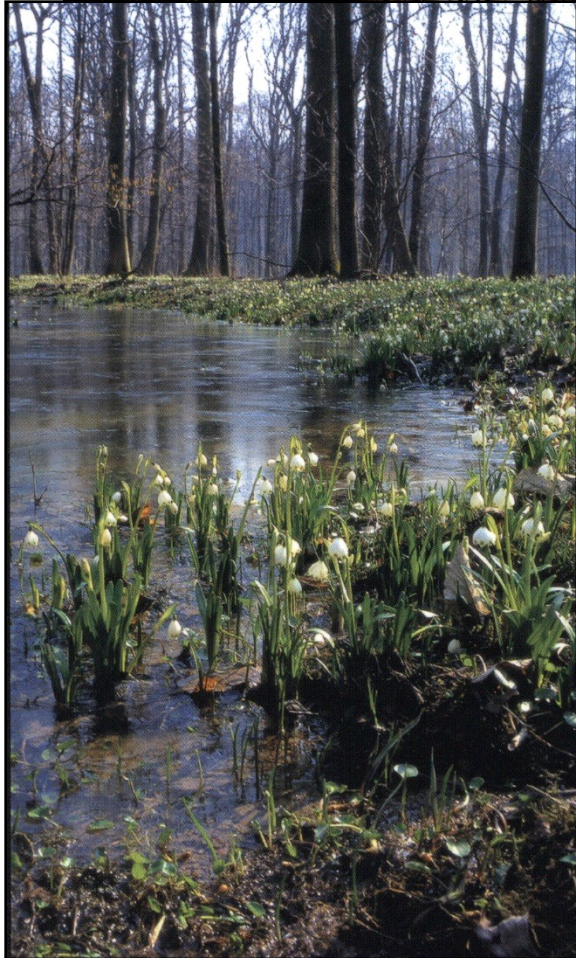
geosféry

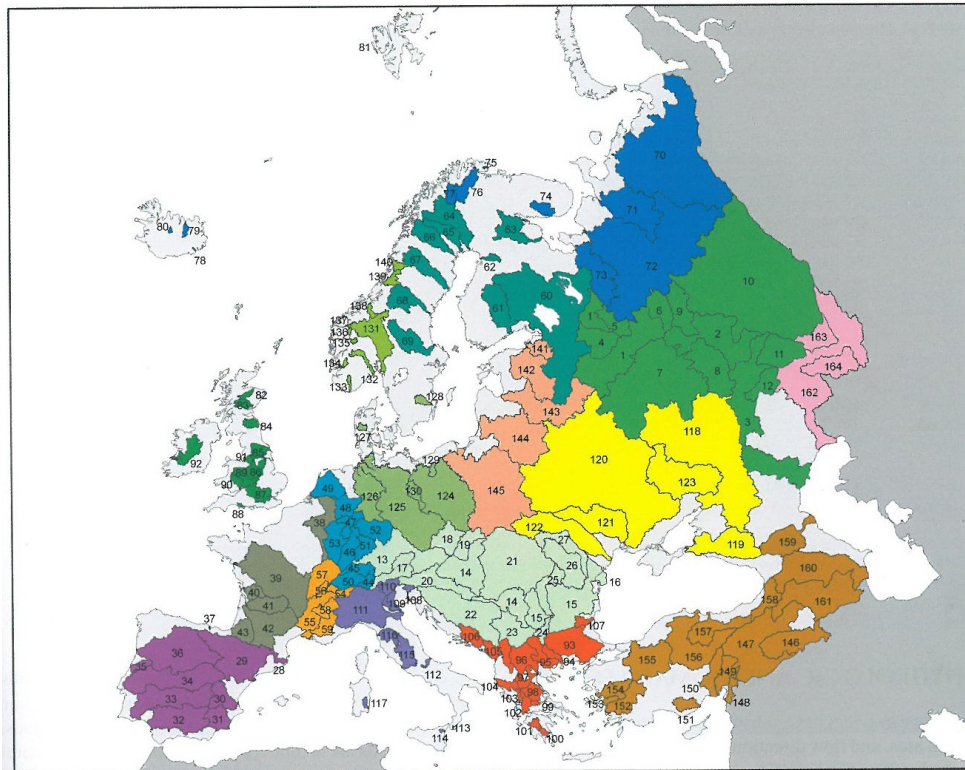
gradient=změna veličiny na jednotku vzdálenosti; **vektor** (=směrově orientovaná veličina); směr podélný-příčný-vertikální

kontinuum =spojité prostředí; **podélné-příčné-vertikální k.**

vymezení říční krajiny - podélný aspekt







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LGB



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Kilometers

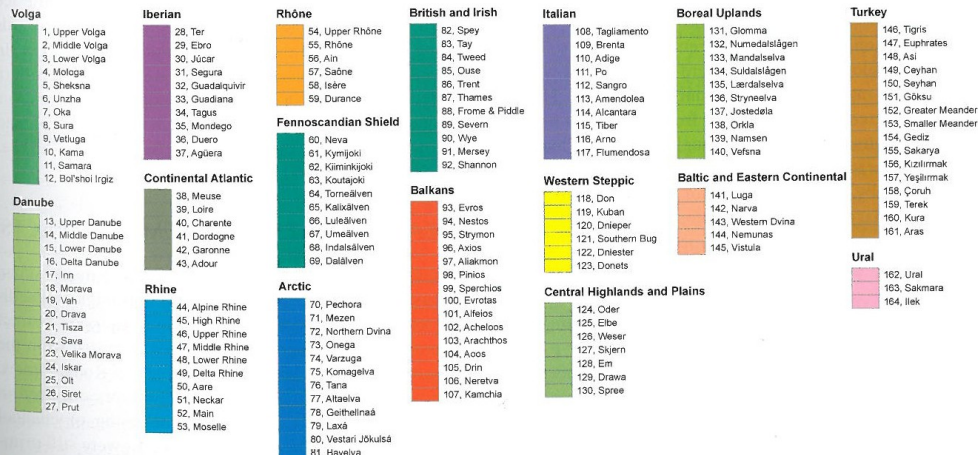


FIGURE 1.2 Spatial distribution of European catchments in 17 different geographic regions (different colors), including subcatchments of the Volga, Danube, Rhine, and Rhone Basins. Data sources: see Appendix.



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0 250 500 1'000
Kilometers

- | | | |
|---|--|--|
| 1, Aegean and Western Turkey sclerophyllous and mixed forests | 26, Cyprus Mediterranean forests | 51, Northwest Russian-Novaya Zemlya tundra |
| 2, Alps conifer and mixed forests | 27, Dinaric Mountains mixed forests | 52, Pannonian mixed forests |
| 3, Anatolian conifer and deciduous mixed forests | 28, East European forest steppe | 53, Pindus Mountains mixed forests |
| 4, Appenine deciduous montane forests | 29, Eastern Anatolian deciduous forests | 54, Po Basin mixed forests |
| 5, Arctic desert | 30, Eastern Anatolian montane steppe | 55, Pontic steppe |
| 6, Atlantic mixed forests | 31, Eastern Mediterranean conifer-sclerophyllous-broadleaf forests | 56, Pyrenees conifer and mixed forests |
| 7, Azerbaijan shrub desert and steppe | 32, Elburz Range forest steppe | 57, Rock and ice |
| 8, Azores temperate mixed forests | 33, English Lowlands beech forests | 58, Rodope montane mixed forests |
| 9, Balkan mixed forests | 34, Euxine-Colchic broadleaf forests | 59, Sarmatic mixed forests |
| 10, Baltic mixed forests | 35, Faroe Islands boreal grasslands | 60, Scandinavian and Russian taiga |
| 11, Caledon conifer forests | 36, Iberian conifer forests | 61, Scandinavian coastal conifer forests |
| 12, Cantabrian mixed forests | 37, Iberian sclerophyllous and semi-deciduous forests | 62, Scandinavian Montane Birch forest and grasslands |
| 13, Carpathian montane forests | 38, Icelandic boreal birch forests and alpine tundra | 63, South Appenine mixed montane forests |
| 14, Caspian-Hyrcanian mixed forests | 39, Illyrian deciduous forests | 64, Southeastern Iberian shrubs and woodlands |
| 15, Caspian lowland desert | 40, Italian sclerophyllous and semi-deciduous forests | 65, Southern Anatolian montane conifer and deciduous forests |
| 16, Caucasus mixed forests | 41, Kazakh forest steppe | 66, Southwest Iberian Mediterranean sclerophyllous and mixed forests |
| 17, Celtic broadleaf forests | 42, Kazakh semi-desert | 67, Tyrrhenian-Adriatic Sclerophyllous and mixed forests |
| 18, Central Anatolian steppe | 43, Kazakh steppe | 68, Ural montane forests and tundra |
| 19, Central Anatolian steppe and woodlands | 44, Kola Peninsula tundra | 69, West Siberian taiga |
| 20, Central Asian northern desert | 45, Lake | 70, Western European broadleaf forests |
| 21, Central Asian southern desert | 46, Middle East steppe | 71, Zagros Mountains forest steppe |
| 22, Central European mixed forests | 47, North Atlantic moist mixed forests | |
| 23, Corsican montane broadleaf and mixed forests | 48, Northeastern Spain and Southern France Mediterranean forests | |
| 24, Crete Mediterranean forests | 49, Northern Anatolian conifer and deciduous forests | |
| 25, Crimean Submediterranean forest complex | 50, Northwest Iberian montane forests | |

FIGURE 1.3 (Continued).

3)



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|---|--|--|
| 1, Aegean and Western Turkey sclerophyllous and mixed forests | 26, Cyprus Mediterranean forests | 51, Northwest Russian-Novaya Zemlya tundra |
| 2, Alps conifer and mixed forests | 27, Dinaric Mountains mixed forests | 52, Pannonian mixed forests |
| 3, Anatolian conifer and deciduous mixed forests | 28, East European forest steppe | 53, Pindus Mountains mixed forests |
| 4, Appenine deciduous montane forests | 29, Eastern Anatolian deciduous forests | 54, Po Basin mixed forests |
| 5, Arctic desert | 30, Eastern Anatolian montane steppe | 55, Pontic steppe |
| 6, Atlantic mixed forests | 31, Eastern Mediterranean conifer-sclerophyllous-broadleaf forests | 56, Pyrenees conifer and mixed forests |
| 7, Azerbaijan shrub desert and steppe | 32, Elburz Range forest steppe | 57, Rock and ice |
| 8, Azores temperate mixed forests | 33, English Lowlands beech forests | 58, Rodope montane mixed forests |
| 9, Balkan mixed forests | 34, Euxine-Colchic broadleaf forests | 59, Sarmatic mixed forests |
| 10, Baltic mixed forests | 35, Faroe Islands boreal grasslands | 60, Scandinavian and Russian taiga |
| 11, Caledon conifer forests | 36, Iberian conifer forests | 61, Scandinavian coastal conifer forests |
| 12, Cantabrian mixed forests | 37, Iberian sclerophyllous and semi-deciduous forests | 62, Scandinavian Montane Birch forest and grasslands |
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| 16, Caucasus mixed forests | 41, Kazakh forest steppe | 66, Southwest Iberian Mediterranean sclerophyllous and mixed forests |
| 17, Celtic broadleaf forests | 42, Kazakh semi-desert | 67, Tyrrhenian-Adriatic Sclerophyllous and mixed forests |
| 18, Central Anatolian steppe | 43, Kazakh steppe | 68, Ural montane forests and tundra |
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| 22, Central European mixed forests | 47, North Atlantic moist mixed forests | |
| 23, Corsican montane broadleaf and mixed forests | 48, Northeastern Spain and Southern France Mediterranean forests | |
| 24, Crete Mediterranean forests | 49, Northern Anatolian conifer and deciduous forests | |
| 25, Crimean Submediterranean forest complex | 50, Northwest Iberian montane forests | |

CURE 1.3 (Continued).

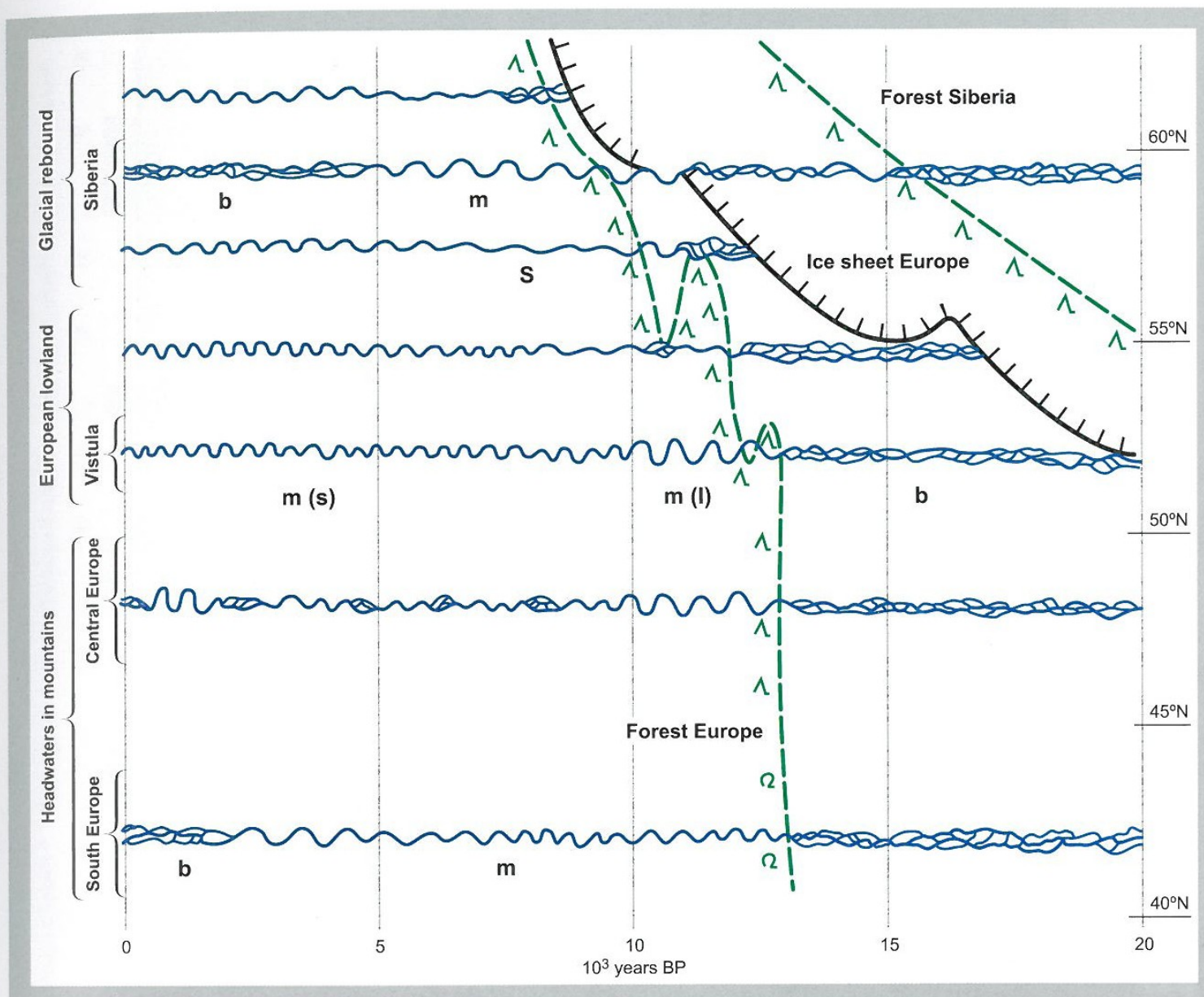


FIGURE 1.4 Changes in fluvial systems in a north–south cross-section through Europe: (b) braided (bed-load river); (m) meandering (suspended-loaded river); (m(s)): small meanders; (m(l)): large meanders. The diagram also includes the probable sequence of channel patterns for Siberian rivers. Redrawn from Starkel (1991).

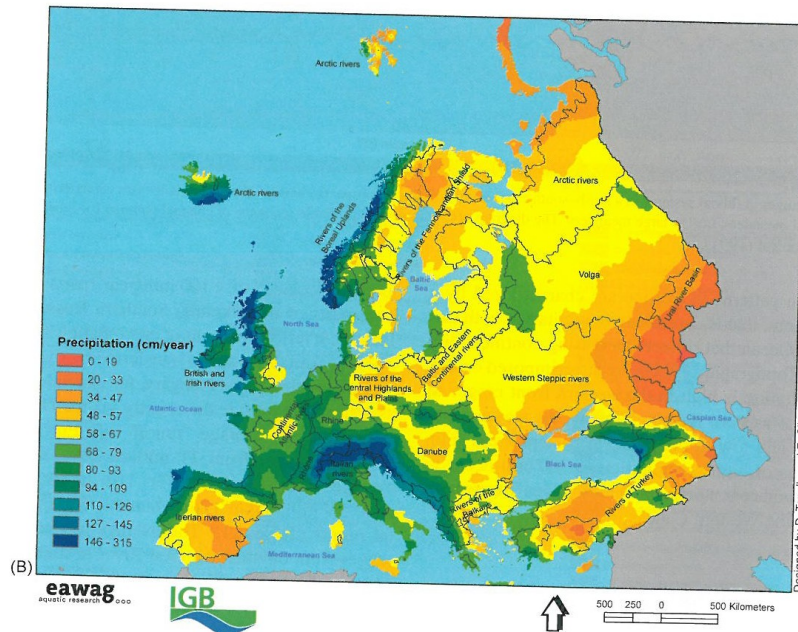
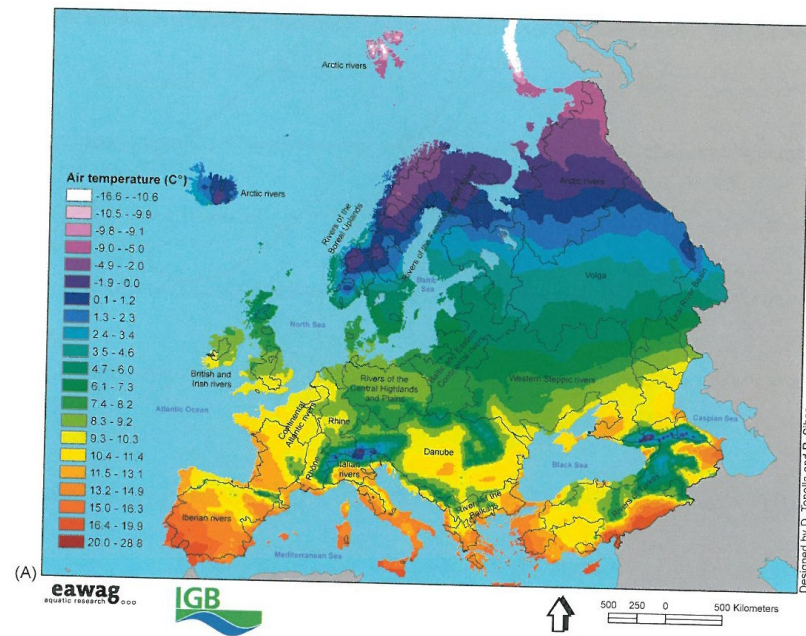


FIGURE 1.5 Mean annual air temperature (A) and mean annual precipitation (B) across Europe. Locations of the geographic regions covered in the book are indicated. Data sources: see Appendix.

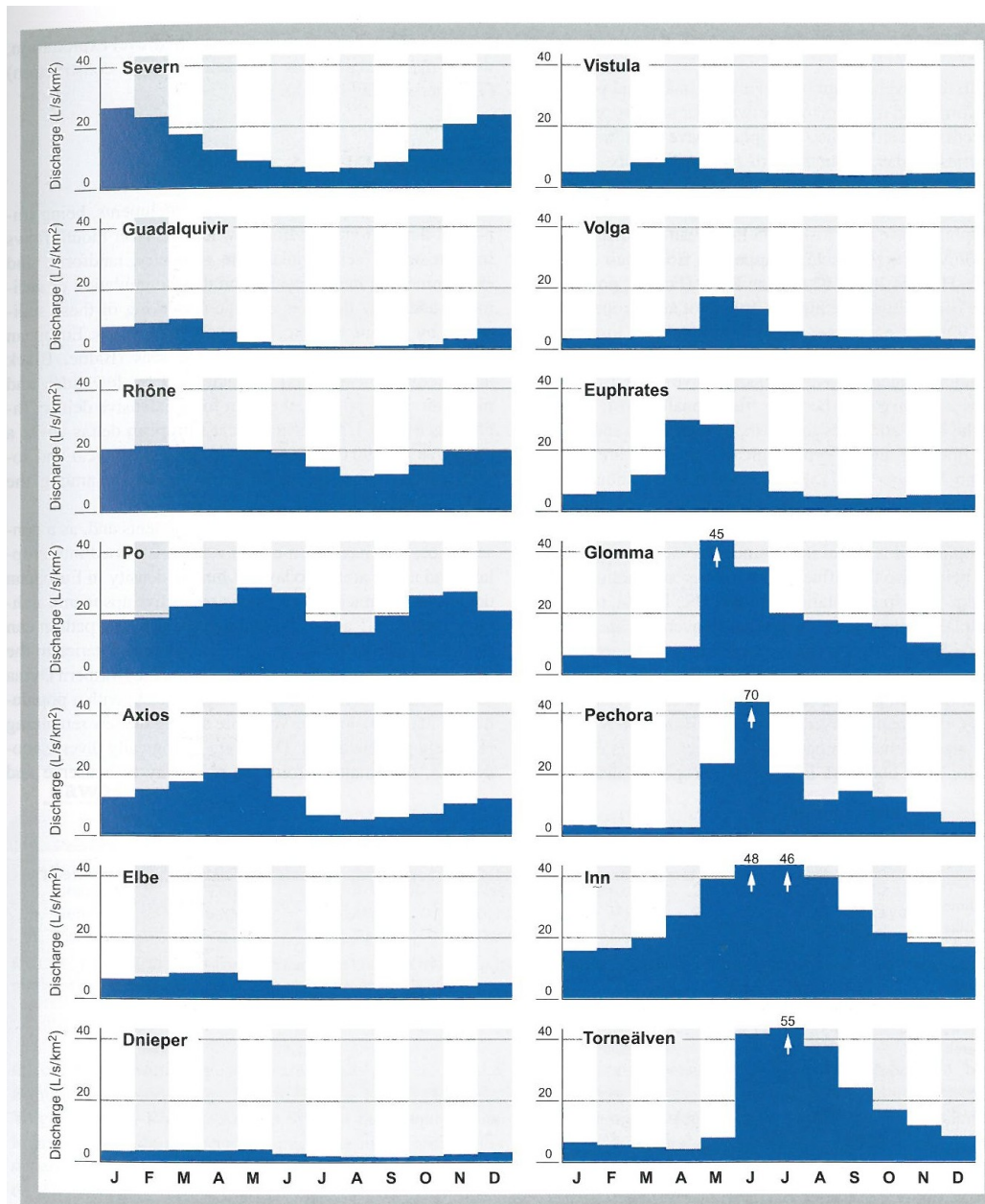
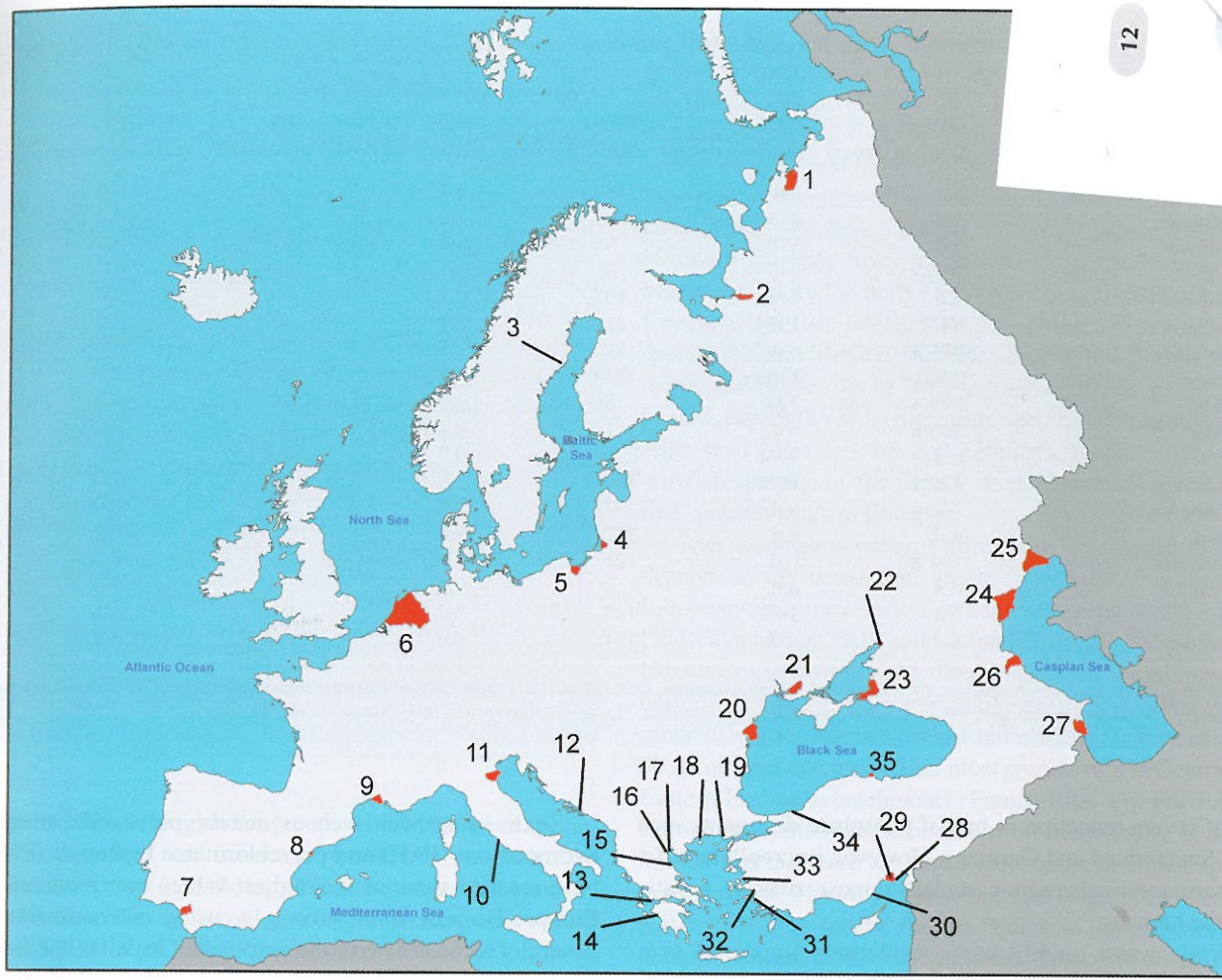
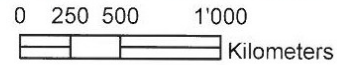


FIGURE 1.6 Seasonal distribution in catchment runoff (L/s/km²) for selected rivers distributed across Europe. Runoff includes the difference between precipitation, evapotranspiration and catchment topography (Data source: Global Water Runoff Data Center, GRDC, <http://grdc.bafg.de/servlet/is/2781/?lang=en>).



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- | | | | | | | |
|-------------------|-----------------|--------------|--------------|-------------|------------|---------------------|
| 1, Pechora | 6, Rhine | 11, Po | 16, Aliakmon | 21, Dnieper | 26, Terek | 31, Greater Meander |
| 2, Northern Dvina | 7, Guadalquivir | 12, Neretva | 17, Axios | 22, Don | 27, Kura | 32, Smaller Meander |
| 3, Umeälven | 8, Ebro | 13, Acheloos | 18, Nestos | 23, Kuban | 28, Ceyhan | 33, Gediz |
| 4, Nemunas | 9, Rhône | 14, Alfeios | 19, Evros | 24, Volga | 29, Seyhan | 34, Sakarya |
| 5, Vistula | 10, Tiber | 15, Pinios | 20, Danube | 25, Ural | 30, Göksu | 35, Kızılırmak |

FIGURE 1.7 Spatial distribution of 35 important European river deltas (K. Tockner et al., unpublished data). The delimitation of each delta is based on published literature, expert opinion, and a river networks DEM.

TABLE 1.2 Twenty of the largest river deltas in Europe (including Turkey and the Caucasus).

	Area (km ²)	Average temperature (°C)	Population (people/km ²)	Arable and Pasture (%)	Protected (%)
Rhine	25 347	9.2	492	66.2	0.9
Volga	11 446	10.3	53	68.4	24.7
Ural	8586	9.1	24	49.0	<0.1
Pechora	5490	-4.0	<1	1.4	26.3
Kuban	5422	11.7	63	51.5	20.3
Danube	4560	10.7	34	24.0	89.1
Kura	4175	15.5	78	17.6	20.6
Terek	4026	11.6	46	76.1	3.3
Po	2878	12.8	119	83.8	10.0
Dnieper	2833	8.7	80	78.8	7.4
N Dvina	2229	0.6	118	29.5	5.9
Guadalquivir	2213	17.6	152	60.8	31.9
Seyhan	1903	17.1	116	46.8	<0.1
Vistula	1858	7.7	187	85.7	<0.1
Rhone	1783	13.5	64	56.9	59.7
Nemunas	1088	6.7	24	60.0	18.6
Don	604	10.1	541	40.9	80.8
Kızılırmak	474	11.1	126	3.8	<0.1
Ebro	331	15.9	116	82.2	22.3
Nestos	319	12.5	53	29.5	14.6

Average annual temperature (1961–1990). Human population density: people per km². Protected: National parks, Ramsar sites, National nature reserves, and other nationally protected areas.
 For data sources and detailed explanation see Appendix.

TABLE 1.3 Estimated catchment yields for particulate and dissolved organic matter and nutrients for selected European rivers

	DIP (kg/km ² /year)	DIN (kg/km ² /year)	DOC (kg/km ² /year)	TSS (ton/km ² /year)	POC (ton/km ² /year)	PN (ton/km ² /year)	PP (ton/km ² /year)
Volga	2.39	n.d.	n.d.	18	0.2	0.0	0.0
Danube	30.21	n.d.	1152	86	1.0	0.1	0.0
Dnieper	2.96	n.d.	570	5	0.2	0.0	0.0
Don	13.60	19.1	245	5	0.1	0.0	0.0
N Dvina	5.65	n.d.	1494	10	0.4	0.1	0.0
Pechora	5.94	64.7	1954	21	0.5	0.1	0.0
Vistula	36.98	371.8	n.d.	14	3.1	0.4	0.1
Rhine	119.32	2200.4	1388	21	2.4	0.4	0.1
Elbe	63.94	795.4	753	6	1.6	0.2	0.1
Oder	32.61	389.8	n.d.	1	0.4	0.1	0.0
Loire	30.95	n.d.	1065	4	0.7	0.1	0.0
Kuban	25.88	330.9	1044	120	1.0	0.2	0.0
Nemunas	9.42	74.1	n.d.	7	0.6	0.1	0.0
Ebro	2.34	n.d.	n.d.	217	1.6	0.2	0.1
Glomma	16.06	191.8	n.d.	321	1.5	0.2	0.1
Kymijoki	3.95	n.d.	n.d.	3	0.3	0.1	0.0
Po	77.18	n.d.	3046	147	3.2	0.4	0.1
Seyhan	4.21	n.d.	n.d.	151	n.d.	n.d.	n.d.

DIP: dissolved inorganic phosphorus, DIN: dissolved inorganic nitrogen, DOC: dissolved organic carbon, TSS: total suspended solids, POC: particulate organic carbon, PN: particulate nitrogen, PP: particulate phosphorus. n.d.: no data. (Sources: Beusen et al. 2005; Dumont et al. 2005; Harrison et al. 2005).

TABLE 1.4 Global and European freshwater fauna species richness (after Lévêque et al. 2005; Balian et al. 2008)

Group	World	Europe	Proportion of global (%)
Bivalvia	1000	50	5
Gastropoda	4000	163	4
Ostracoda	2000	400	20
Copepoda	2085	902	43
Amphipoda	1700	350	21
Ephemeroptera	>3000	350	<10
Odonata	5500	150	3
Plecoptera	2000	423	21
Trichoptera	>10 000	1724	<17
Hemiptera	3300	129	4
Coleoptera	>6000	1077	<18
Diptera	>20 000	4050	<20
Lepidoptera	>1000	5	<1
Hymenoptera	>130	74	<56
Megaloptera	300	6	2
Pisces	>13 000	400	<3
Amphibia	5504	74	1
Aves	1800	253	14
Total	>82 500	10 580	<13

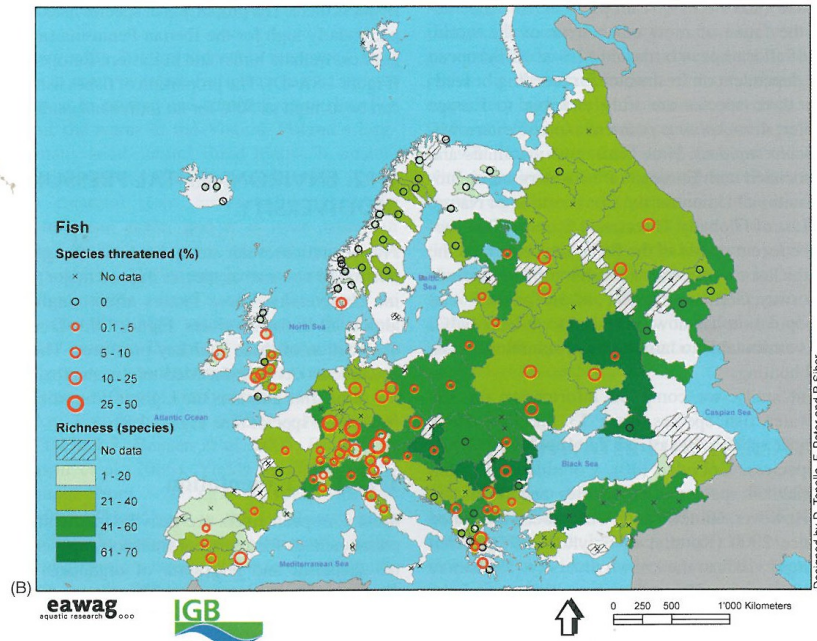
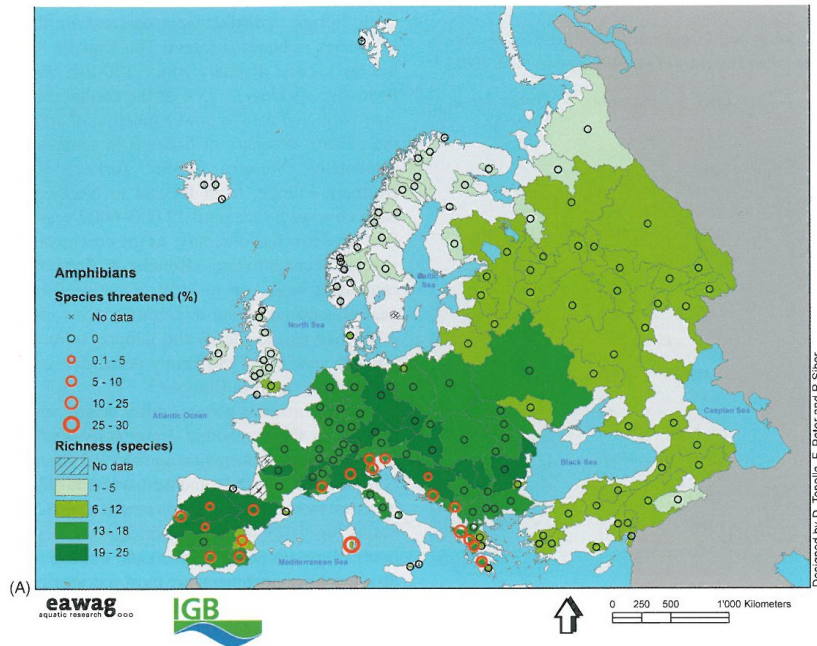
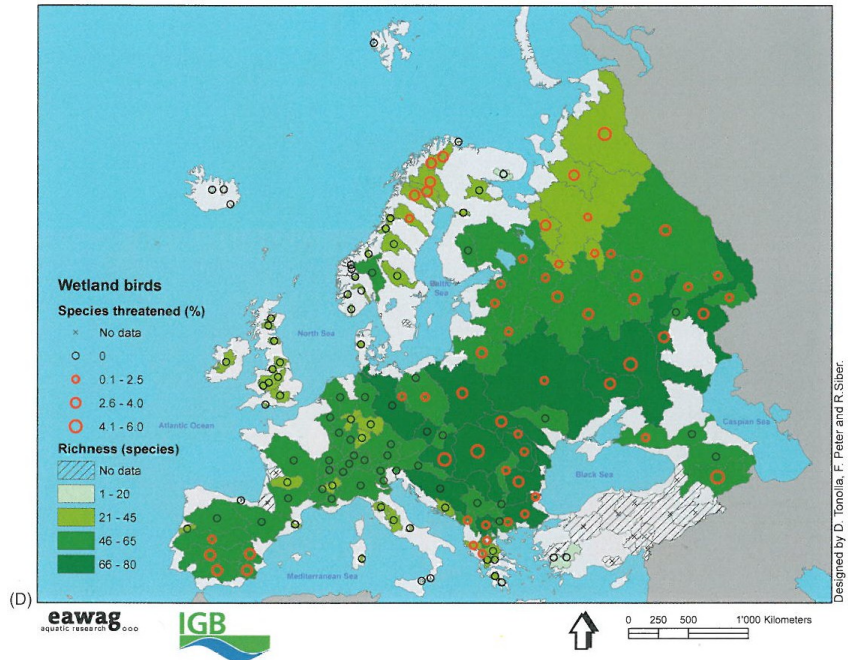
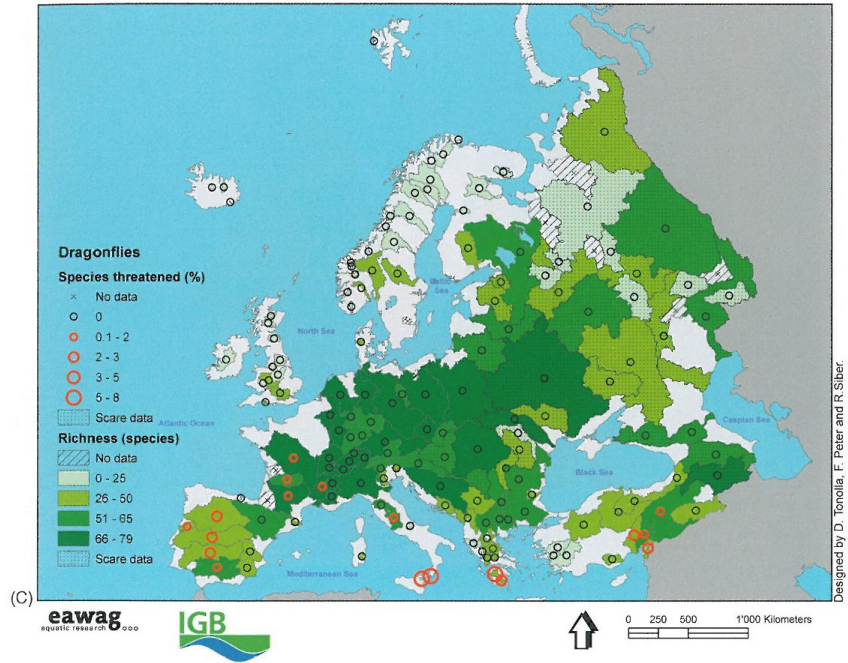


FIGURE 1.8 Species richness and relative proportions (%) of threatened species for each individual catchment: (A) Amphibians; (B) Fish; (C) Dragonflies; (D) Wetland birds. Data sources: see Appendix. Catchments are not always identical with catchments in Figure 1.2.



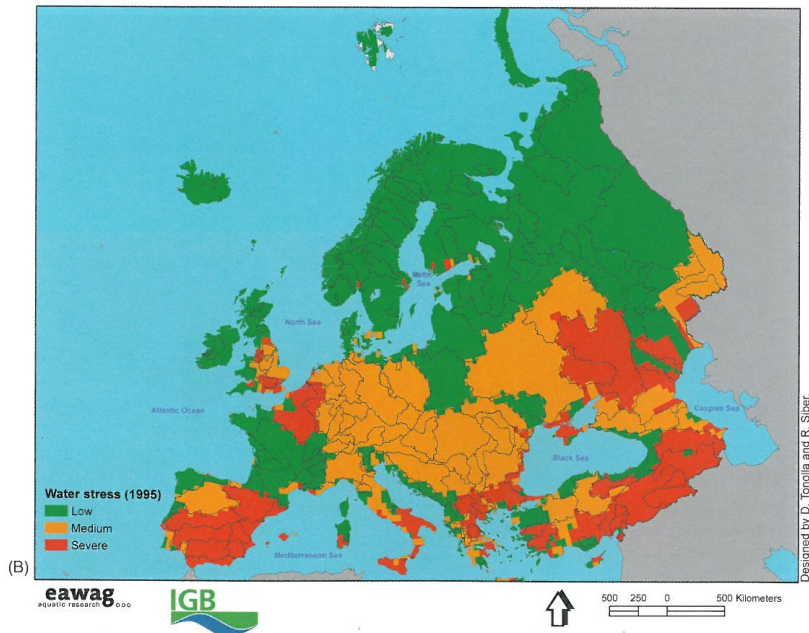
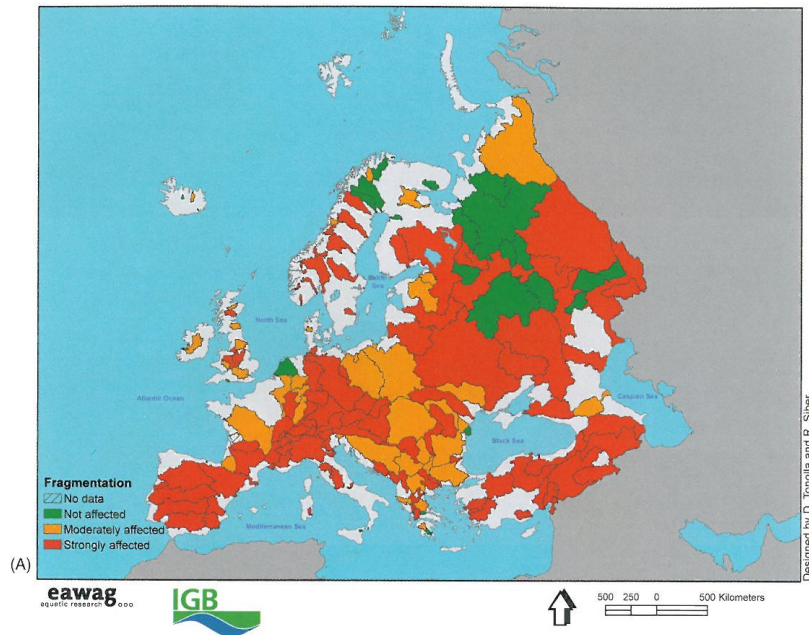
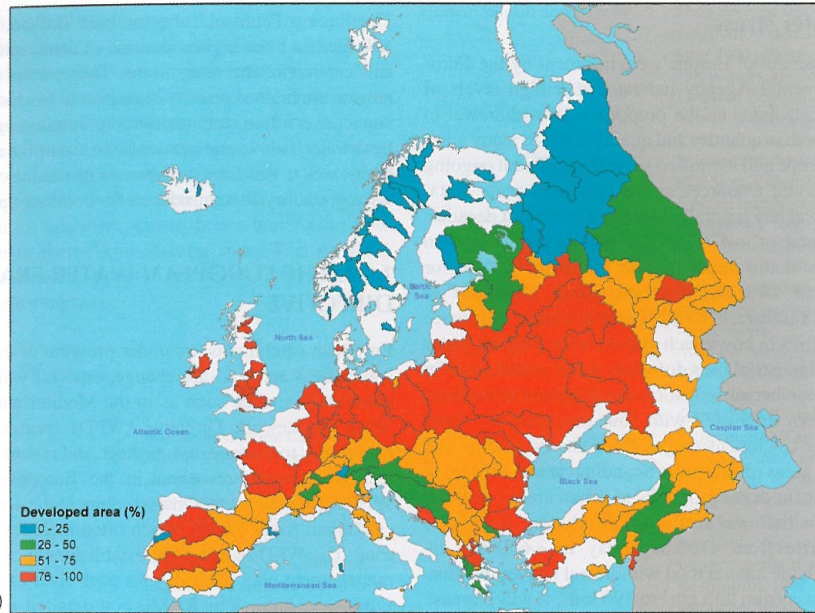


FIGURE 1.9 (A) Degree of fragmentation, (B) water stress as the proportion of withdrawal to availability, (C) developed area (urban, arable and pasture in % of the catchment), (D) relative proportion (%) of non-native fish species (Peter 2006). Data sources: see Appendix. Catchments are not always identical with catchments in Figure 1.2.



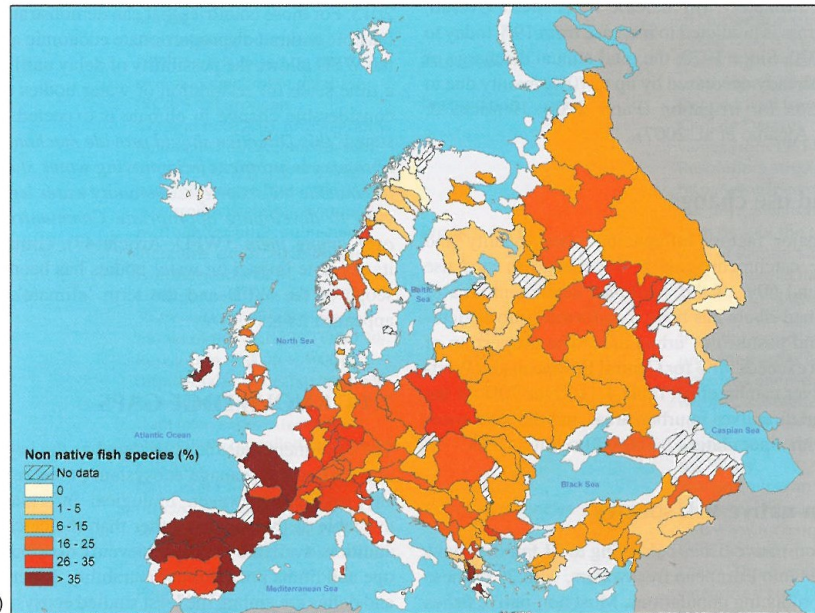
(C)

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(D)

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500 250 0 500 Kilometers

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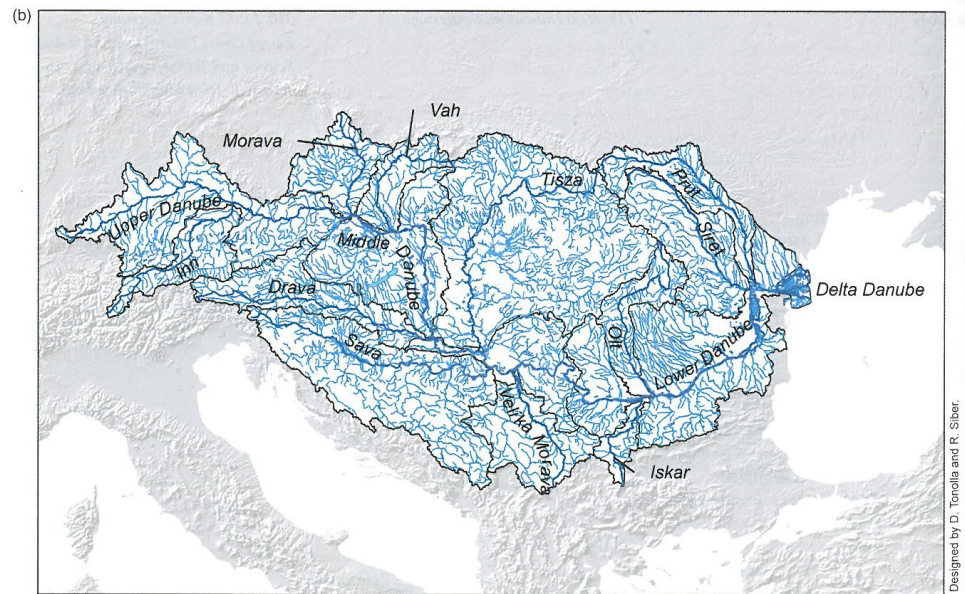


FIGURE 3.1 Digital elevation model (upper panel) and drainage network (lower panel) of the Danube River Basin.

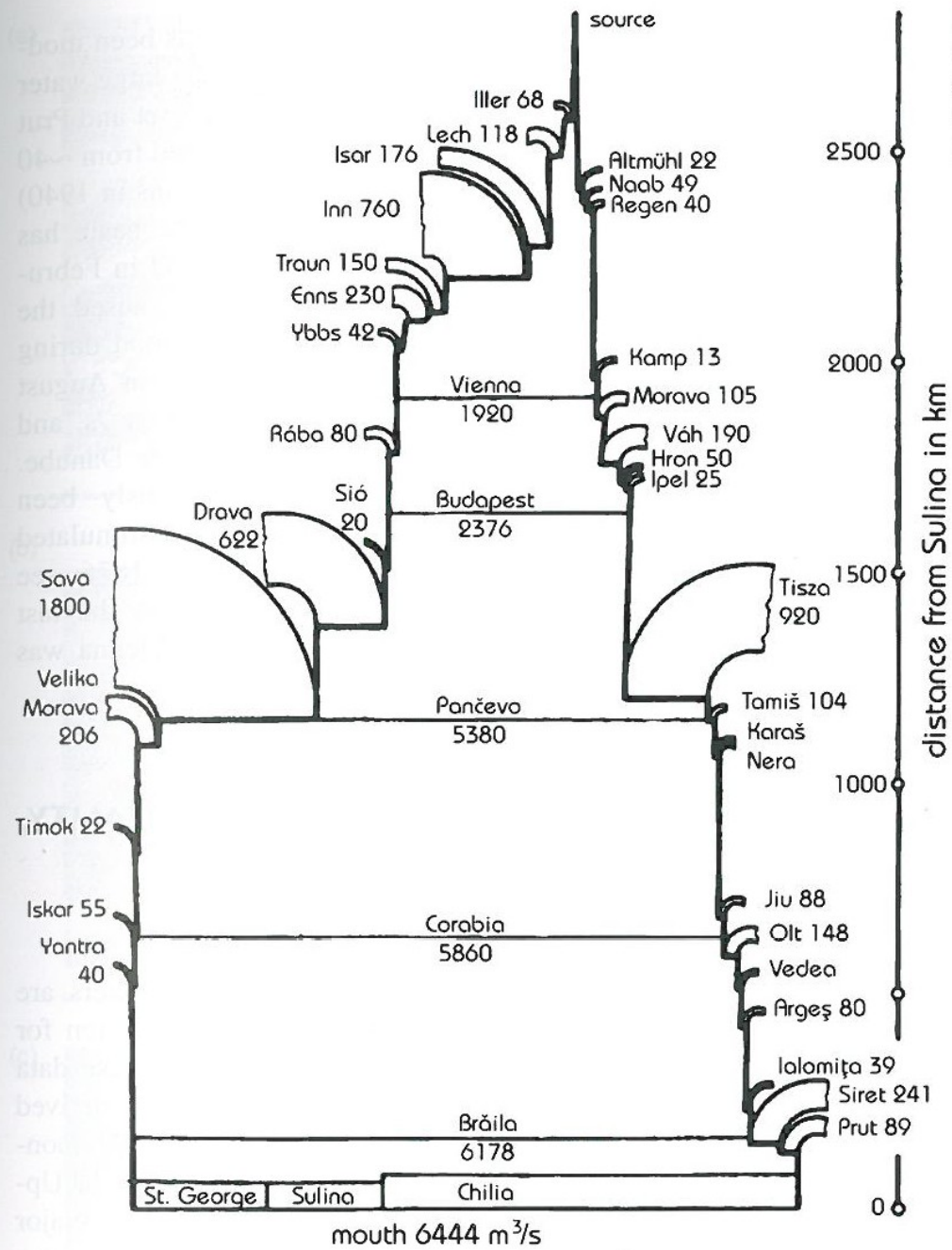


TABLE 3.4 Flood plain loss in the Danube River Basin

River stretch	Morphological floodplain (km ²)	Recent floodplain (km ²)	Loss
Upper Danube	1762	95	95%
Middle/Central Danube	8161	2002	75%
Lower Danube	7862	2200	72%
Danube delta	5402	3799	30%
In total	23 187	8096	65%
cf. River Rhine	8000	1200	85%

Data from Schneider (2002).

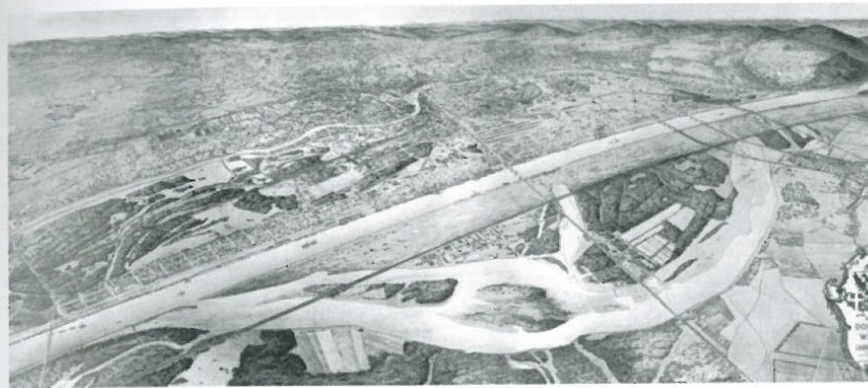
(a)



Die Donau bei Wien 1848

The Danube i

(b)



Die Donau bei Wien 1888

The Danube in

(c)



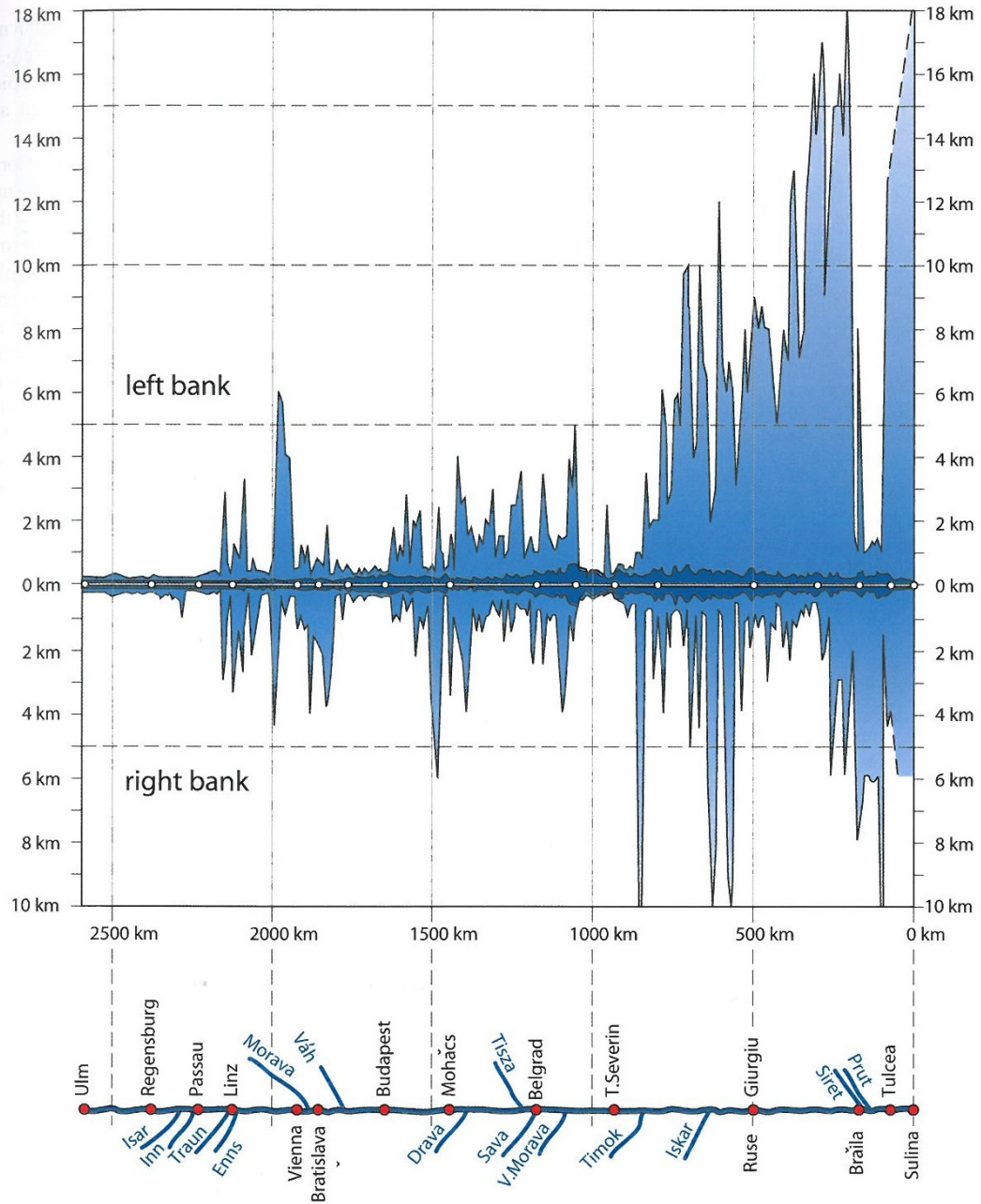


FIGURE 3.8 Extension of former inundation areas along the Danube River (area shaded in light blue)(from Ulm, Germany, downstream to the mouth). Dark blue band marks the average width of the main river channel based on Lászlóffy (1967) and modified after Tockner et al. (1998).

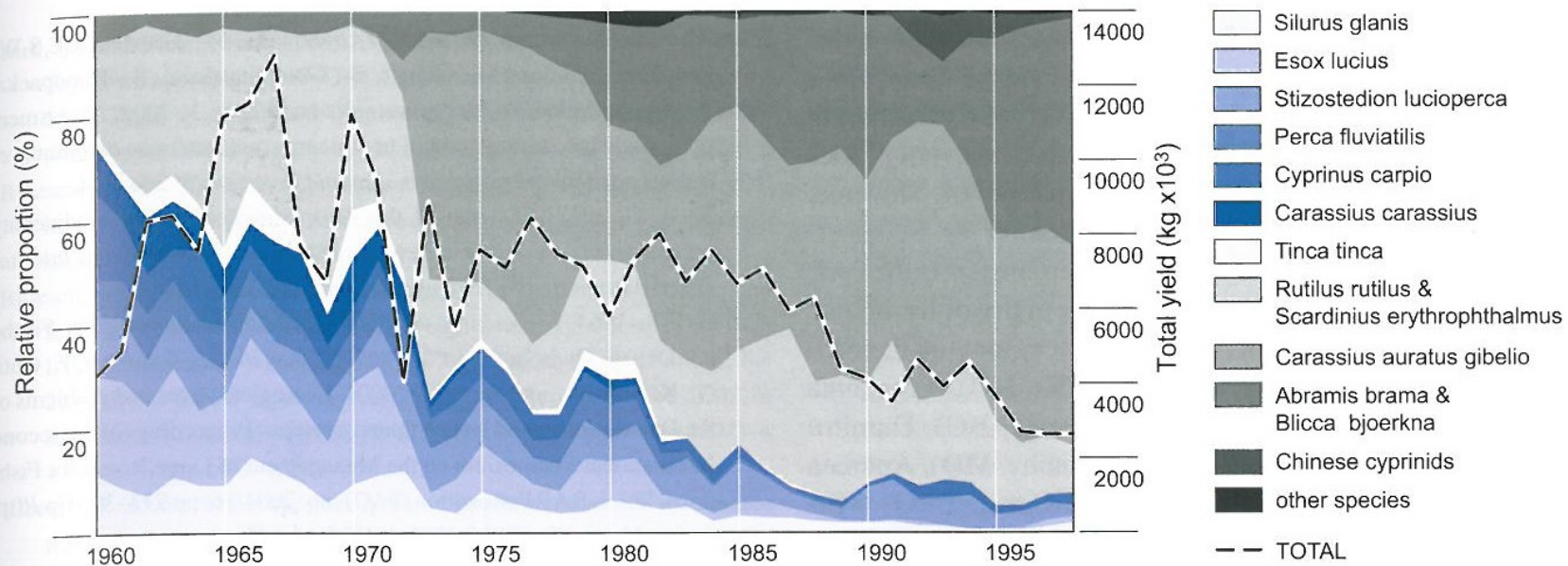
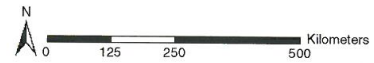
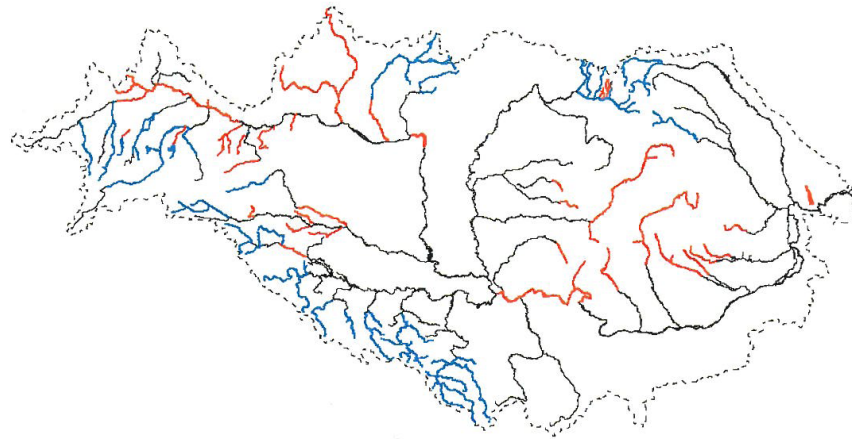


FIGURE 3.9 Total yield (dashed line; right axis) and relative proportion of species (left axis) of the commercial freshwater fishery in the lakes of the Danube delta (1960–1998; redrawn from Navodaru et al. 2002).

(a) **Legend**

■ Present occurrence
■ Past occurrence



(b) **Legend**

■ Present occurrence
■ Past occurrence

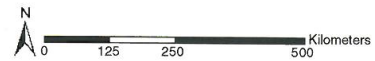
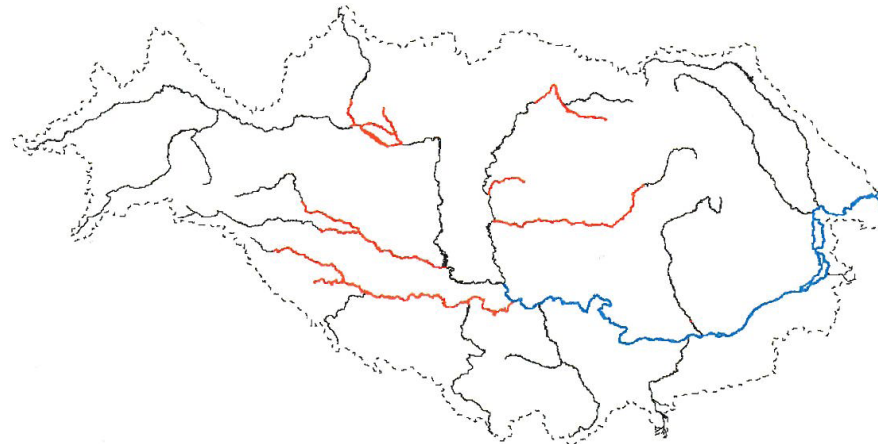


FIGURE 3.6 Past and present spatial distribution of huchen (*Hucho hucho*) (a) and sturgeon (*Acipenseridae*) (b) within the Danube River Basin, after Holčík et al. (1989) and Reinartz (2002). Maps produced by D. Tonolla.

Water quality of the Danube and its tributaries 2002



River quality classes

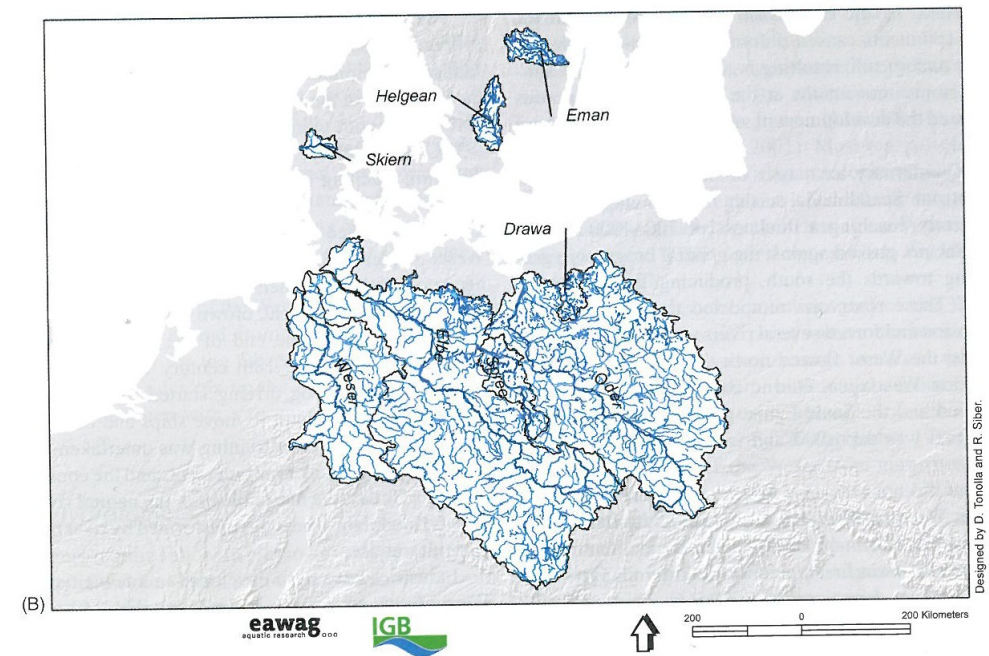
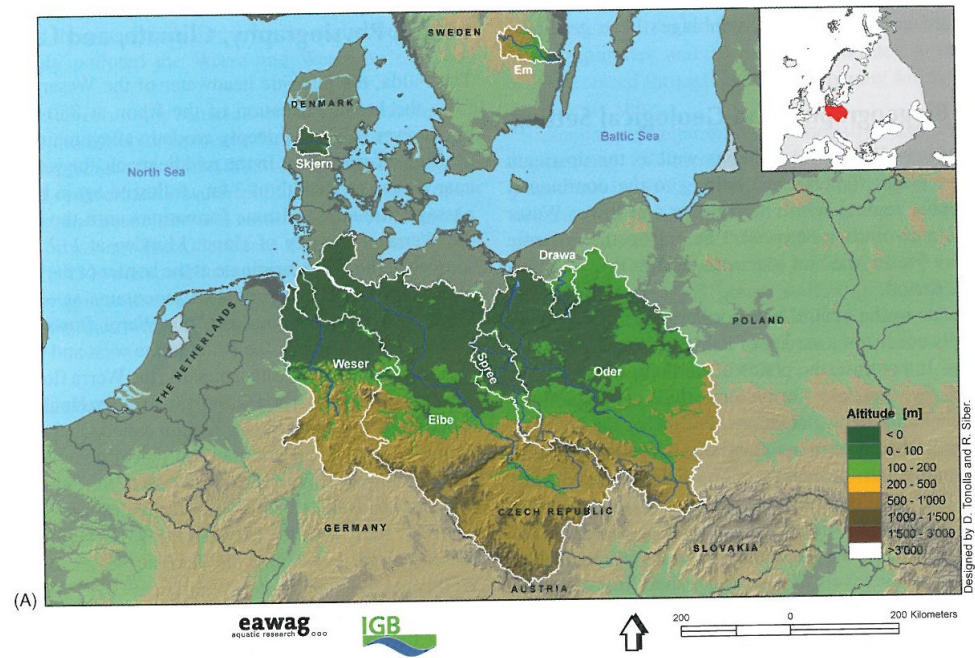
<p>I: Unpolluted to very slightly polluted (oligosaprobic)</p> <p>River reaches with clear water with oxygen permanently near saturation level and low nutrient (exceedable bacteria) concentration; moderately diverse colonization mainly by algae, mosses, filamentous and fixed larvae; water cool in summer; suitable for spawning of salmonids.</p>	<p>II-III: Slightly polluted (oligosaprobic to beta-mesosaprobic)</p> <p>River reaches with low inorganic nutrient inputs and without significant oxygen consumption; densely colonized with mostly high species diversity; water cool in summer; suitable for spawning of salmonids.</p>	<p>II-IV: Critically polluted (beta-mesosaprobic to alpha-mesosaprobic)</p> <p>River reaches where lack of organic oxygen depleting substances cause critical conditions possible fish kills; decreasing number of macrophyte species; tendency to outbreaks of some plant and animal species.</p>	<p>III-IV: Very heavily polluted (alpha-mesosaprobic to polysaprobic)</p> <p>River reaches with extremely modified living conditions for higher life forms; the very high organic pollution often causes total oxygen depletion; turbidity due to suspended wastewater constituents; widespread sapropteric deposits; densely colonized by chironomid larvae and oligochaetes.</p>
<p>I-II: Moderately polluted (beta-mesosaprobic)</p> <p>River reaches with moderate pollution and good oxygen supply; very high species diversity and abundance of algae, snails, earthworms, insect larvae; aquatic plants may cover wide areas; high fish diversity.</p>	<p>II: Heavily polluted (alpha-mesosaprobic)</p> <p>River reaches with heavy organic pollution; the usually low oxygen content is often insufficient for higher water organisms like fish; local sludge deposition; mass occurrences of sewage bacteria and ciliates; occasionally also sponges, leeches, and isopods; sparse aquatic vegetation.</p>	<p>IV: Excessively polluted (polysaprobic)</p> <p>River reaches with excessive pollution by organic oxygen depleting wastewater; bacteria, flagellates and ciliates dwell on widespread sapropteric banks; often total absence of oxygen, so that survival of higher life-forms is locally and temporarily limited.</p>	<p>Legend:</p> <ul style="list-style-type: none"> Green: I: Unpolluted to very slightly polluted (oligosaprobic) Light Green: I-II: Moderately polluted (beta-mesosaprobic) Yellow-Green: II-III: Slightly polluted (oligosaprobic to beta-mesosaprobic) Yellow: II: Heavily polluted (alpha-mesosaprobic) Orange: II-IV: Critically polluted (beta-mesosaprobic to alpha-mesosaprobic) Red-Orange: III-IV: Very heavily polluted (alpha-mesosaprobic to polysaprobic) Red: IV: Excessively polluted (polysaprobic)
<p>More explanations overleaf</p>			

HUBER
TECHNOLOGY

MAX BÖGL
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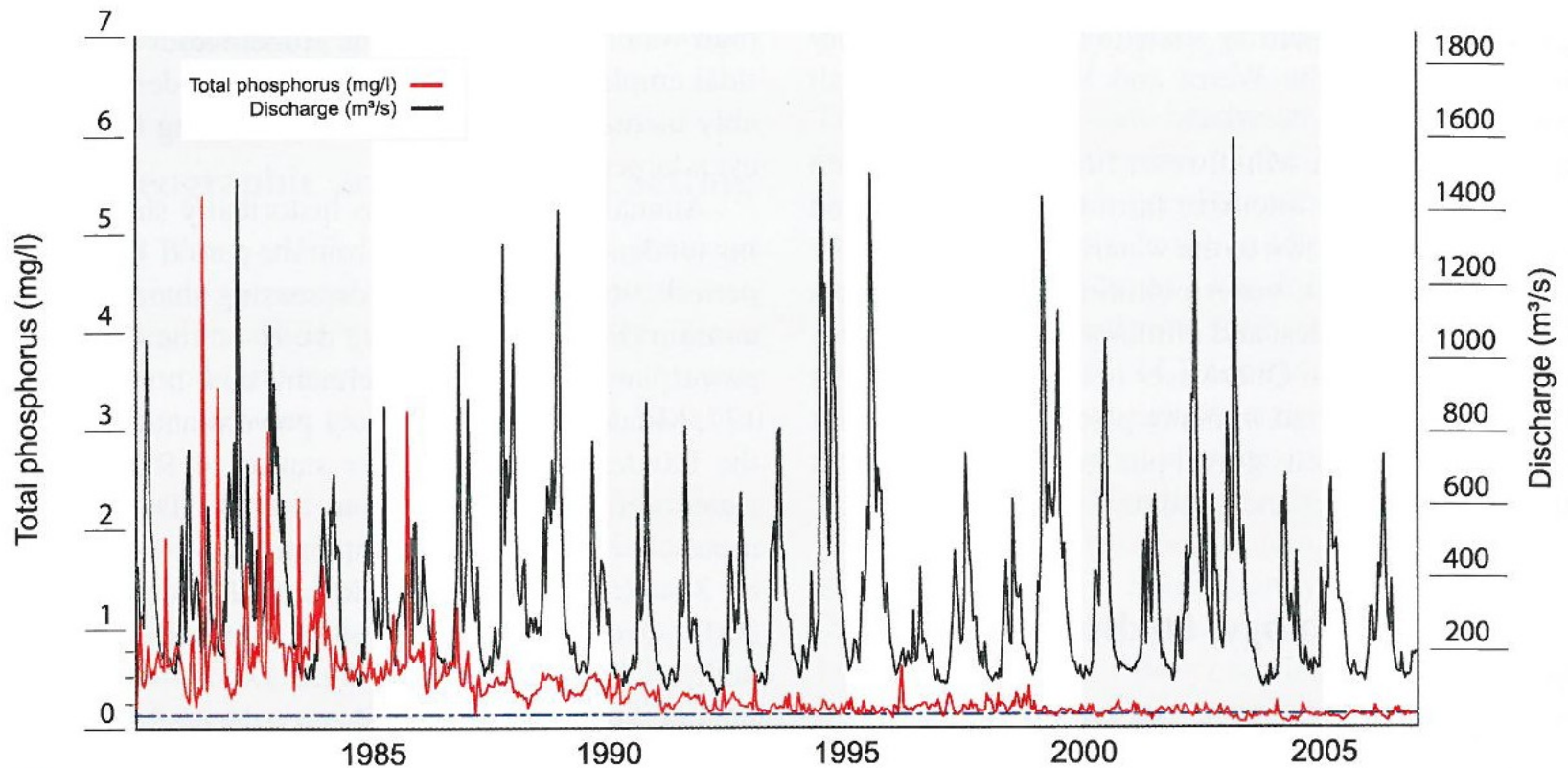
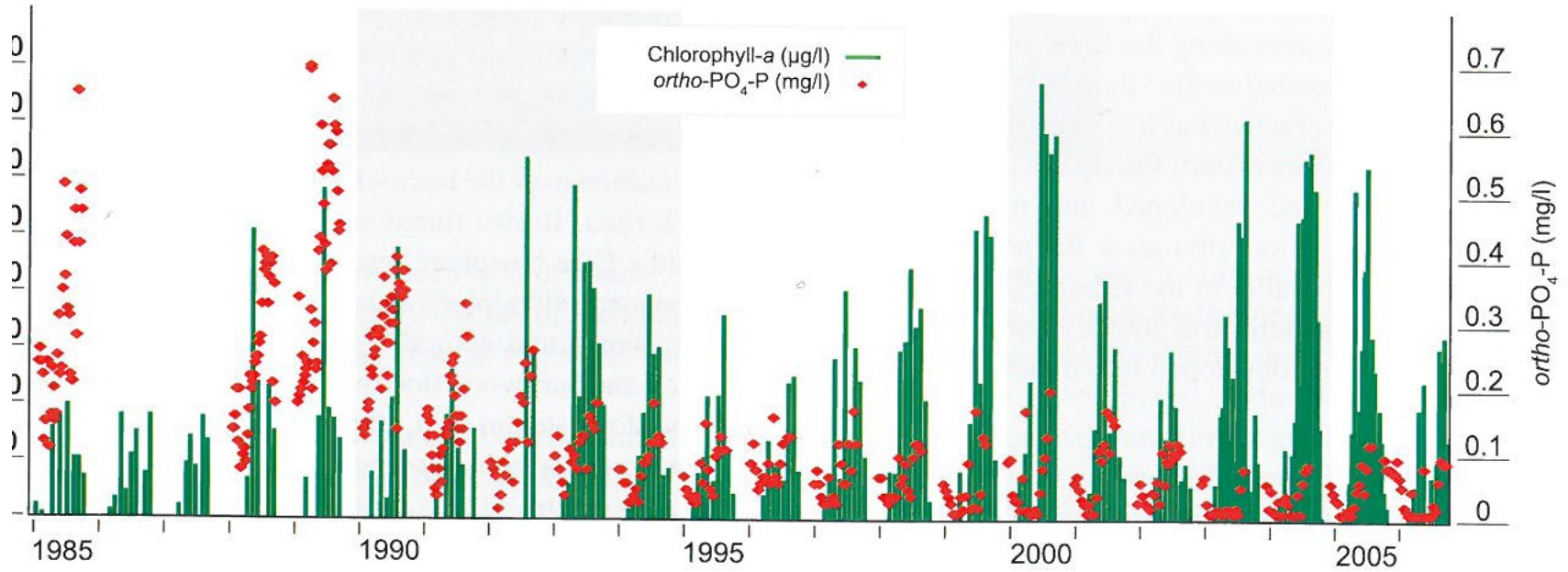
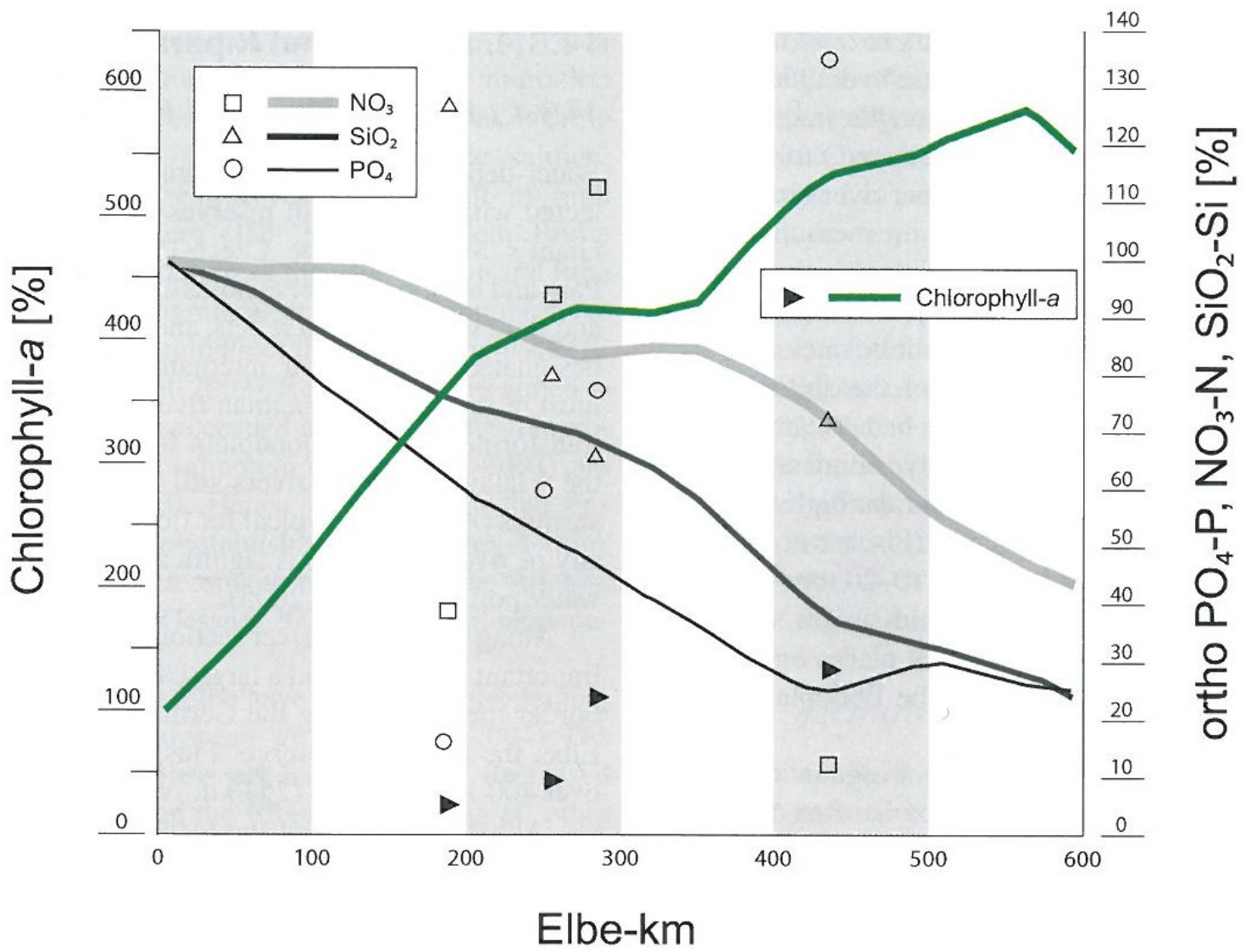


FIGURE 14.2 Long-term dynamics of phosphorous concentrations and discharge at the Bremen/Hemeligen measuring station (data: FGG Weser).



14.6 Long-term development of the concentrations of chlorophyll-*a* and ortho-phosphate at the measuring station Schnackenburg (Rkm 475, downstream of Hamburg; data by ARGE Elbe).



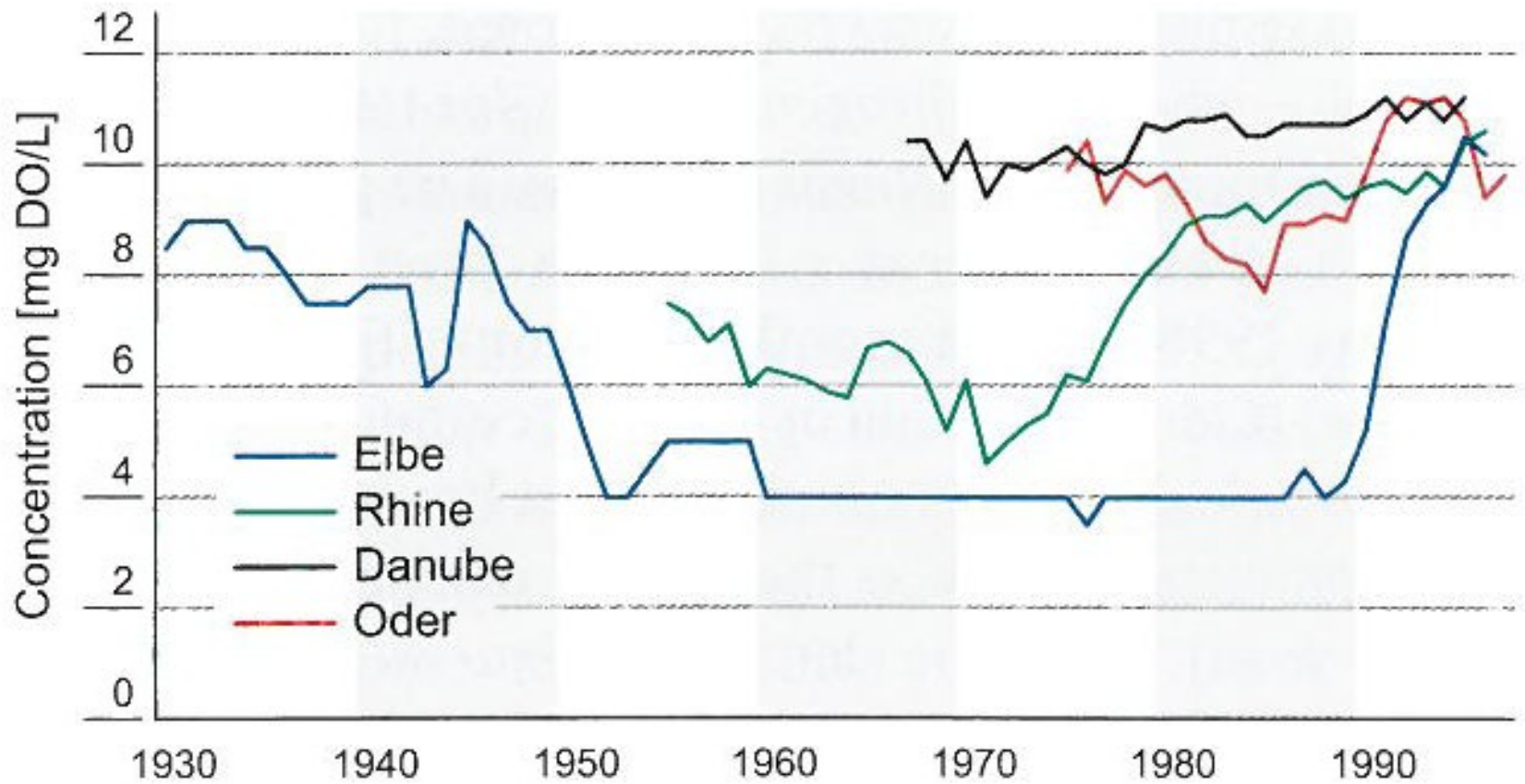


FIGURE 14.16 Historic course of dissolved oxygen concentrations in major rivers of central Europe (Graph: F. Schöll, BfG).

TABLE 14.2 Invasive benthic invertebrates in the Oder, with geographic origin

Species name	Original ecoregion
<i>Cordylophora caspia</i>	Pontocaspis
<i>Dugesia tigrina</i>	North America
<i>Ferrissia wauteri</i>	Southwest Europe
<i>Lithoglyphus naticoides</i>	Pontocaspis
<i>Physella acuta</i>	Southwest Europe
<i>Potamopyrgus antipodarum</i>	New Zealand
<i>Viviparus viviparus</i>	East-Europe
<i>Corbicula fulminea</i>	Asia
<i>Dreissena polymorpha</i>	Pontocaspis
<i>Branchiura sowerbyi</i>	South Asia
<i>Hemimysis anomala</i>	Pontocaspsis
<i>Limnomysis benedeni</i>	Pontocaspis
<i>Echinogammarus ishnus</i>	Pontocaspis
<i>Chelicorophium curvispinum</i>	Pontocaspis
<i>Dikerogammarus villosus</i>	Pontocaspis
<i>Dikerogammarus haemobaphes</i>	Pontocaspis
<i>Pontogammarus robustoides</i>	Pontocaspsis
<i>Gammarus tigrinus</i>	North America
<i>Obesogammarus crassus</i>	Pontocaspis
<i>Orconectes limosus</i>	North America
<i>Erichoeir sinensis</i>	East Asia



- Invazní blešivci
- Corophium
 - Dikerogammarus
 - Echinogammarus





Invazní měkkýši



Invazní rakovci





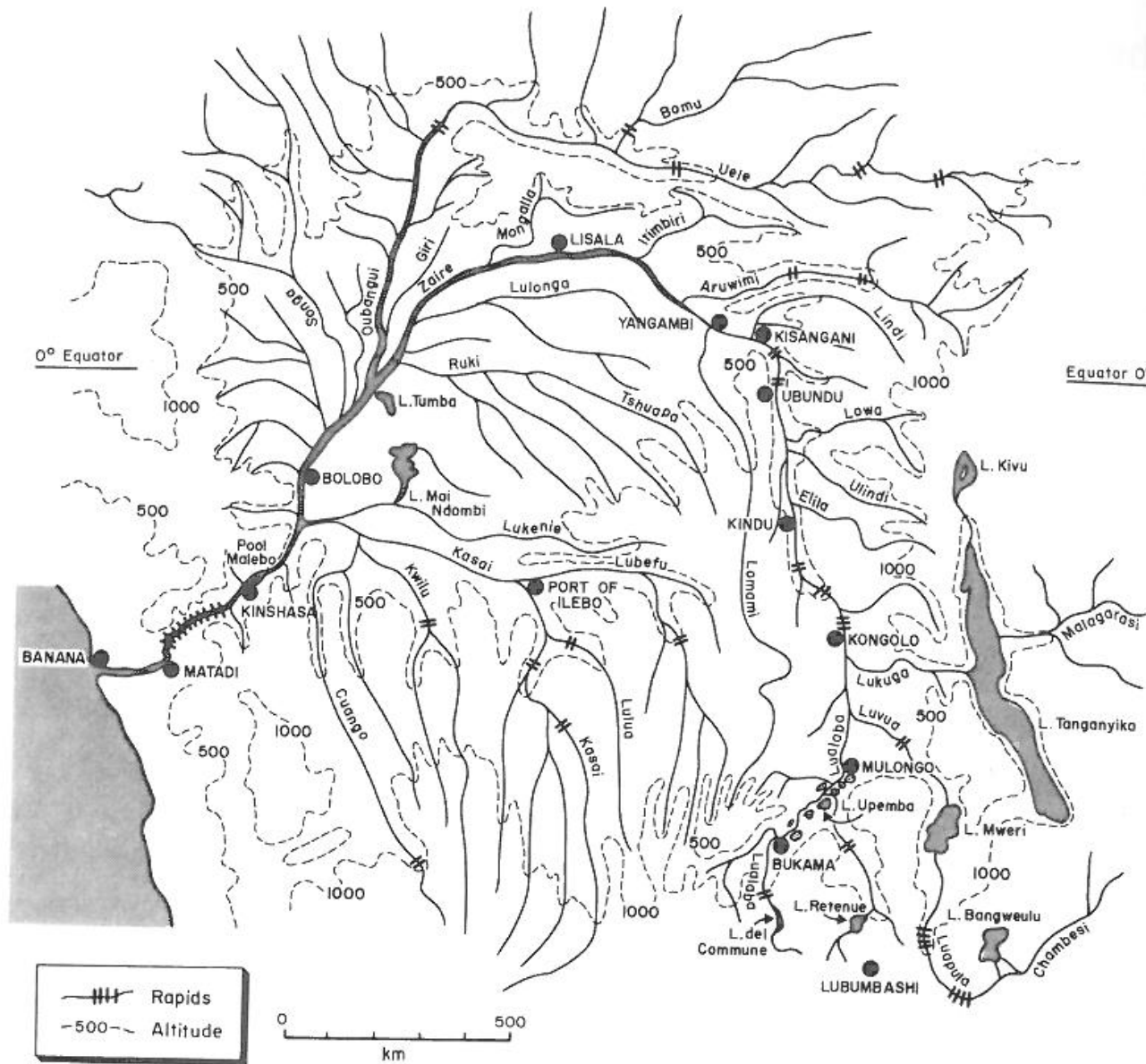


Figure 1. Some geographic features of the Zaire Basin. Contours are metres AMSL.









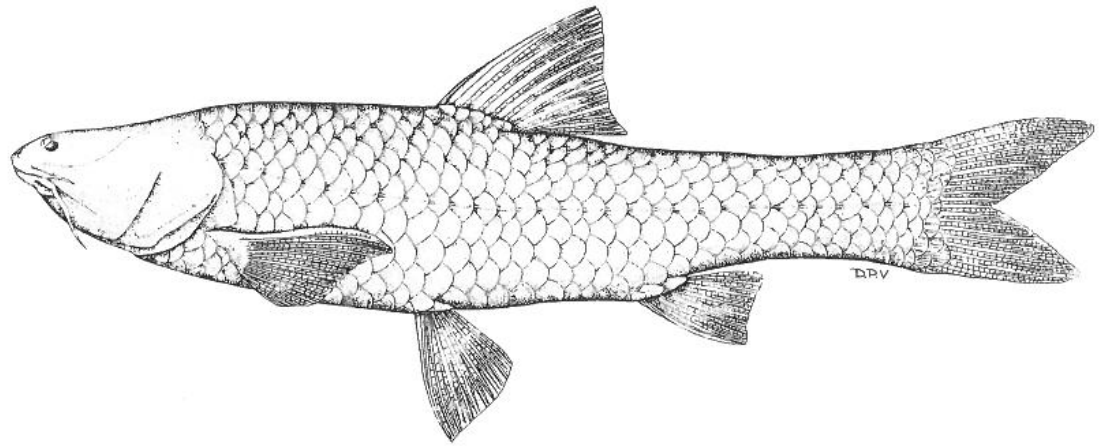


Figure 2. *Caecobarbus geertsi*, the blind cave barb from caves near Thysville.

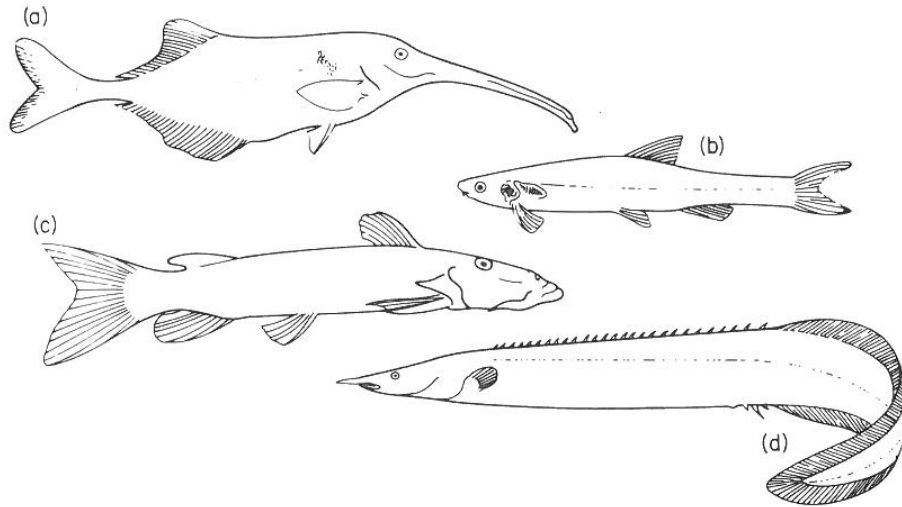


Figure 1. Fish of the Zaire system. (a) *Campylomormyrus rhynchophorus*, (b) *Kneria auriculata*, (c) *Euchilichthys royauxi*, (d) *Mastacembelus* sp.







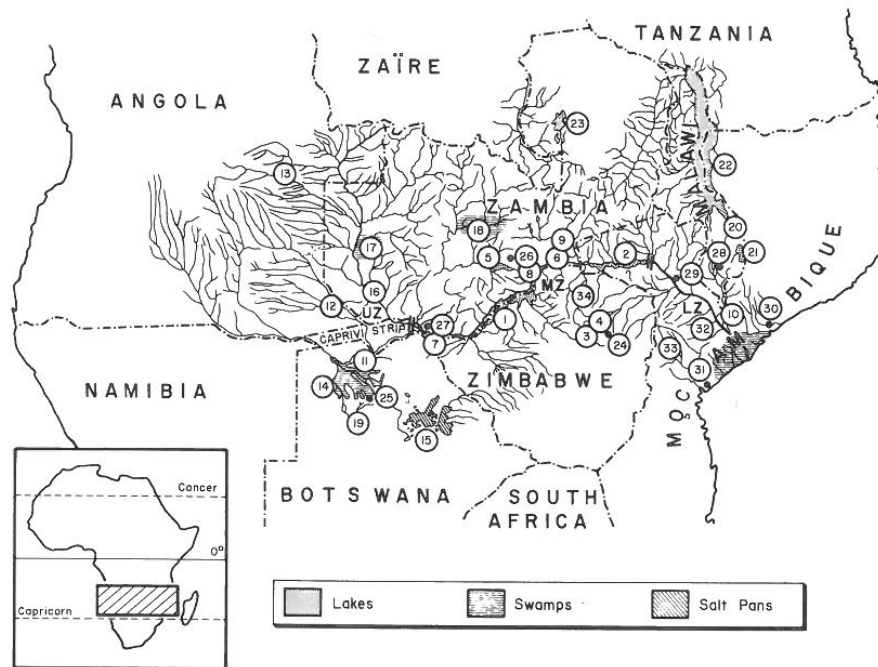


Figure 1. Geographic features of the Zambezi River System. Key: UZ, Upper Zambezi, eastern boundary at Victoria Falls (paired vertical lines); MZ, Middle Zambezi, eastern boundary at the Cahora Bassa Gorge (paired vertical lines); LZ, Lower Zambezi.

- | | |
|---|------------------------|
| 1. L. Kariba | 18. Lukanga Swamps |
| 2. L. Cahora Bassa | 19. L. Ngami |
| 3. L. Darwendale | 20. L. Malombi |
| 4. L. McIlwaine | 21. L. Chilwa |
| 5. L. Kafue | 22. L. Malawi |
| 6. Proposed Mupata Gorge project | 23. L. Bangweulu |
| 7. Proposed Batoka Gorge project below Victoria Falls | 24. Harare (Salisbury) |
| 8. Kafue R. | 25. Maun |
| 9. Luangwa R. | 26. Lusaka |
| 10. Shiré R. | 27. Livingstone |
| 11. Chobe R. | 28. Blantyre |
| 12. Kwando (Cuando) R. | 29. Tete |
| 13. Lungwebungu R. | 30. Quelimane |
| 14. Okavango Swamps | 31. Beira |
| 15. Makgadikgadi Pans | 32. Zangué R. |
| 16. Barotse Floodplain | 33. Pungoé R. |
| 17. Luena Flats | 34. Hunyani R. |

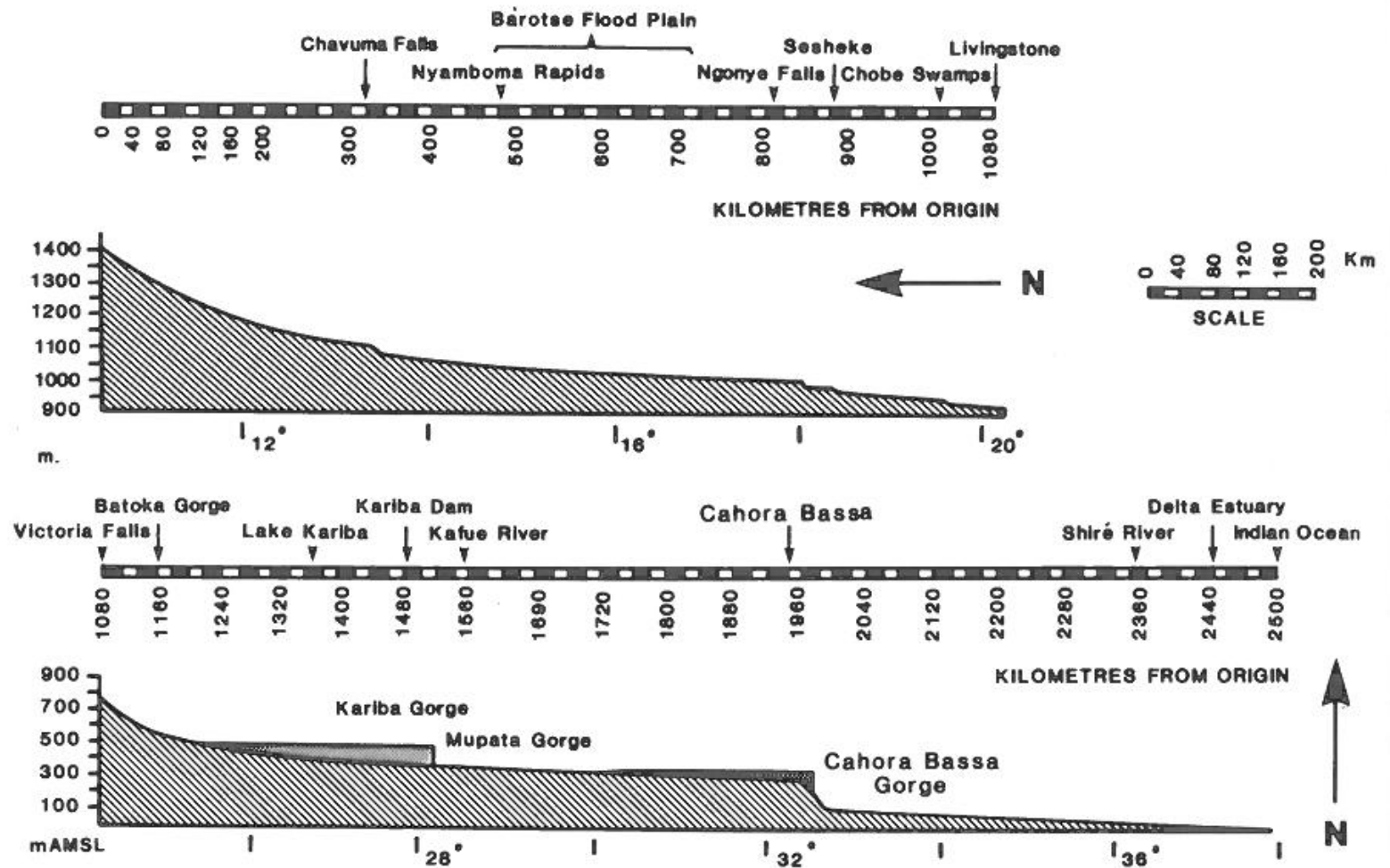


Figure 3. Profile of the Zambezi system (after Balon & Coche 1974).

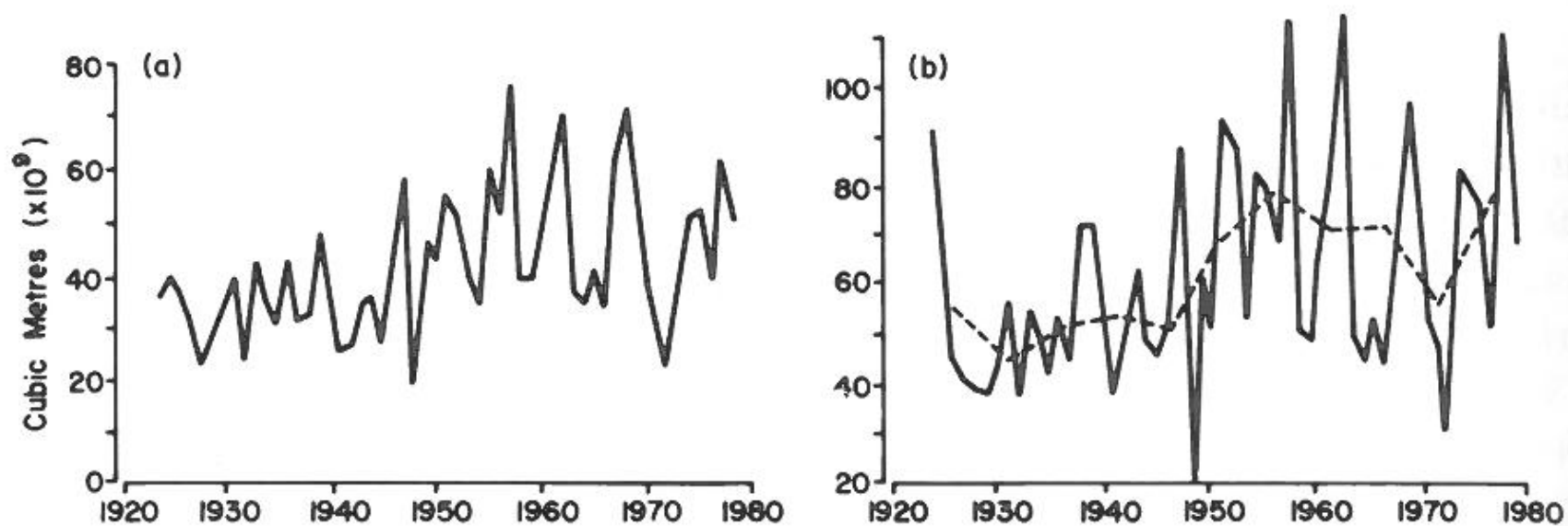
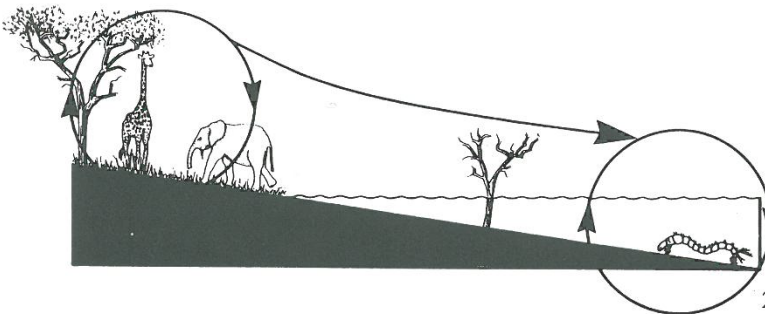
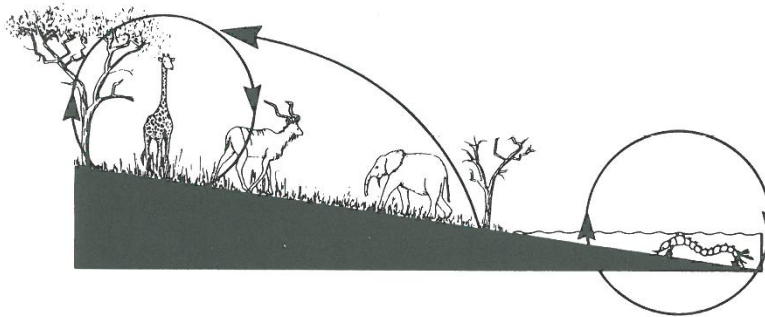
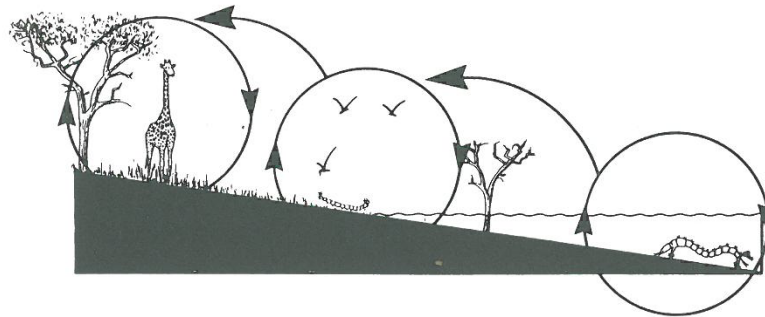
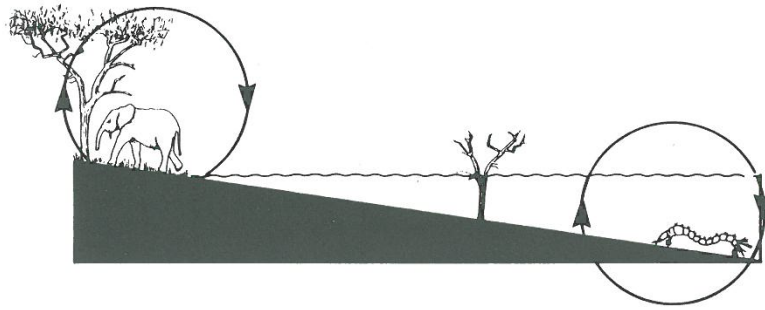


Figure 4. (a) Mean annual runoff as $\text{m}^3 \times 10^9$ from the Upper Zambezi catchment (above Victoria Falls), over 1924–79. From Central African Power Corporation records (1978, 1981). (b) Mean annual runoff ($\text{m}^3 \times 10^9$); “potential” (unbroken line) and mean “potential” (broken line) flow summed over 5-y periods between 1924–79, for the Upper Zambezi, the Kariba Catchment below Victoria Falls and the Kafue catchment (i.e. the potential supply to L. Cahora Bassa and the Lower Zambezi, excluding the Luangwa inflow). These figures exclude evaporation and rainfall effects of Lake Kariba and the Kafue Hydro-Electric schemes (after R. Du Toit 1982).



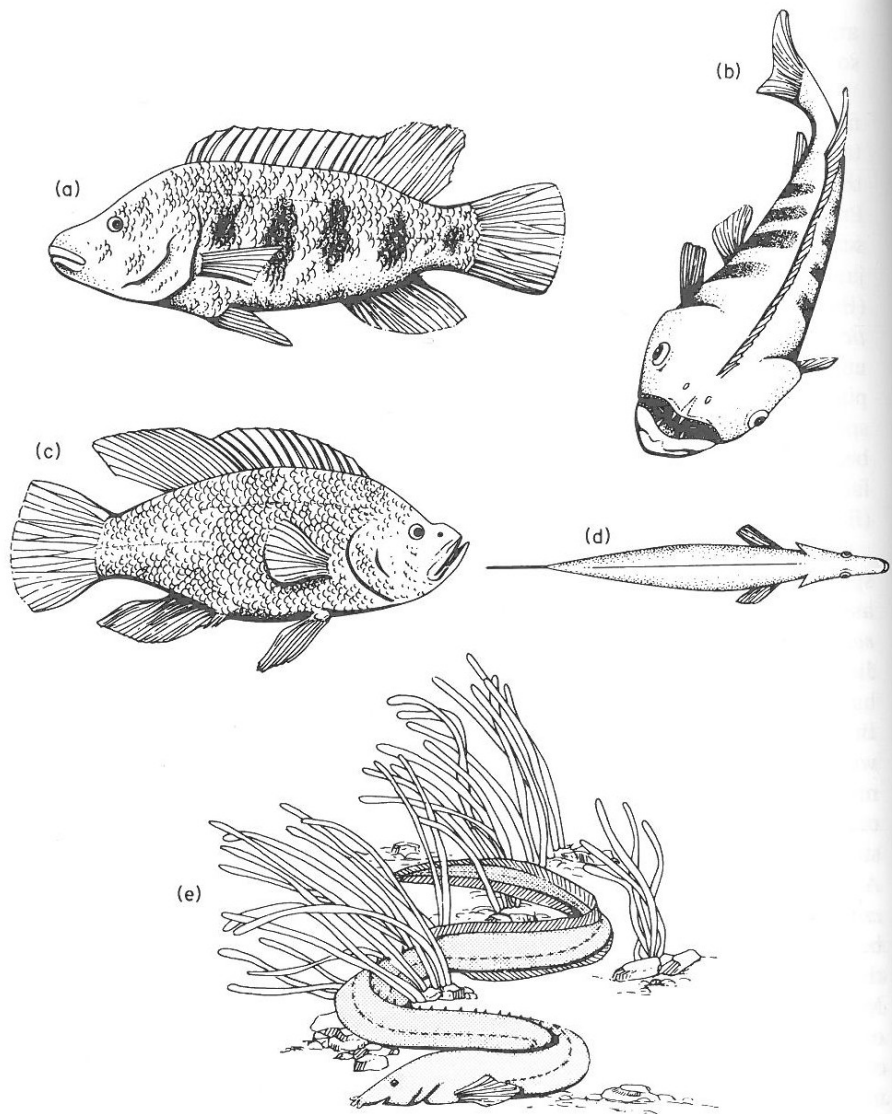


Figure 2. Adaptations of predators to Zambezi floodplain environments. (a)–(b) *Hemichromis elongatus* takes a toll of smaller fish, seizing them with the two pointed canines in each jaw. (c)–(d) The upturned jaw, narrow profile and protrusible mouth of *Serranochromis angusticeps*, another voracious floodplain predator, enables it to attack top minnows, small *Barbus* and other prey from below. (e) The eel-like shape of *Afromastacembelus frenatus* allows it to lurk in the most dense vegetation, capturing small crustaceans and insects. It may hide among rocks in deeper water.

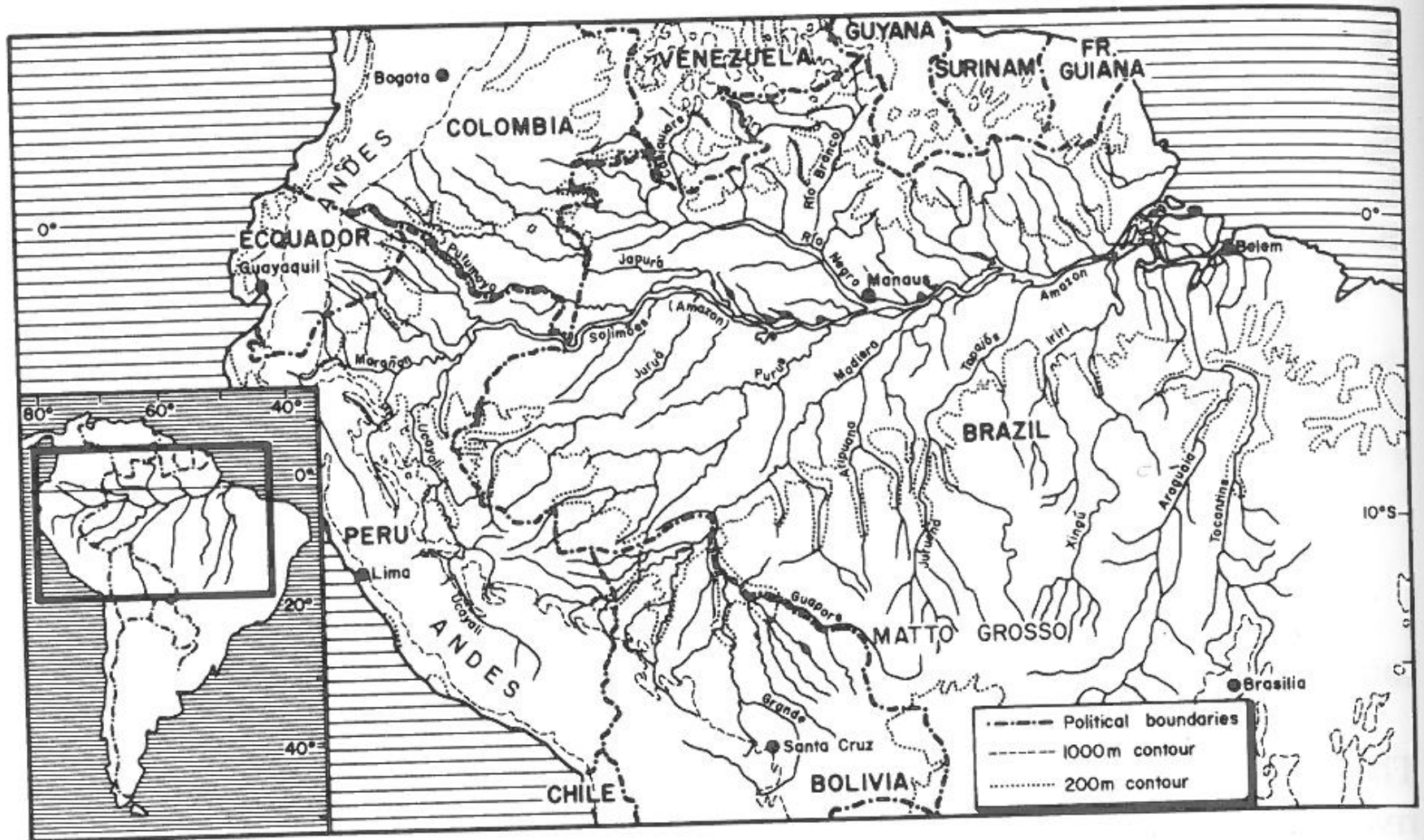


Figure 1. Major geographic features of the Amazon Basin.

Table 2. Selected climatic data for various parts of the Amazon catchment or nearby regions (after Fullard & Darby 1975)

	Temperature (°C)			Rainfall (mm)		
	Mean Annual Range	Daily Range "summer"	Daily Range "winter"	Mean Annual Range	Mean Monthly "wet"	Mean Monthly "dry"
La Paz (Bolivian Andes)	3.9	7–18 Oct	1–17 July	574	120 Jan	20 June
Quito (Ecuadoran Andes)	0.6	5–18/20	year round	1123	160 April	20 July
Manaus (Central Amazon)	1.7	24–32 Sept–Oct	24–30 Jan–June	1811	260 Mar	30 Aug
Cuiaba (Mato Grosso)	4.2	21–23 Sept	17–28 July	1395	220 Mar	10 July
Belém (Estuary)	0.8	23–32 Dec	21–29 Sept	2438	350 Feb–Mar	60 Nov

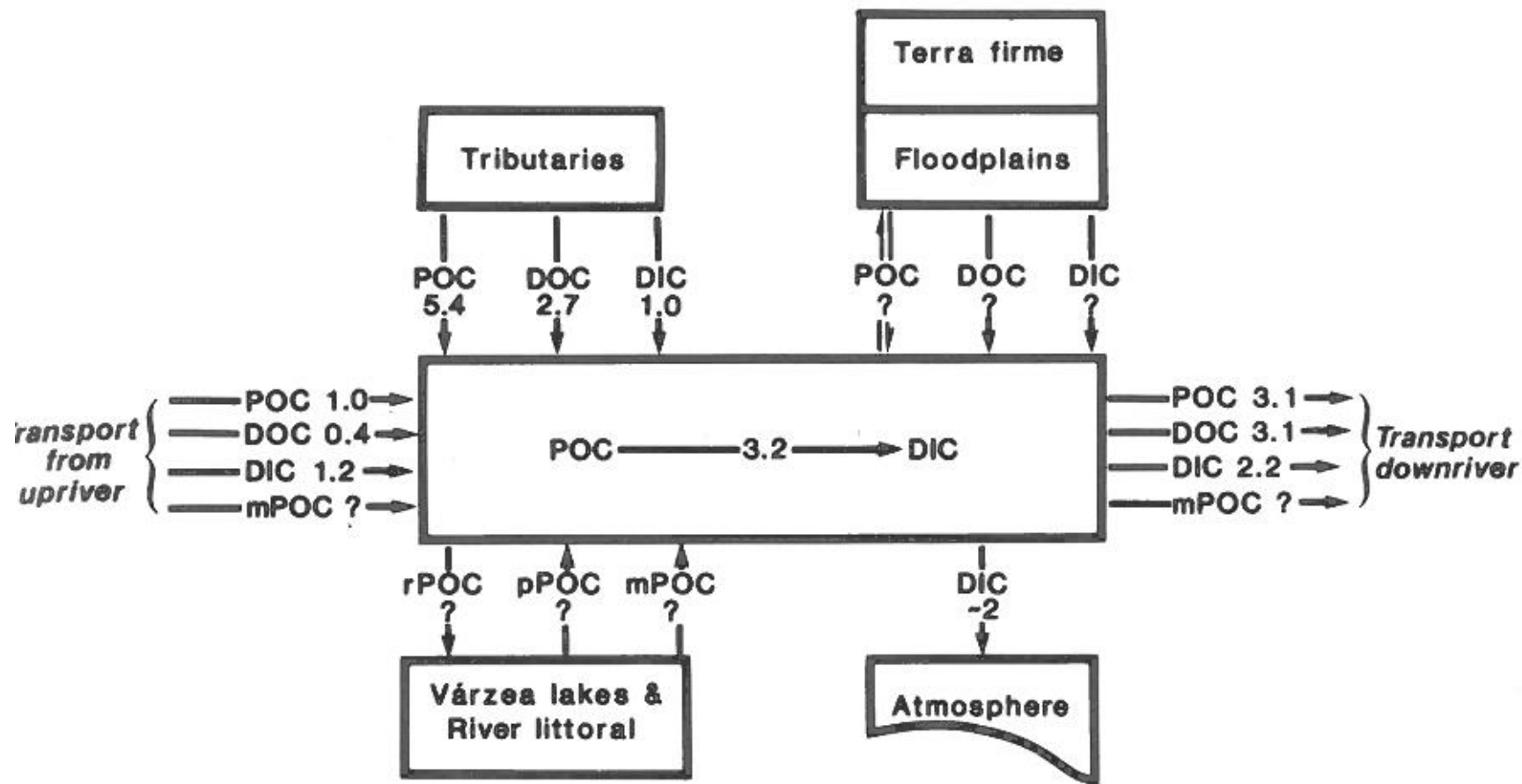


Figure 5. A carbon budget for the Amazon River (see text for explanation). Modified after Richey (1982).

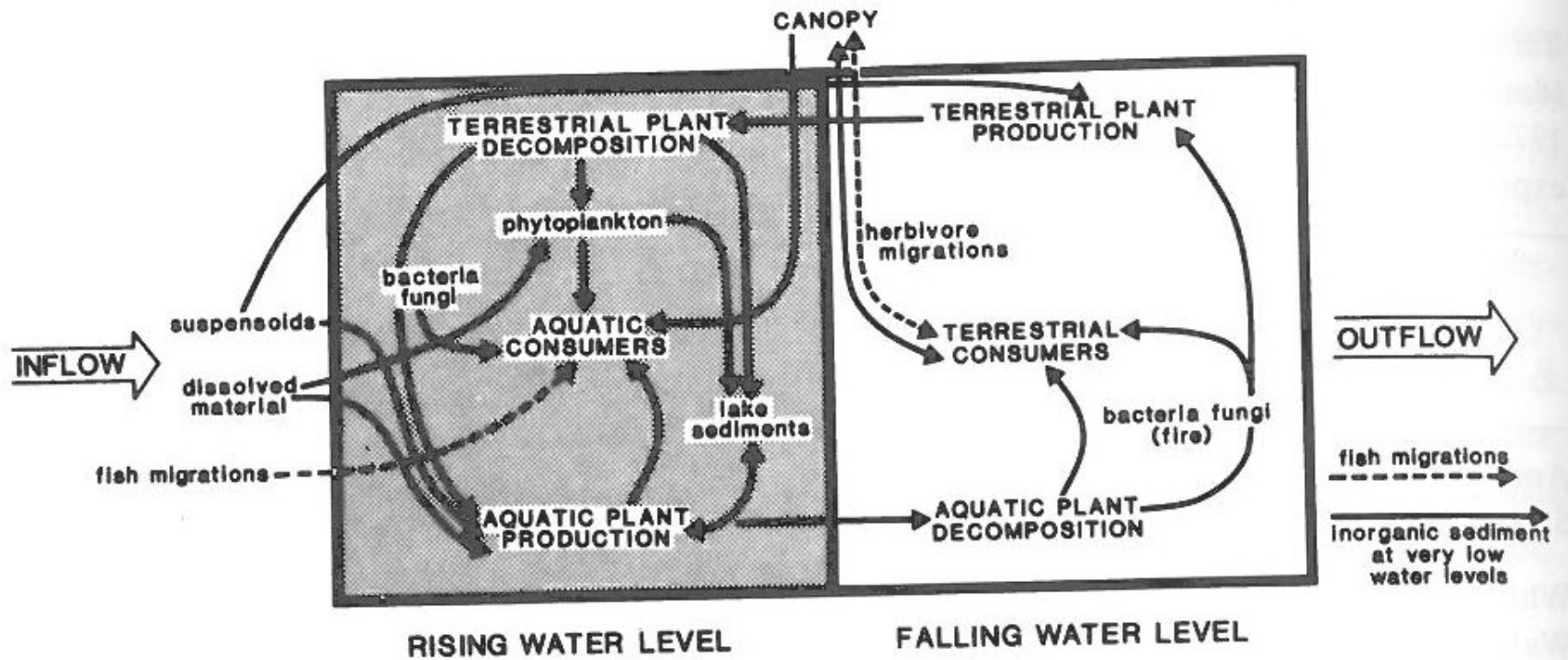


Figure 6. A nutrient budget for the Amazon (after Junk 1980).

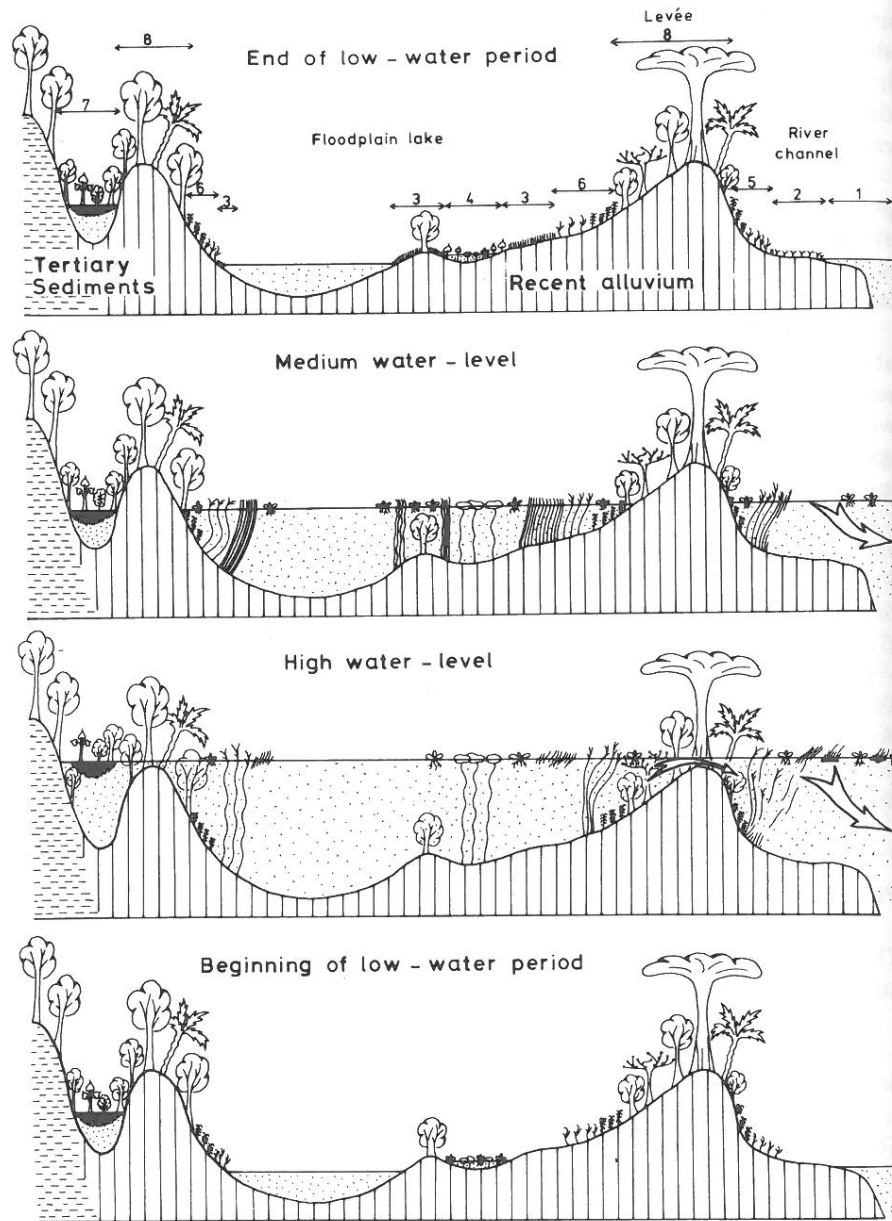


Figure 2. Aquatic plant habitats and communities in the middle Amazon floodplain. (1: river channel; 2: low-lying channel bar; 3: low-lying flat; 4: swale; 5: river shore; 6: lake shore; 7: habitat with minor water-level variation; 8: levée).

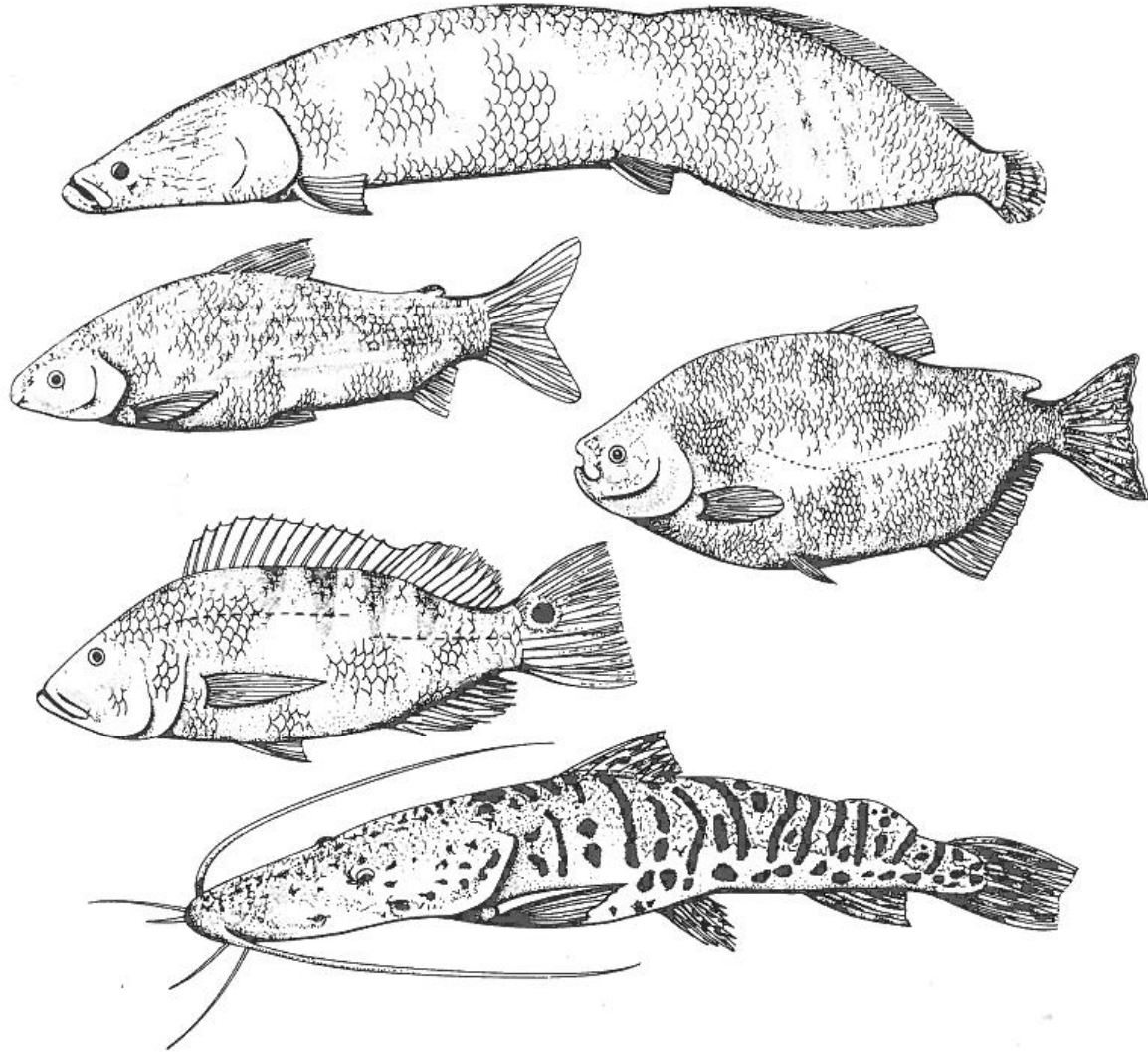


Figure 1. Representative fish from the Amazon system (after Lowe-McConnell 1975). From top: *Arapaima* (length to 300 cm SL, Osteoglossidae), *Prochilodus* (to 50 cm SL, Prochilodontidae), *Colossoma* (to 90 cm SL, Characidae), *Cichla* (to 75 cm SL, Cichlidae) and *Pseudoplatystoma* (to 40 cm SL, Pimelodidae).



Figure 1. Physiographic regions of the Mackenzie Basin. The inset map shows the extent of the basin (cross-hatching) within Canada. Modified after MRBC (1981), with permission of the Mackenzie River Basin Committee.

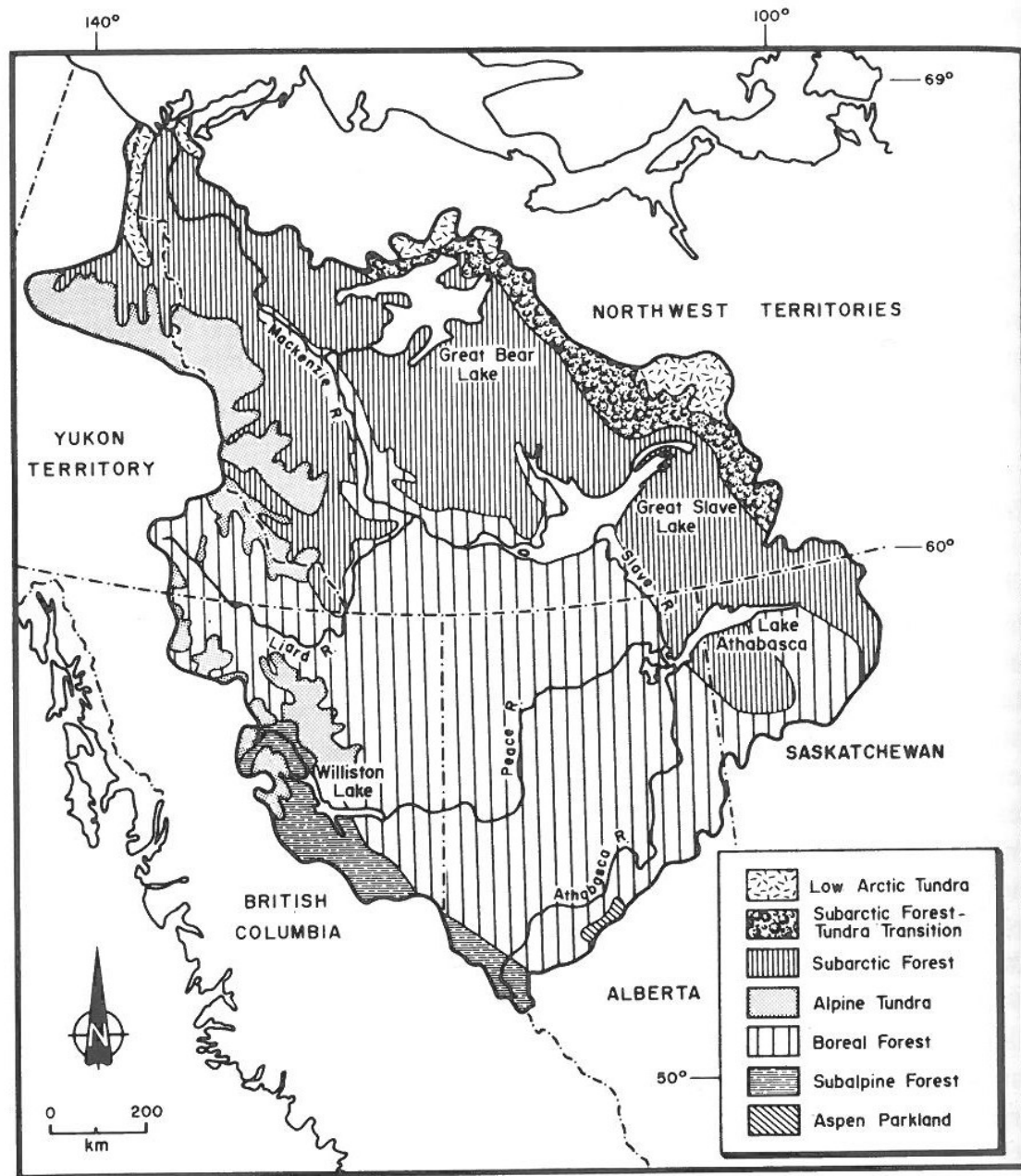


Figure 1. Vegetation regions of the Mackenzie Basin. Modified after MRBC (1981), with permission of the Mackenzie River Basin Committee.



Mackenzie Delta



Table 1. Mean percent composition of invertebrates from baskets of stones suspended in the Athabasca (A–B), Mackenzie (C) and Liard (D) rivers, from debris on anchor lines (E) and airlift samples from bedrock substrata (F) in the Athabasca River (ND = no data). Sources – A: McCart *et al.* (1977); B: Flannagan *et al.* (1979); C–D: Brunskill *et al.* (1973), E–F: Barton (1980b)

Taxon	A	B	C	D	E	F
Oligochaeta	2.0	2.7	0.3	0.3	1.0	6.2
Ephemeroptera	15.0	9.0	5.1	14.2	16.2	13.8
Plecoptera	54.4	35.2	24.8	27.1	46.2	17.7
Trichoptera	6.0	34.7	11.0	8.3	15.8	6.3
Simuliidae	1.0	40.9	46.5	1.0	12.8	0.2
Chironomidae	18.8	12.5	18.0	3.4	6.9	35.4
Empididae	1.6	ND	0	0	0	13.0
Other Insecta	0.9	ND	0	0.2	0.7	1.4

Table 2. Mean standing stock and percent contribution of benthic invertebrate taxa in fresh waters of the Mackenzie Delta during summer (August–September; $N = 21$) and winter 1971 (December; $N = 4$). From Brunskill *et al.* (1973)

Taxon	Summer	Winter
Nematoda	0.3	0.6
Oligochaeta	22.3	0.9
Gastropoda	18.3	0.5
Bivalvia	6.6	0.8
Amphipoda	4.9	4.8
Chironomidae	27.3	76.2
Ceratopogonidae	9.8	13.0
Other Insecta	10.5	3.1
Mean number m^{-2}	166.1	417.1

Table 3. Mean total standing stocks (individuals m^{-2}) and percent contribution of major taxa in stream riffles at different latitudes in the Mackenzie Basin. Based on Surber samples between July and early October (ND = no data). Sources – A–C: Brunskill *et al.* (1973) (fast streams only); D: Barton & Wallace (1980); E: Clifford (1972c)

Taxon	Study and latitude ($^{\circ}$ N)				
	A 67 $^{\circ}$	B 64–65 $^{\circ}$	C 61–62 $^{\circ}$	D 57 $^{\circ}$	E 53 $^{\circ}$
Oligochaeta	9.6	57.5	8.2	7.0	5.2
Amphipoda	11.8	0.3	0.1	ND	ND
Ephemeroptera	3.5	8.9	18.0	33.6	17.8
Plecoptera	10.5	12.7	5.2	3.8	7.6
Trichoptera	0.8	3.1	5.2	13.6	8.6
Chironomidae	52.4	12.4	47.4	37.6	42.4
Mean individuals m^{-2}	850	192	4046	12 781	4772