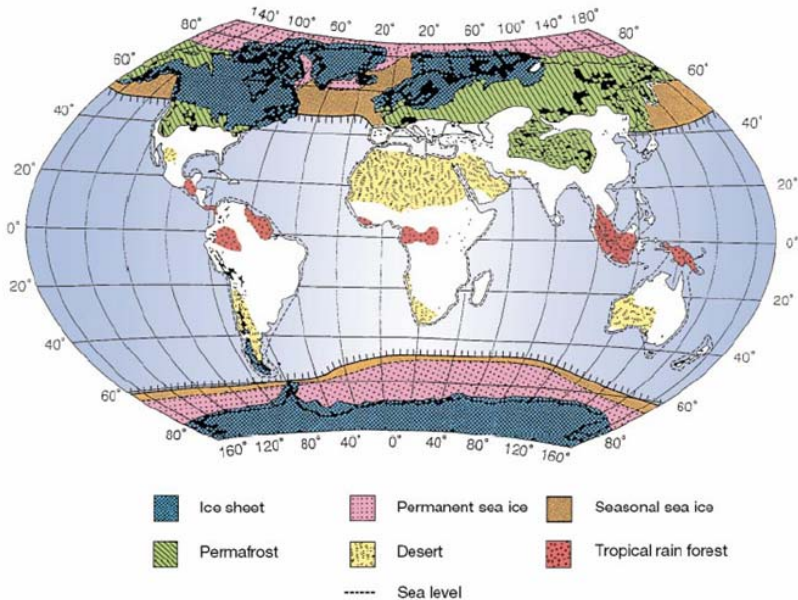


## Pleistocénní glaciace a biogeografie



**Figure 1** The maximum extent of ice and permafrost at the end of the last ice age 20,000 yr. The lowered sea level, large deserts and main blocks of tropical forest are indicated. Modified with permission from ref. 2.

## Pleistocénní glaciace a biogeografie

**vyšší taxony** – starší než kontinenty

➔ distribuce zásadně ovlivněna (a vysvětlena) **tektonikou**

**nižší taxony** – mladší než kontinenty

➔ distribuce významně ovlivněna **cykly glaciálů/interglaciálů**

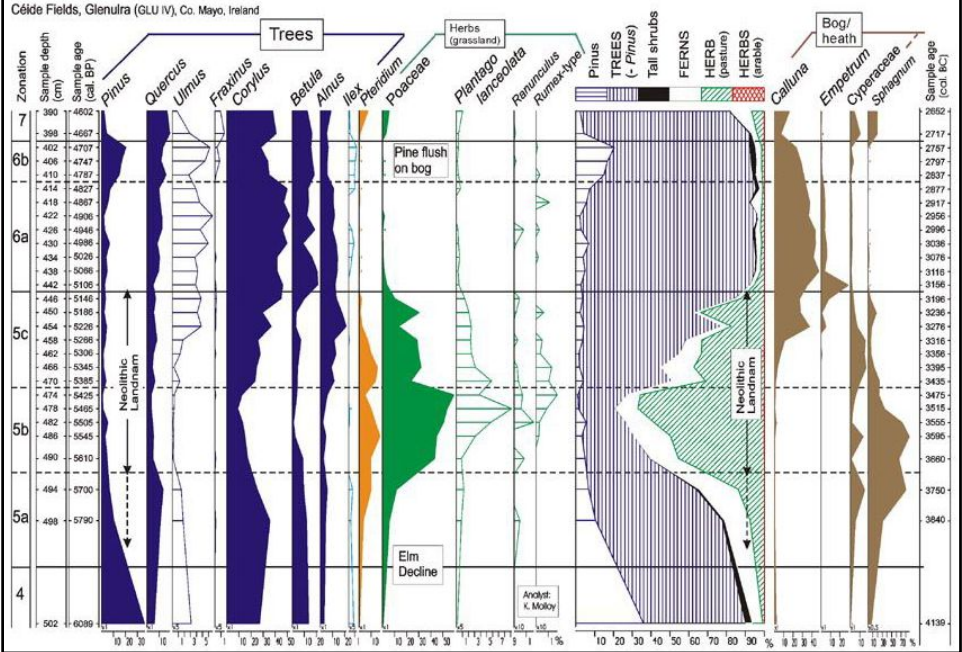
glaciály: 50 – 100 000 let    chladno + sucho

interglaciály: 10 – 20 000 let    teplo + vlhko

**vliv glaciálů (2.4 mil. – 10 tis. let) na klima:**

- pevniny: změny osídlitelné plochy + umístění a velikosti biotů
- oceány: pokles hladiny až o 160 m (rozsah oscilace ~230 m)

## Pleistocénní glaciace: důkazy



## Pleistocénní glaciace: důkazy

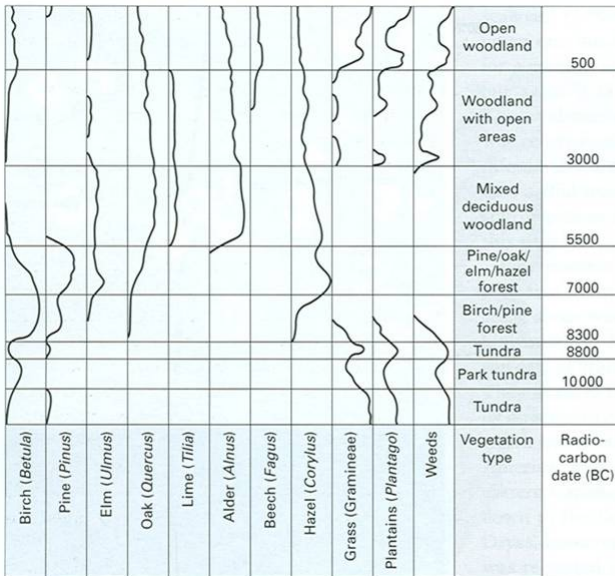
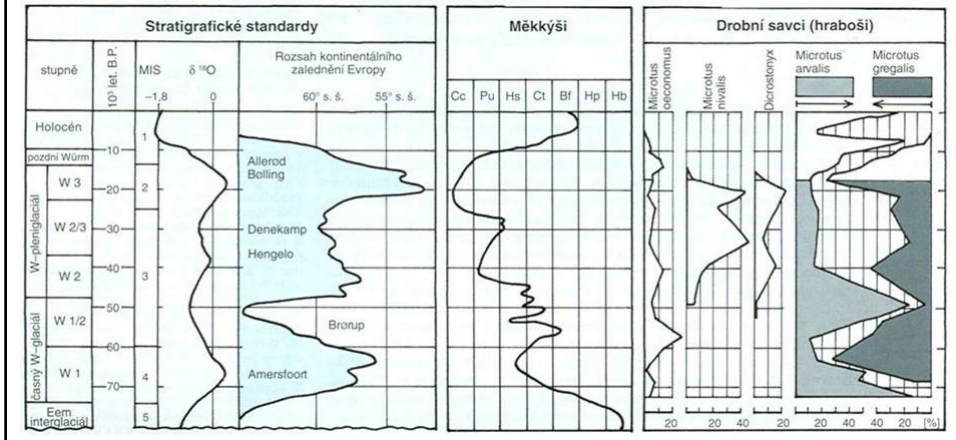


Fig. 10.3 Generalized pollen diagram from the southern part of the British Isles, showing the changing proportions of tree pollen and some non-arboreal types during the final stages of the Pleistocene and through the Holocene.

## Pleistocenní glaciace: důkazy

Průběh posledního glaciálu a změny v zastoupení charakteristických druhů střeoevropských společenstev drobných savců a vúdčích druhů společenstev měkkýšů. Cc — *Columella columella*, Pu — *Pupilla* spp., Hs — *Helicopsis striata*, Ct — *Chondrula tridens*, Bf — *Fruticicola fruticum*, Hp — *Helix pomatica*, Hb — *Drobacia banatica*. MIS — klimatostratigrafické stupně;  $\delta^{18}\text{O}$  — izotopická teplotní křivka. Podle I. Horáčka a V. Ložka 1988 kreslil S. Holeček



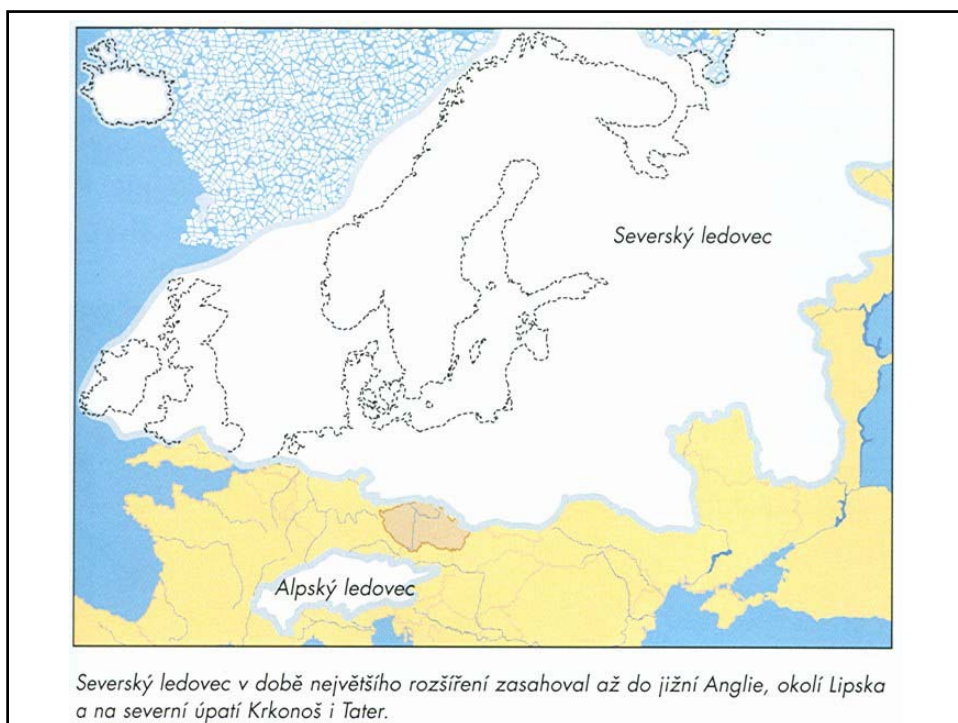
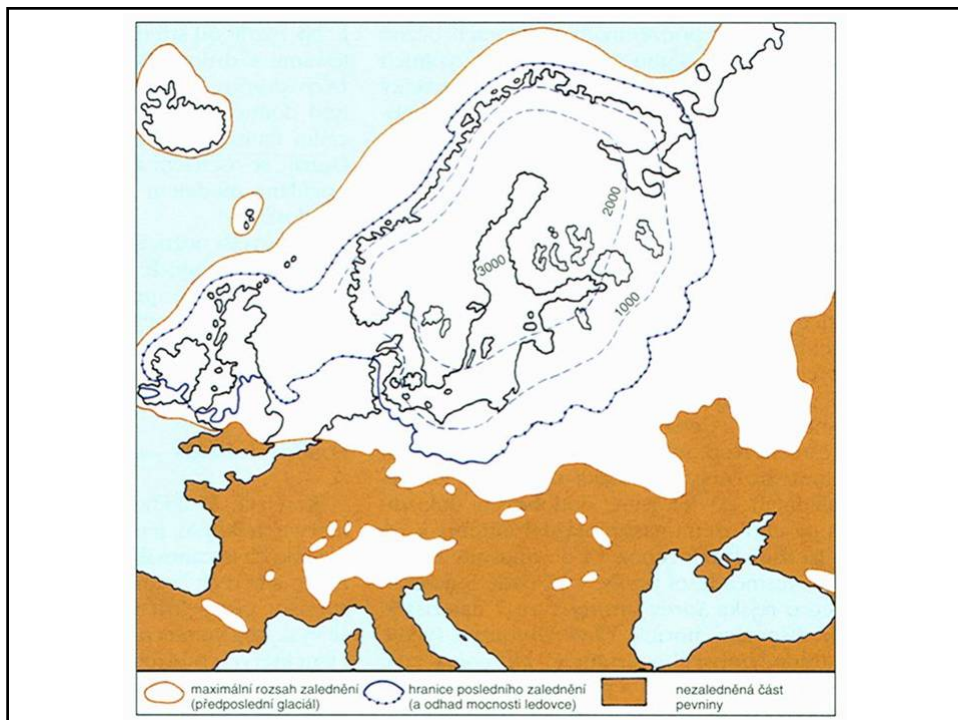
## Pleistocenní glaciace: důkazy



početné kosterní pozůstatky z potravy sovice sněžné (*Nyctea scandiaca*). Pro tyto nabromaděliny kosterních fragmentů je rovněž charakteristická kombinace s mrazovou drtí ostrohranných úlomků horniny a sprašovou hlinou.

Horáček I. & Ložek V. 2004: Ledová doba z pohledu zoologa. I. Glaciální fauna a historie její výpovědi. *Živa* 52(1): 5–8.

Ložek V. & Horáček I. 2004: Ledová doba z pohledu zoologa. II. Glaciál ve světle rozboru fosilních zocenóz. *Živa* 52(2): 50–54.



## Pleistocenní glaciace: důkazy

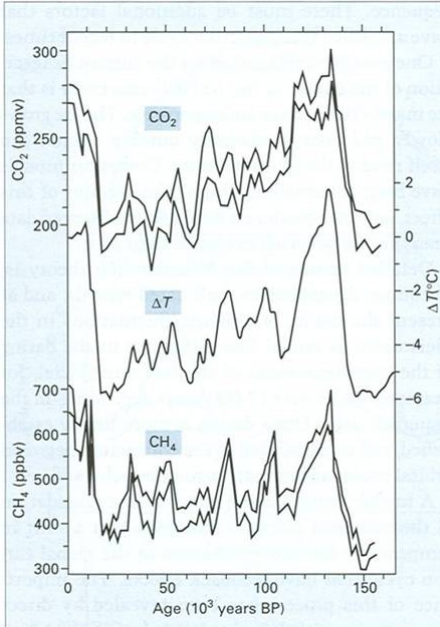


Fig. 9.17 Analyses of gas bubbles in an ice core taken from the Antarctic ice cap. These are regarded as fossil samples of the ambient atmosphere of the past. The concentrations of carbon dioxide (upper) and methane (lower) are shown together with a reconstruction of temperature change derived from oxygen isotope studies of the same area (middle). From Lorius *et al.* [21].

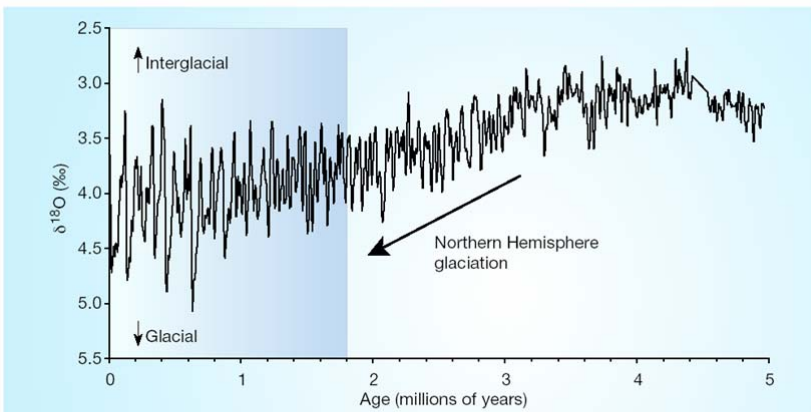


Figure 1 Global climate change from 5 million years ago to the present. This record is inferred from the foraminiferal oxygen-isotope archive from the eastern equatorial Pacific<sup>12</sup>, with  $^{18}\text{O}/^{16}\text{O}$  ratios plotted as a per mil deviation from a standard —  $\delta^{18}\text{O}$  (‰). Over this time there has been a general trend towards cooler climate; at the moment, we are in a peak warm interval within the overall cooling trend. The increase in foraminiferal  $\delta^{18}\text{O}$  values between 3 million and 2 million years ago signifies the (poorly understood) growth of ice sheets in the Northern Hemisphere. Liu and Herbert<sup>1</sup> have constructed a separate record for the eastern equatorial Pacific from 1.8 million years ago (shaded), and provide evidence that cyclic processes operating at high latitudes produce a surface-ocean response at low latitudes.

Billups K. 2004: Low-down on a rhythmic high. *Nature* 427: 686–687.

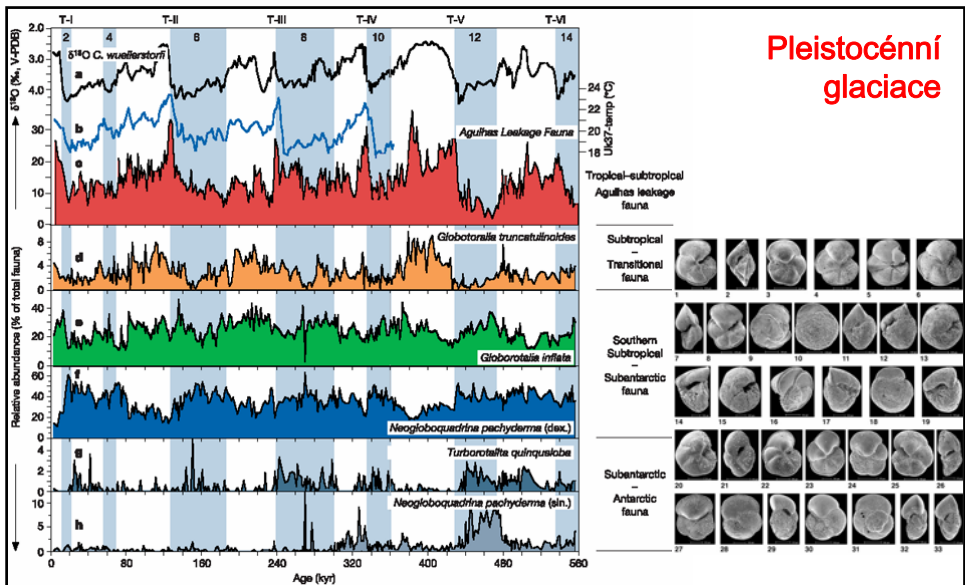
## Pleistocénní glaciace a biogeografie

20 – 30 glaciálů/interglaciálů

ochlazování – celé třetihory, rozkývání klimatu

Temp.	North America	Alps	North-west Europe	Britain	Approx. date
C	Wisconsin	Würm	Weichsel	Devensian	← 10 000
W	Sangamon	Riss/Würm	Eamian	Ipswichian	← 70 000
C	Illinoian	Riss	?Saale	?Wolstonian	← 250 000
W	Yasmouth	Mindel/Riss	?Holstein	?Hoxnian	← 500 000
C	Kansan	Mindel	?Elster	?Anglian	← 500 000
W	Aftonian	Günz/Mindel	?Cromerian complex	?Cromerian	
C	Nebraskan	Günz	?Menapian		← 1 x 10 <sup>6</sup>
W		Donau/Günz	?Waalian		
C		Donau	?Eburonian		
W		Biber/Donau	?Tiglian		
C		Biber	?Pretilgian		← 2.4 x 10 <sup>6</sup>
W			Reuverian		

Fig. 9.6 Conventional correlations assumed between local glacial and interglacial stages in the Pleistocene. Local complexities render such correlations tentative, particularly in the earlier stages. See Fig. 9.7 for a suggested correlation of European stages in the early part of the Pleistocene. C, cold; W, warm.



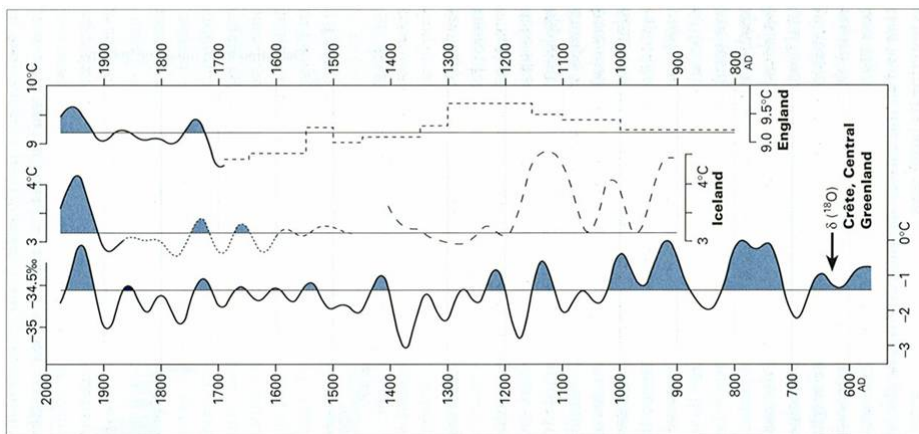
## Pleistocénní glaciace

Figure 2 Late Pleistocene proxy records of the Cape Basin record. a, The oxygen isotope composition of the benthic foraminifer *Cibicides wuellerstorfi*, largely indicating global ice volume (V-PDB, Vienna Pee-Dee Belemnite standard). Even numbers at top refer to glacial Marine Isotopic Stages, T-I to T-VI refer to the major glacial terminations. b, The  $(U_{15})$  SST proxy for the upper part of the CBR (core GeoB-3603-2). c, The relative abundance of the Agulhas leakage fauna as a measure of Indian Ocean advection into the Atlantic. d, The relative abundance of *Globobulimina truncatulinoides*, indicative of subtropical-transitional waters. e, The relative abundance of *Globobulimina inflata* and f, *Neogloboquadrina pachyderma* (dex.) indicative of southern subtropical to subantarctic waters. g, The relative abundance of *Turborotalita quinqueloba*, reflecting subantarctic waters. h, The relative abundance of *Neogloboquadrina pachyderma* (sin.), indicative of Antarctic waters<sup>10–19</sup>.

## Malá doba ledová: 1580 – 1850

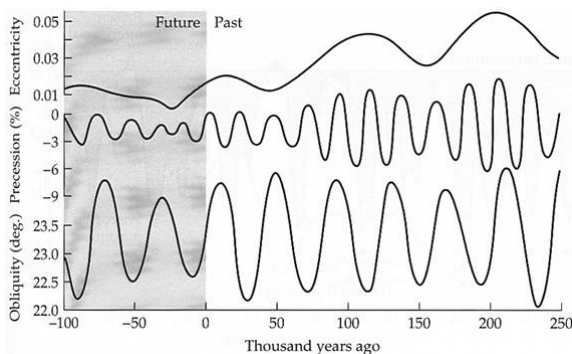
Skandinávie 1570 – 1650 vs Británie 1300 – 1700

Fig. 10.15 Oxygen isotope curve from an ice core taken in central Greenland (left), and the projected temperature curve for Iceland (centre) and for England (right). From Dansgaard *et al.* [40].



## Proč glaciály a interglaciály?

### Milankovičovy cykly



#### excentricita (eliptičnost)

- perihelion, aphelion
- 30% rozdíl v sluneční E
- perioda 100 000 let

#### precese

- orientace (směr) z. osy
- perioda 22 000 let

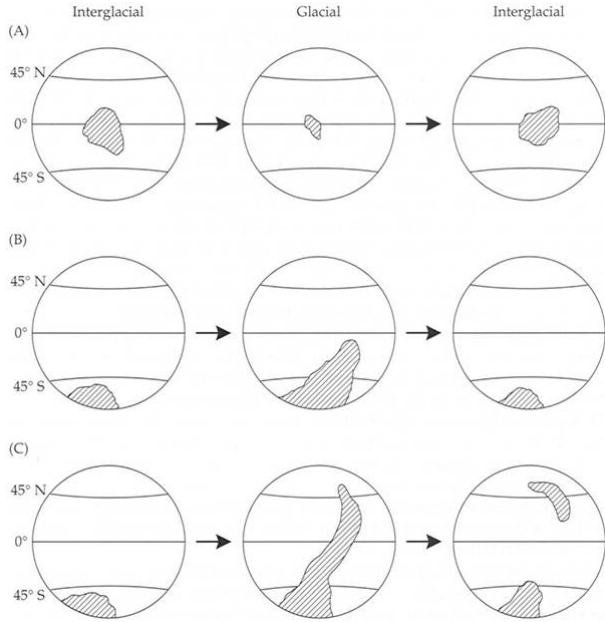
#### sklon zemské osy

- 22.1°–24.5°,  $\bar{\theta} = 23.5^\circ$
- perioda 41 000 let

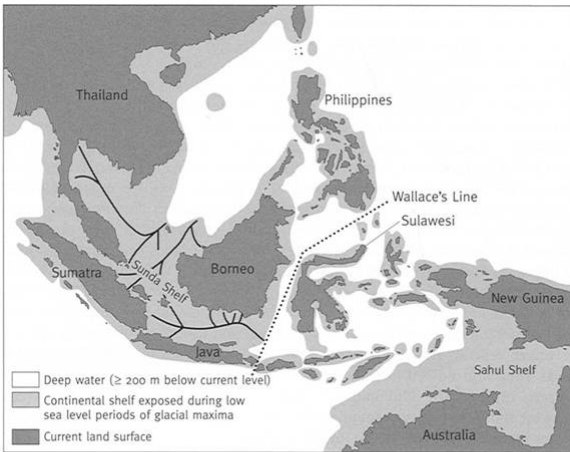
➤ Cílek V. 1995: Milankovičovy cykly. *Astronomické teorie klimatických změn*. Vesmír 74(9): 488–491.

## Vliv glaciace: bipolární areály?

**Figure 7.25** Potential range expansions and contractions of hypothetical warm stenothermal (A) and cool stenothermal (B and C) marine taxa. During a glacial period, cool stenothermal taxa could penetrate from one hemisphere to the other (middle diagram in C) and could possibly achieve bipolar distributions when waters re-warm and their ranges contract toward the poles. (After Crame 1993.)



## Vliv glaciace: Sundský a Sahulský šelf



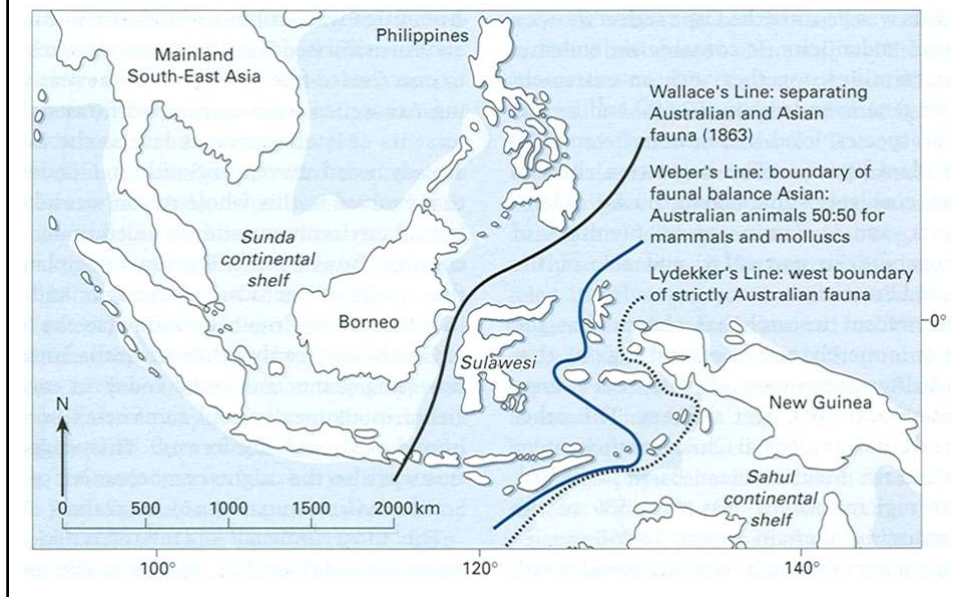
**Fig. 1.9** The Sunda Shelf (shaded) was exposed during the peaks of glaciation, allowing the movement of animals and plants along the river valleys connecting Borneo, Sumatra, Java, the Malay Peninsula, and smaller islands. These river valleys (shown as solid black lines) are submerged today beneath the South China Sea. Note that the Philippines is still separated from the Sunda Shelf. The Sahul Shelf, which surrounds Australia and New Guinea, is also shown. The area between the Sunda Shelf and the Sahul Shelf is known as Wallace; the western boundary of Wallacea was described by Wallace as the eastern limit of distribution for many species of Asian animals, and is known today as Wallace's line. (From Brown & Lomolino 1998.)

*Shorea parviflora*



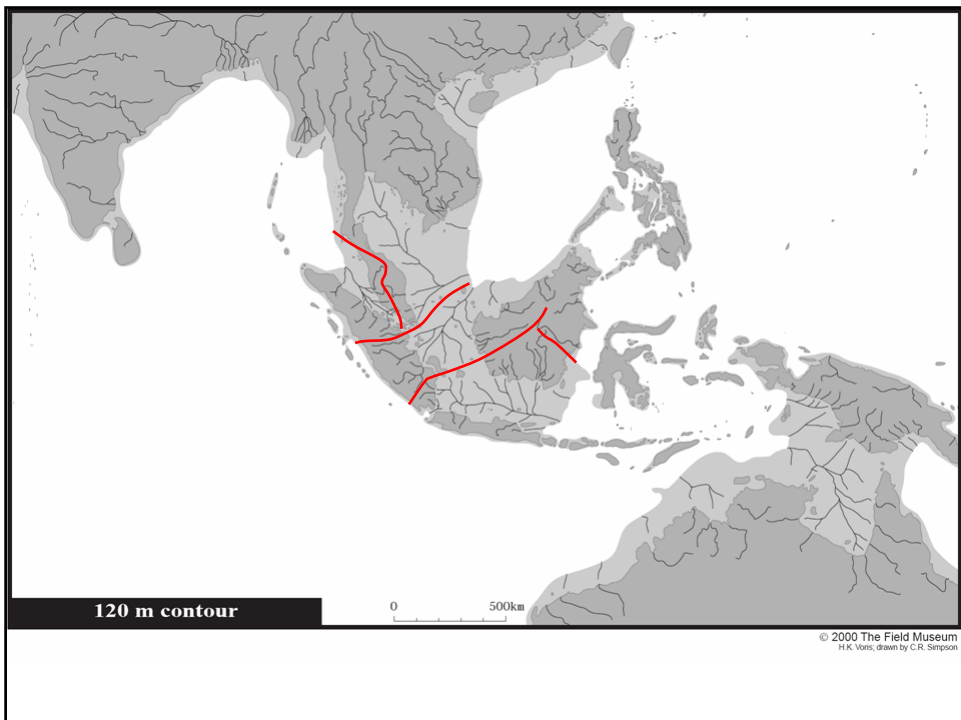
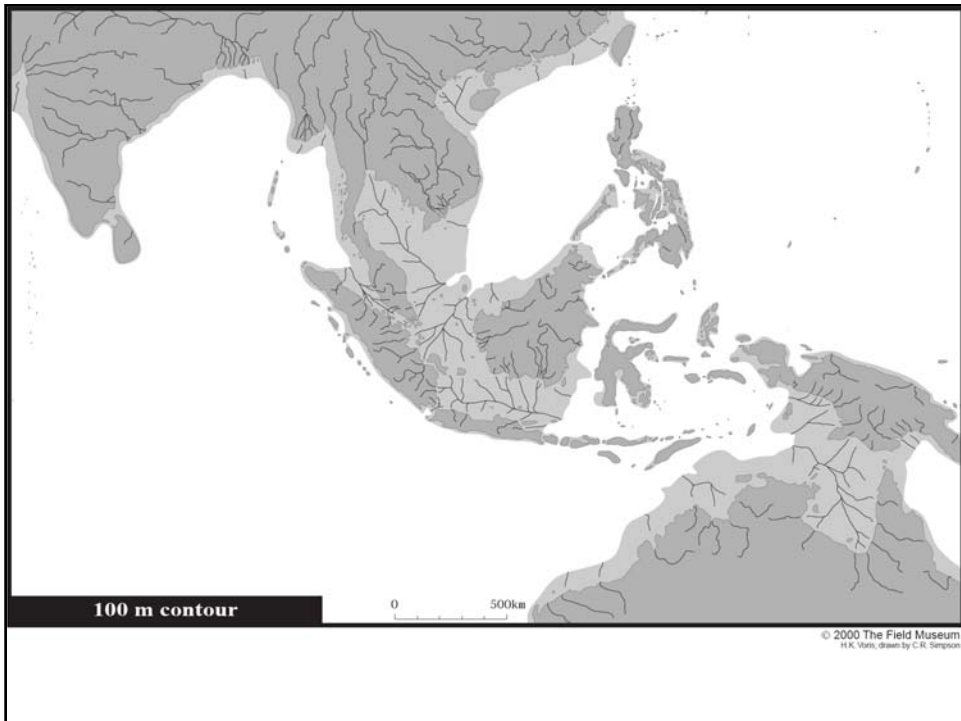


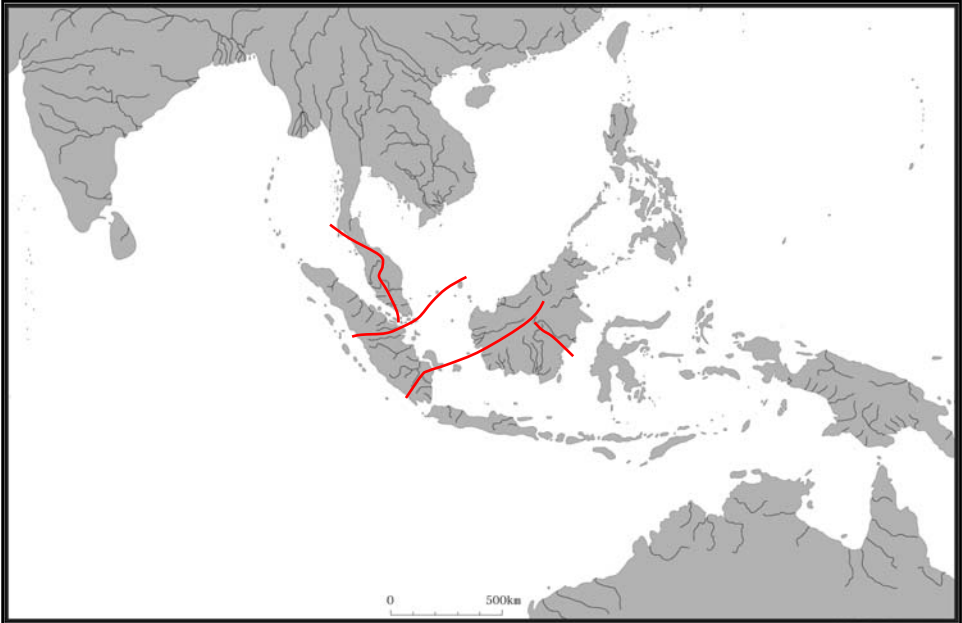
## Vliv glaciace: Sundský a Sahulský šelf



© 2000 The Field Museum  
H.K. Voors, drawn by C.R. Simpson

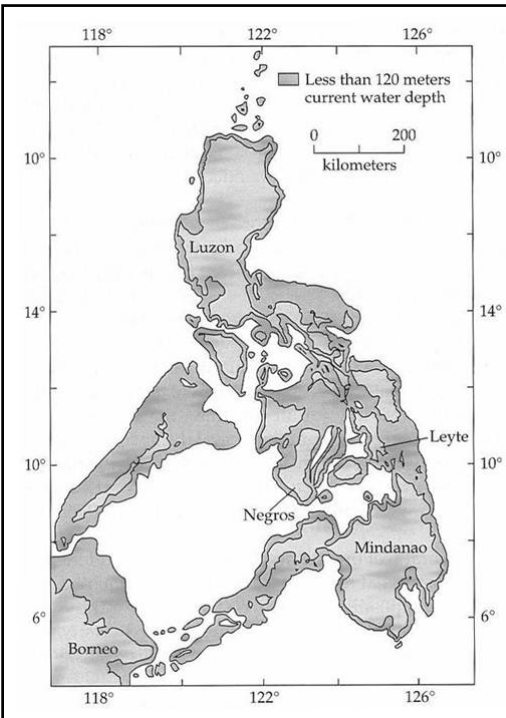
Oblasti endemismu ryb – odraz zaniklých říčních glaciálních systémů



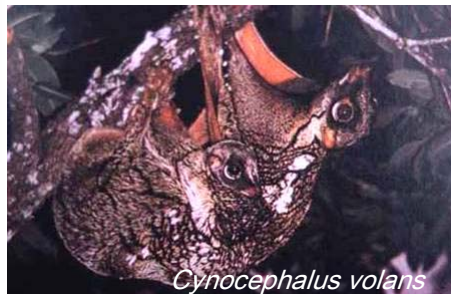


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H.K. Voris, drawn by C.R. Simpson

[http://www.fieldmuseum.org/research\\_collections/zoology/zoo\\_sites/seamaps/mapindex.htm](http://www.fieldmuseum.org/research_collections/zoology/zoo_sites/seamaps/mapindex.htm)

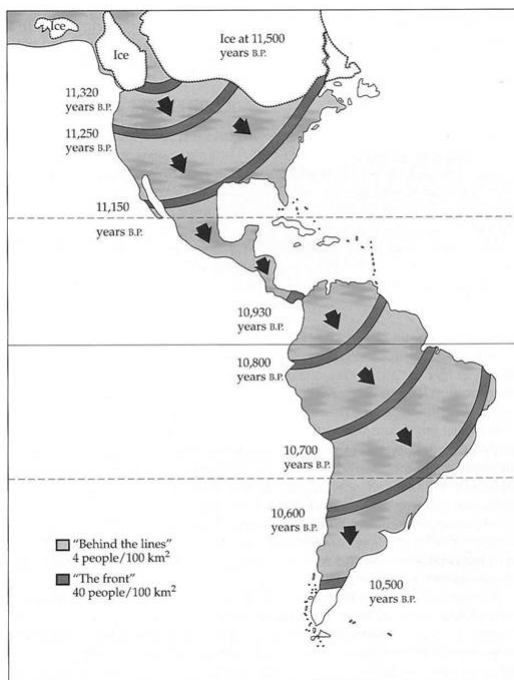
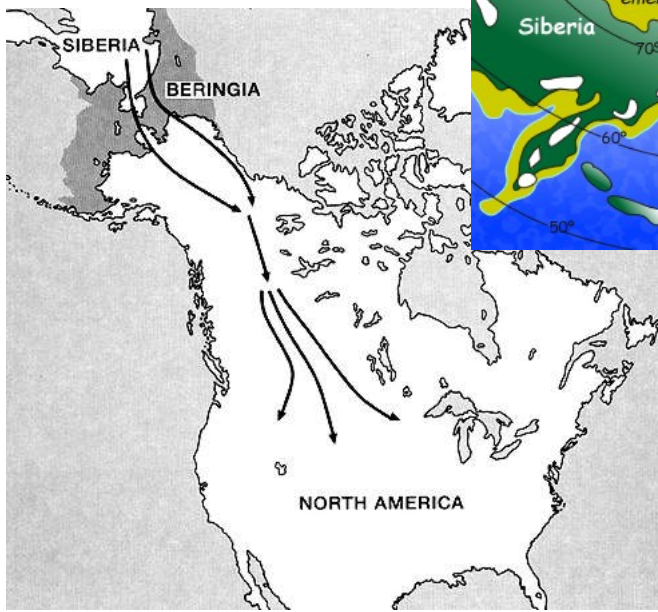


### Vliv glaciace: Filipíny



*Cynocephalus volans*

## Vliv glaciace: Beringia



## Pleistocénní extinkce: „overkill hypothesis“

Beringia – „most“ i pro lidi

pleistocénní megafauna

> 50kg

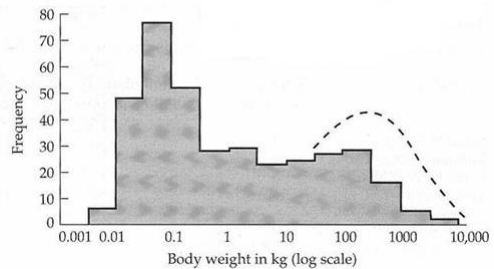
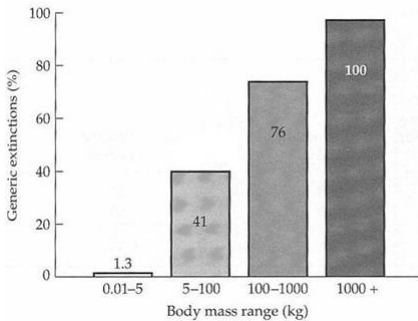
vyhubení herbivorů +  
závislých predátorů a  
mrchožroutů

velice rychlé ⇨  
hypotéza bleskové války  
(*blitzkrieg hypothesis*)

jedna z nejdůležitějších  
událostí v recentu!

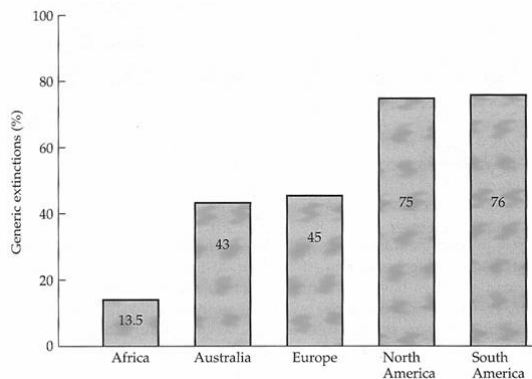
## Predace vs areály: „overkill hypothesis“

- koexistence prehistorických lidí a megafauny (... krátce)
- extinkce postupovaly severo-jíže
- koincidence šíření člověka a extinkcí megafauny
- nenáhodnost extinkcí
- los, sob karibu, jelen – přišli a přežili s člověkem (koevoluce)
- lovecké nástroje, zbytky po hromadných lovech



## Predace vs areály: „overkill hypothesis“

- absence současných extinkcí jinde ve světě
- nelze vysvětlit environmentálními změnami – extinkce dříve, ale vymírá *reprezentativní* vzorek velikostí zvířat
- podobné „koincidence“
- v Austrálii (35 000 let)
- na Madagaskaru (1000 let)
- na Galapágách (1000 let)
- podíl nových nemocí kompetitorů?  
klimatu?



➤ Diamond J. 2004: Třetí šimpanz. Vzestup a pád lidského rodu. Paseka, Praha. Kapitola 18.

➤ Hošek P. 1998: Poslední velké vymírání. Zánik velkých zvířat na Madagaskaru. Vesmír 77(11): 615–619.

## Pleistocénní extinkce & člověk



**Afroeurasia:** No major episodes of extinction during past 100,000 years, although some losses occurred.

**Meganesia:** Humans arrive 40,000–60,000 years B.P.; major extinction episode follows, but extends to circa 15,000 years B.P. (or later?).

## Pleistocénní extinkce & člověk



**Americas:** Ecologically significant human populations arrive 12,500 years B.P.; major extinction episode terminates circa 10,500 years B.P., few extinctions thereafter.

**Mediterranea:** Humans arrive 10,000 years B.P.; major extinction episode follows and terminates circa 4,000 years B.P., few extinctions thereafter.

## Pleistocenní extinkce & člověk



**Antillea:** Humans arrive 7000 years B.P.; major episode of extinction follows, but extends to circa A.D. 1600 (or later?).

**Madagascar:** Humans arrive 2000 years B.P.; major episode of extinction follows and terminates circa A.D. 1500, few extinctions thereafter.

**Mascarenes (Ms):** Humans arrive A.D. 1600; major episode of extinction follows and terminates circa A.D. 1900.

**New Zealand:** Humans arrive 800–1000 years B.P.; major episode of extinction follows and terminates circa A.D. 1500.

## Pleistocenní extinkce & člověk



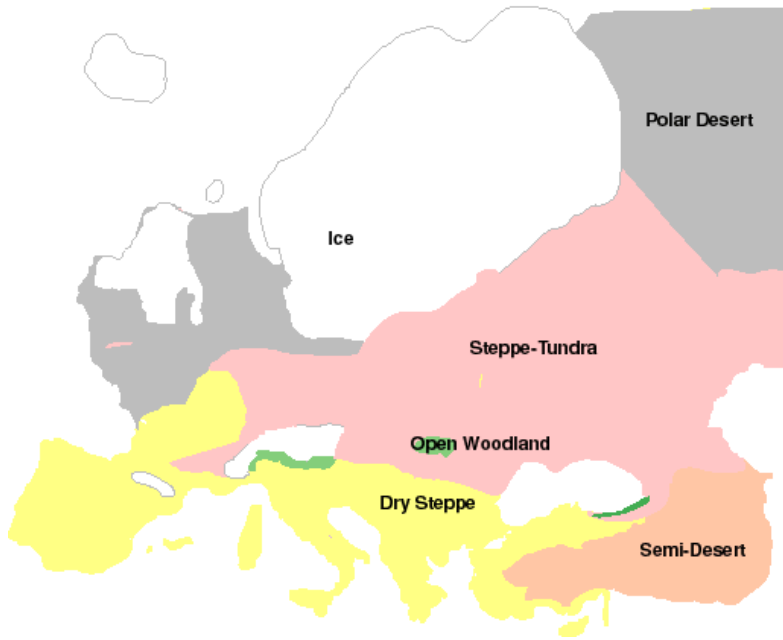
**Commander Islands (C):** Humans arrive A.D. 1741; Steller's sea cow extinct by A.D. 1768.

**Wrangel Island (W):** Humans arrive ?; mammoths survive to 4000 years B.P.

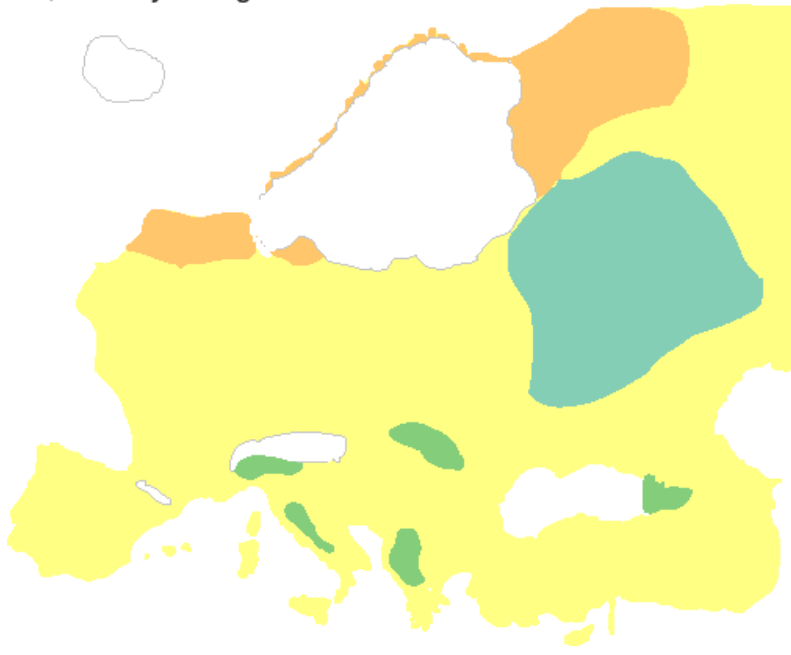
**Galápagos Islands (G):** Humans arrive A.D. 1535; modern-era extinctions only.

**Figure 7.35** The geography and chronology of Pleistocene extinctions may be correlated with major episodes of human colonization. Extinction episodes during the Pleistocene were relatively minor in regions with a long history of human occupation, but severe and coincident with colonization by ecologically significant human cultures elsewhere (see also Chapter 18). (After MacPhee and Marx 1997; based on drawings by Clare Flemming.)

22,000 – 14,000 <sup>14</sup>C years ago

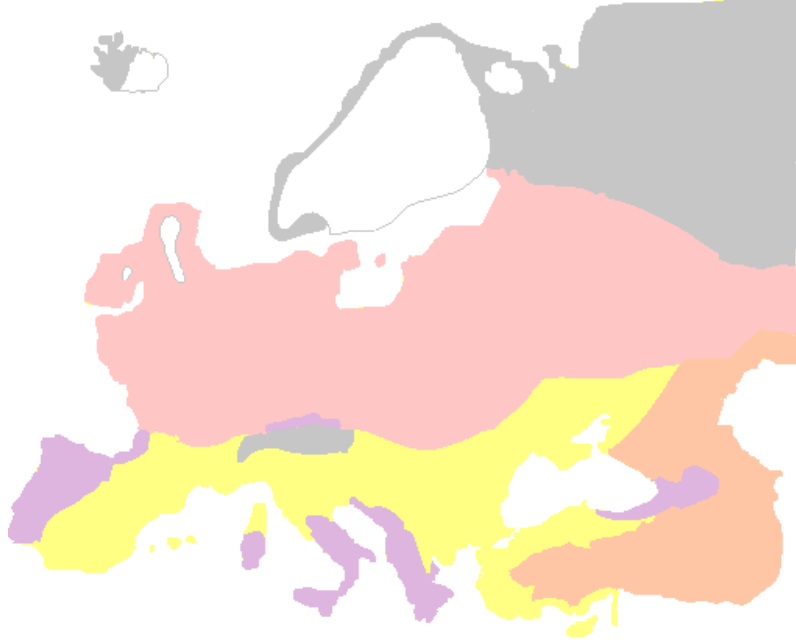


13,000 <sup>14</sup>C years ago

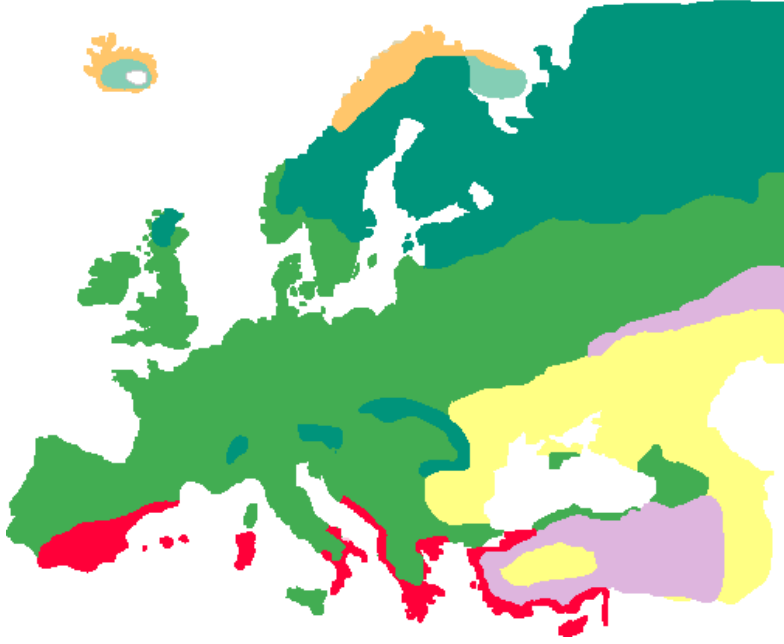




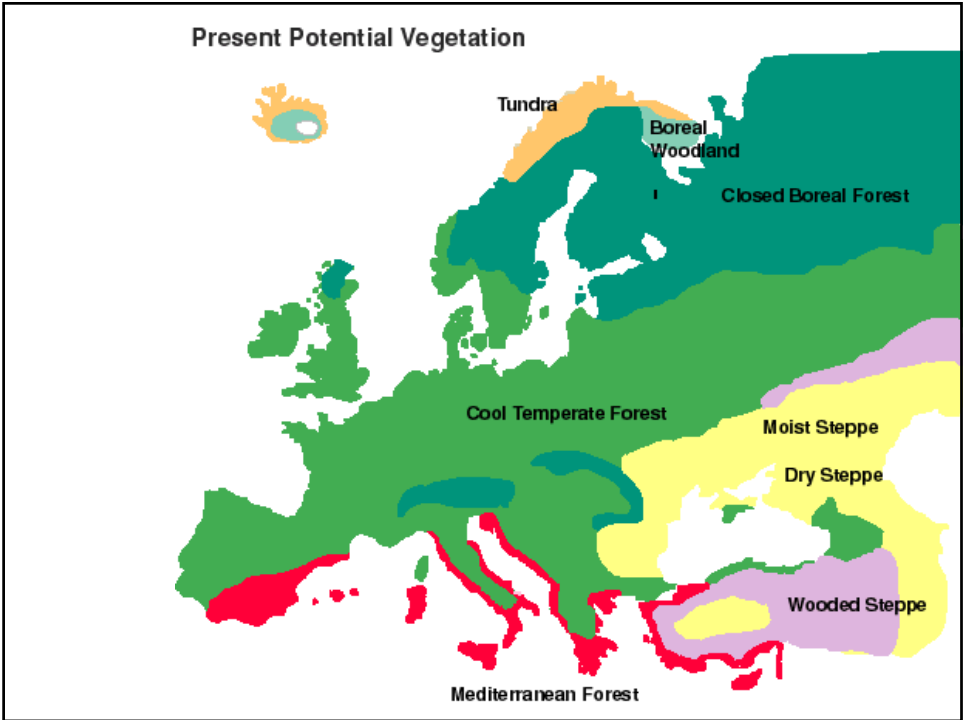
11,000 – 10,000  $^{14}\text{C}$  years ago



5,000  $^{14}\text{C}$  years ago

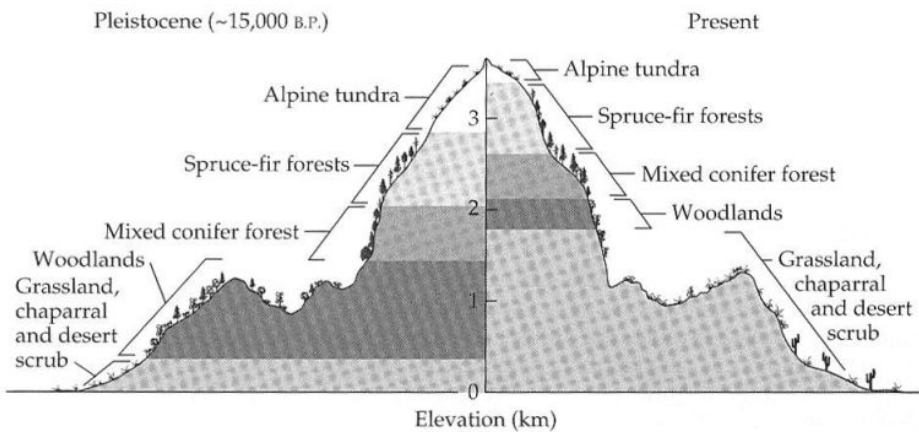


## Present Potential Vegetation

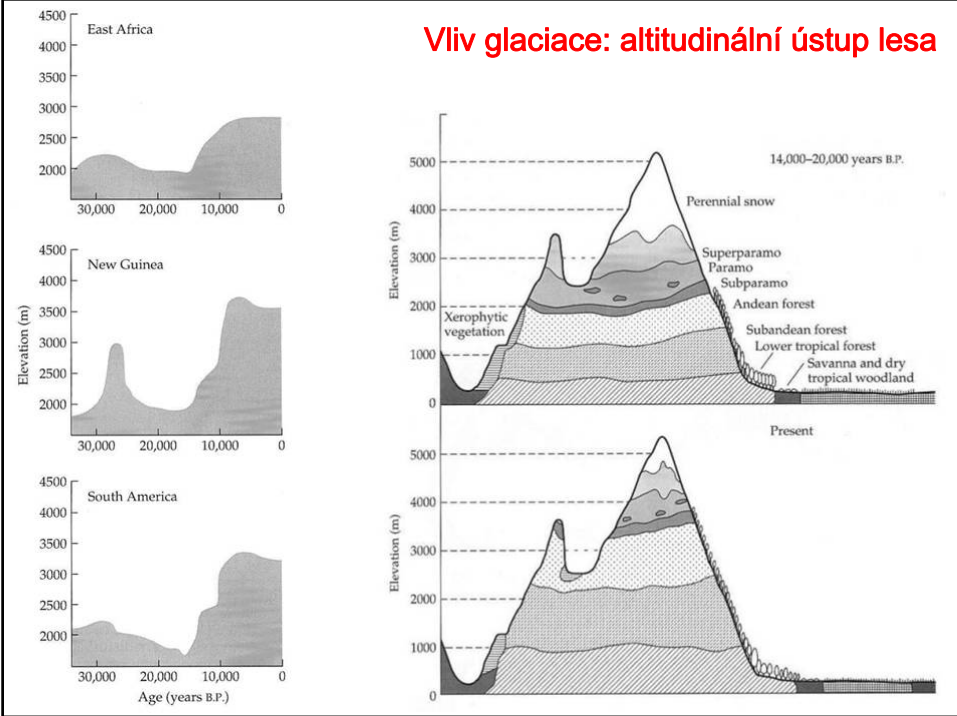


## Vliv glaciace: altitudinální posun vegetačních pásem

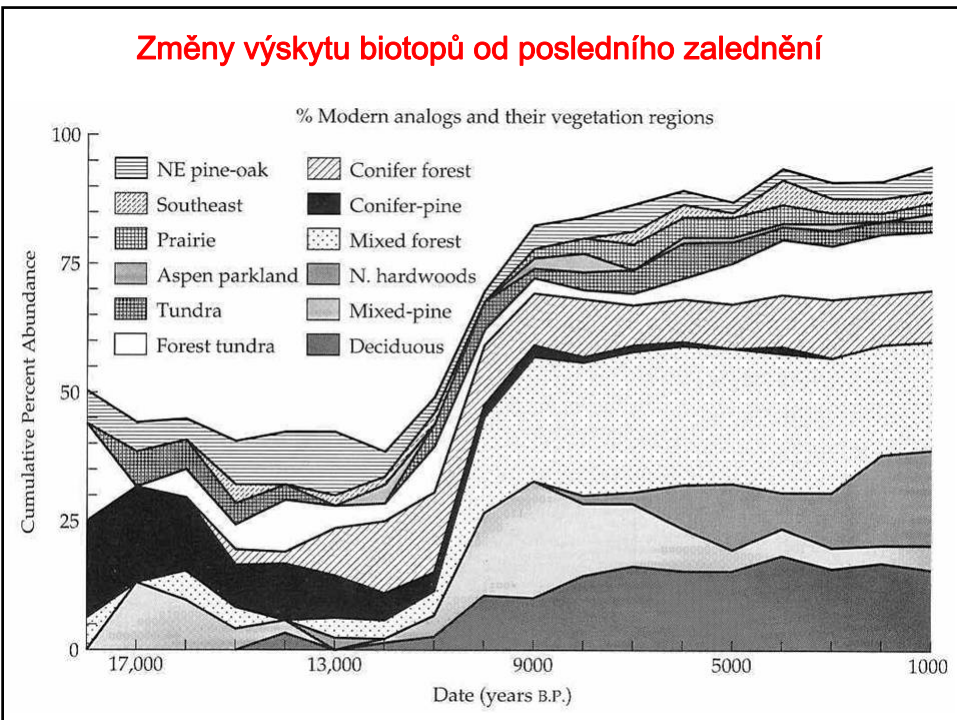
- elevational shifts in vegetation zones



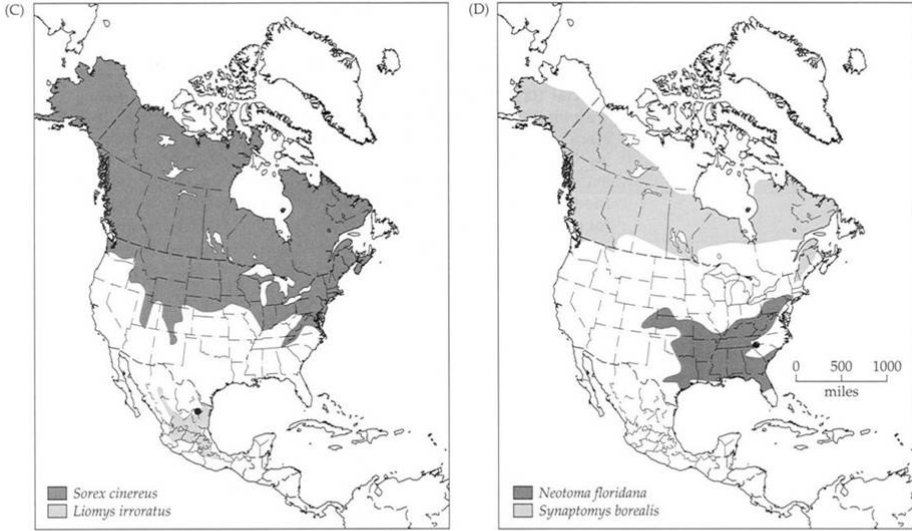
## Vliv glaciace: altitudinální ústup lesa



## Změny výskytu biotopů od posledního zalednění



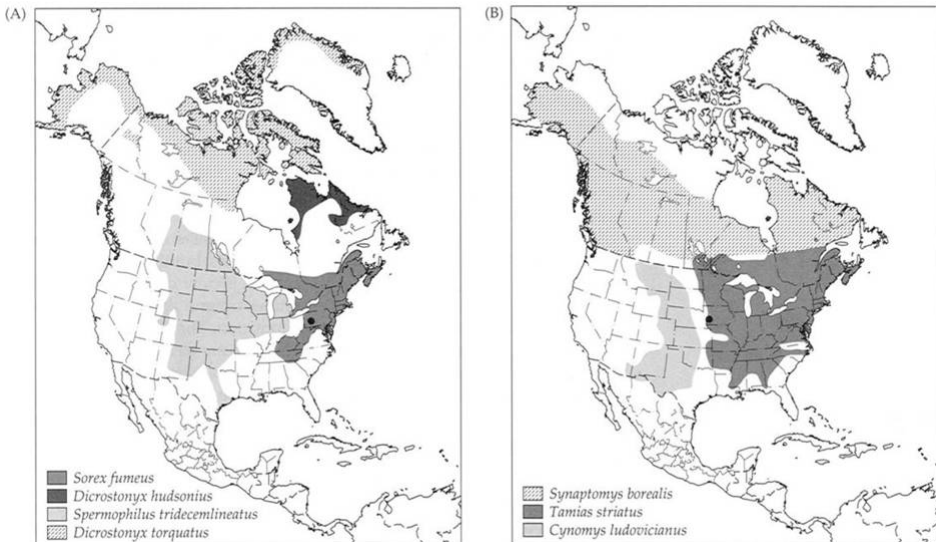
## Dynamika „společenstev“



**Figure 7.21** As a result of the differences in extent and direction of range shifts during the Holocene, species that co-occurred during the most recent glacial maximum often exhibit disjunct ranges today. In each map, the black dots indicate coincident occurrences of the named species during the late Pleistocene, while the shaded areas indicates their current ranges. (After Graham 1986.)

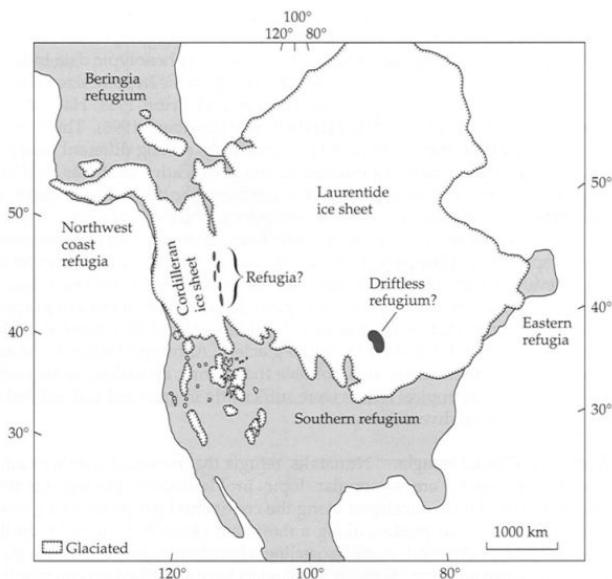
## Dynamika „společenstev“

Glaciation and Biogeographic Dynamics of the Pleistocene 199

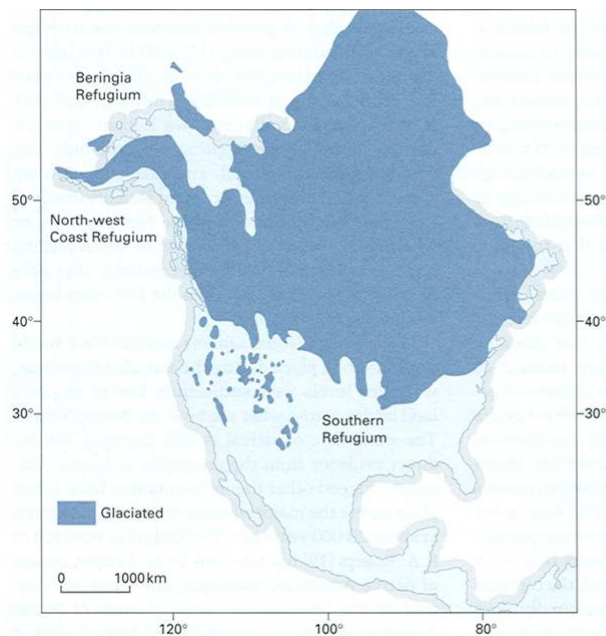


## Vznik glaciálních refugií

**Figure 7.27** Even during the Wisconsin glacial maximum, ice-free refugia may have occurred between the Laurentide and Cordilleran ice sheets and in a region called the driftless area.



## Glaciální refugia a lidské jazyky

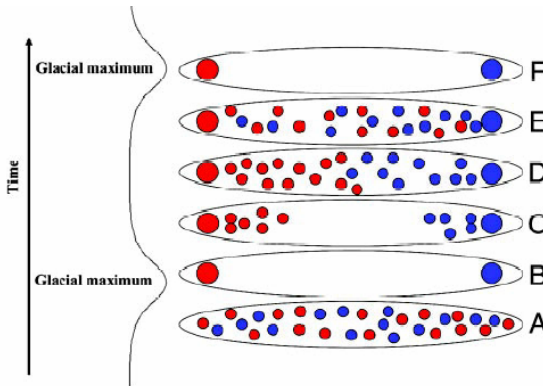


**Fig. 10.6** Maximum extent of the last (Wisconsin) glacial in North America, showing the three ice-free areas (refugia) which correspond to the language groups of native Americans. From Rogers *et al.* [19].

## Refugia a ústup kontinentálního ledovce v S. Americe



## Glaciální refugia a genetická diferenciace



**Fig. 5.** Schematic figure showing the possible effects of glacial cycles on phylogeographic mtDNA patterns. (A) A population that lacks phylogeographic structure is shown shortly before a glacial maximum. (B) During a glacial maximum only individuals in the refugia survive. By drift, different mtDNA types become fixed in the two refugia. (C) After the glaciation, recolonization from the refugia occurs. (D) Individuals from the two clades meet to form a "hybrid zone." (E) Migration eventually erases the phylogeographic pattern for most of the population's range, but the higher population density slows migration into the refugia. (F) During a subsequent glacial maximum the refugia are likely to remain distinct with respect to mtDNA clades.

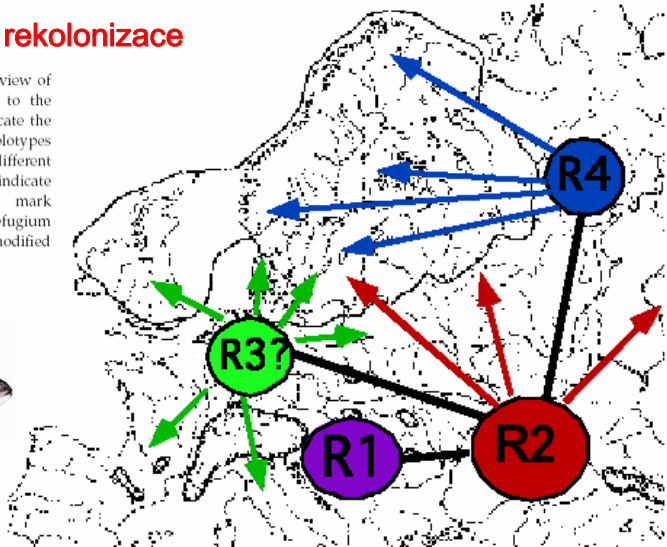
➤ Hofreiter M. et al. 2000:  
Lack of phylogeography in  
European mammals before  
the last glaciation.  
Proc. Nat. Acad. Sci. USA  
101: 12963–12968.

## Po glaciaci: rekolonizace z refugii

- molekulární fylogeografie (*phylogeography*)
- „geographic distribution of genealogical lineages“
- postglaciální expanze z refugii
- efekt hrdla láhve (*bottle-neck effect*)
- efekt zakladatele (*founder effect*) – snížení gen. variability
- refugium iberské, apeninské, balkánské, kavkazsko-karpatské
- horské bariéry (Alpy)
- východní druhy – vše z balkánského refugia
- západní druhy – z různých refugii
- severní Evropa – nižší počet druhů, poddruhů a alelická diverzita
- palearkt – vyšší diverzita na východě + trvajcí kolonizace západu
- S. Amerika – jiná orientace pohoří, ledovce jižněji, méně tundry

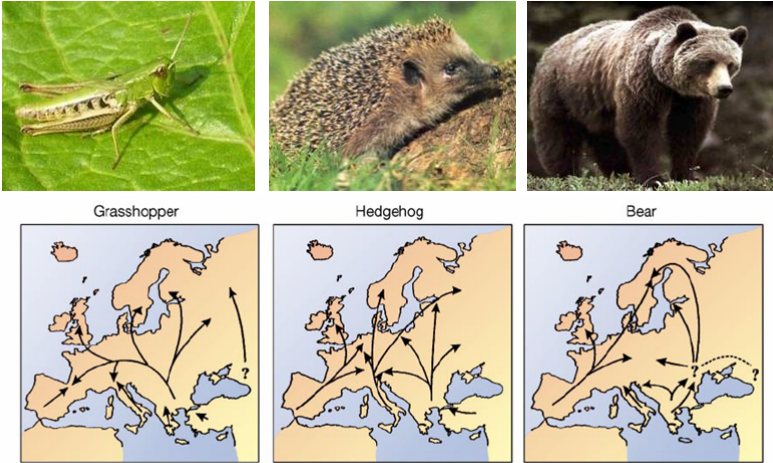
## Glaciální refugia a rekolonizace

Fig. 6 Map showing a schematic overview of the suggested refugia. Colours refer to the cladogram in Fig. 1C. Black lines indicate the phylogenetic relationship among haplotypes presumed to originate from the different refugia (see Fig. 2). Coloured arrows indicate postglacial dispersal. The question mark indicates that the position of the R3 refugium is somewhat unclear. The map was modified from fig. 11.42 in Banareescu (1992).



Nesbo C. et al. 1999: Genetic divergence and phylogeographic relationships among European perch (*Perca fluviatilis*) populations reflect glacial refugia and postglacial colonization. *Molecular Ecology* 8: 1378–1404.

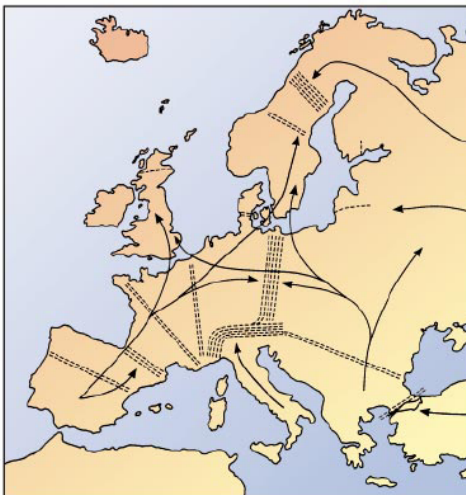
## Po glaciaci: rekolonizace z refugií



**Figure 2** Three paradigm postglacial colonizations from southern Europe deduced from DNA differences for the grasshopper, *Chorthippus parallelus*, the hedgehog, *Erinaceus europaeus/concolor*, and the bear, *Ursus arctos*. The main refugial areas, Iberia, Italy, the Balkans and Caucasus, contributed differently to the repopulation of northern parts.

➤ Hewitt G. 2000: The genetic legacy of the Quaternary ice ages. *Nature* 405: 907–913.

## Po glaciaci: refugia a hybridní zóny

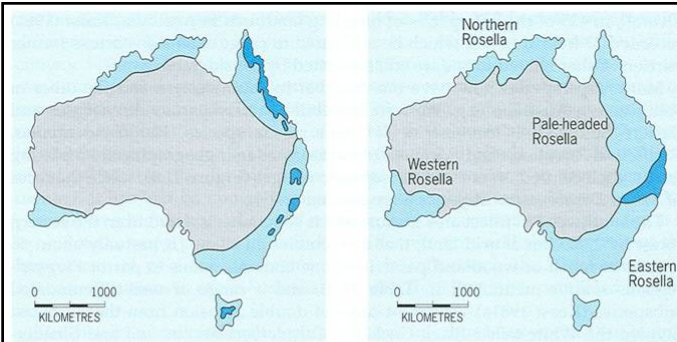


- „suture zones“
- střední Evropa
- Alpy
- Skandinávie
- Balkán

**Figure 3** The general position of some well-known hybrid zones in Europe, which show major clustering in Scandinavia, central Europe and the Alps. Other clusters are apparent in the Pyrenees and the Balkans. These suture zones are caused by commonalities of ice-age refugia, rate of postglacial expansion and physical barriers. There is further subdivision in the southern regions.

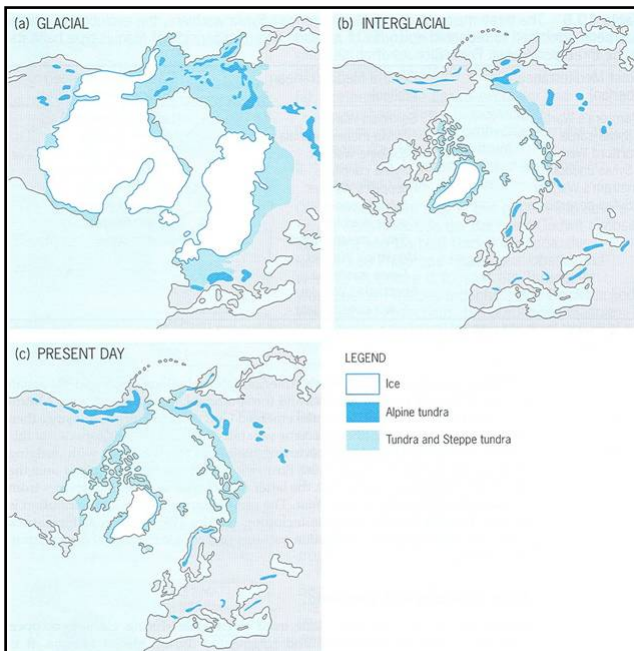


## Glaciální refugia i v tropech



**Figure 11.9** Left. The main refuge areas for birds of rain forest, sclerophyll forest and woodland in Australia. Dark blue shading – rain forest; light blue shading – sclerophyll forest and woodland. In sclerophyll forest species, there is much isolation and differentiation between the southeast, Tasmania and the southwest, and in woodland species between the northwest, southwest, northeast and southeast (to a lesser extent in the Hamersley area of the mid-west). In addition, some bird (especially parrot) distributions are centred on interior drainage basins. Partly from Keast 1981a.

Right. The current ranges of four geographically replacing, closely related parrot species in Australia which are thought to have evolved in the four main dry-period forest-woodland refuges: Northern Rosella *Platycercus venustus* (north), Pale-headed Rosella *P. adscitus* (northeast), Eastern Rosella *P. eximius* (southeast) and Western Rosella *P. icterotis* (southwest). All four show some geographical variation, and the two that overlap do not hybridise. See also **Table 11.2**.



## Interglaciální refugia

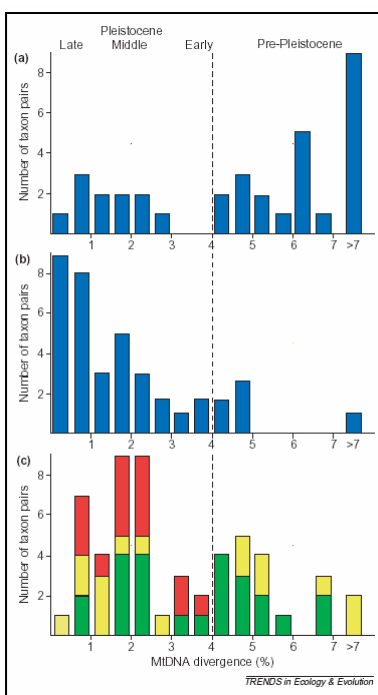
**Figure 10.8** Purported distribution of tundra or steppe-tundra: (a) at the height of the last glacial period; (b) at the height of the last interglacial period, and (c) present. From various sources, especially Frenzel *et al.* 1992.

## Pleistocenní refugia a druhová diverzita v mírném pásu

- tradiční vysvětlení
- Severní Amerika: u obojživelníků (mloci) ano, ale pouze během starších glaciálů
- Severní Amerika: u ptáků s východo-západní vikariací vůbec ne (speciace během posledních 5 000 000 let!)
- Evropa: u brouků ve středomoří to funguje (Ribera & Vogler 2004: Molecular ecology 13 (1): 179–193)
- obecně k roli refugií:
  - významné pro přežívání už existujících taxonů
  - (bez/málo)významné pro speciaci

➤ Klicka J. & Zink R. M. 1997: The importance of recent ice ages in speciation: A failed paradigm. *Science* 277: 1666–1669.

➤ Lovette I. J. 2005: Glacial cycles and the tempo of avian speciation. *Trends Ecol. Evol.* 20: 57–59.



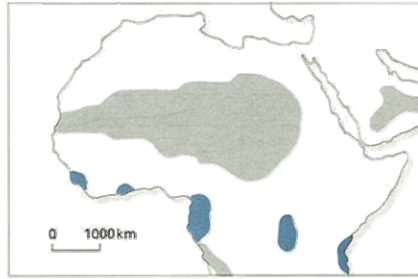
## Pleistocenní refugia a diverzita v mírném pásu

**Figure 1.** The timing of the most recent speciation events in North American birds based on mitochondrial DNA divergence between closely related species. **(a)** In 1997, an influential study by Klicka and Zink [9] rejected the prevailing late Pleistocene speciation paradigm by showing that many putative sister species diverged substantially earlier. **(b)** Subsequent phylogenetic studies have clarified many relationships among North American taxa. Johnson and Cicero [1] recently updated the pairwise comparison approach using only well established sister taxa, and showed that many of these most recent divergences are recent. **(c)** Weir and Schluter [2] partitioned speciation times along a latitudinal gradient and found that boreal species pairs (red bars) tend to have split much more recently than have species pairs at lower latitudes (sub-boreal species, yellow bars; neotropical species, green bars), a pattern that implicates the high disturbance regime of the Pleistocene glacial cycles in generating avian species diversity at northern latitudes. An important caveat to all of these surveys is that, although the revised comparisons provide new evidence for substantial avian speciation during the Pleistocene, most speciation events in the North American avifauna are not included in these comparisons, because they occurred earlier and link older and more differentiated lineages. Reproduced, with permission, from [1–3].

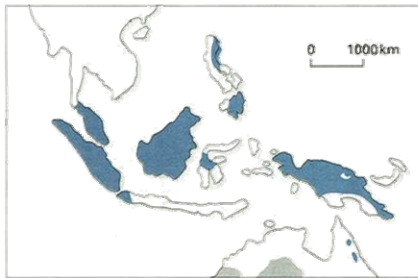
## Pleistocénní refugia a diverzita v tropickém pásu



(a)



(b)



(c)



Fig. 9.12 Possible areas of humid rainforest and arid/semi-arid areas 20 000 years ago, when the glaciation of the higher latitudes was at its maximum. From Tallis [16].

## Nížinná centra endemismu – ptáci

Fig. 5. Lowland endemic centers

1. Chocó
2. Nechí/Magdalena/Maracaibo
3. Guajira
4. Llanos
5. Tumbesian
6. Maraňón
7. Peruvian Coastal
8. Napo
9. Madeira
10. Tapajós
11. Pará (Belém)
12. Guianan
13. Upper Rio Negro
14. Brazilian Coastal
15. Caatinga
16. Cerrado
17. Chaco
18. Pampas
19. Patagonian Steppe



Fig. 5

## Horská centra endemismu – ptáci

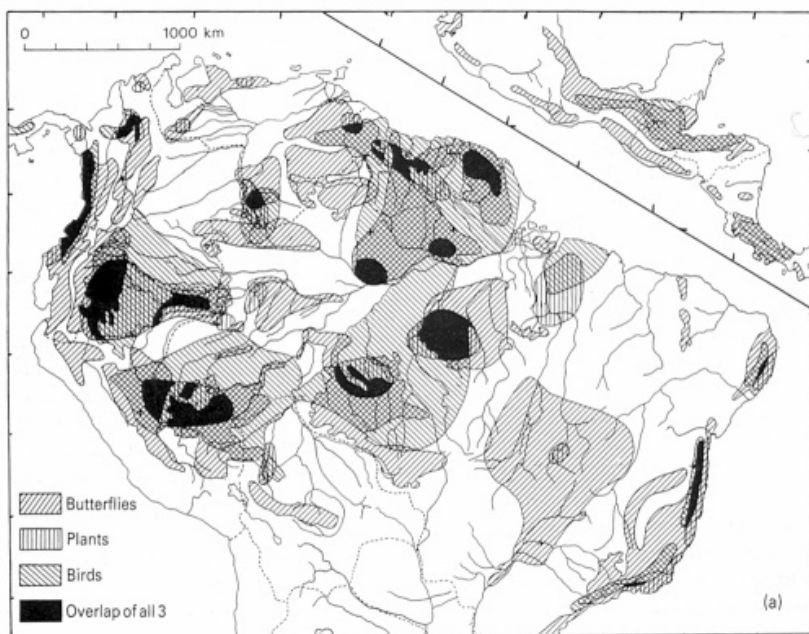
Fig. 6. Montane endemic centers

1. Santa Marta
2. Perijá
3. Venezuelan Coastal
4. Paria
5. Mérida Andean
6. North Andean
7. Peruvian Andean
8. Argentinian Andean
9. Austral
10. Tepui
11. Serra do Mar

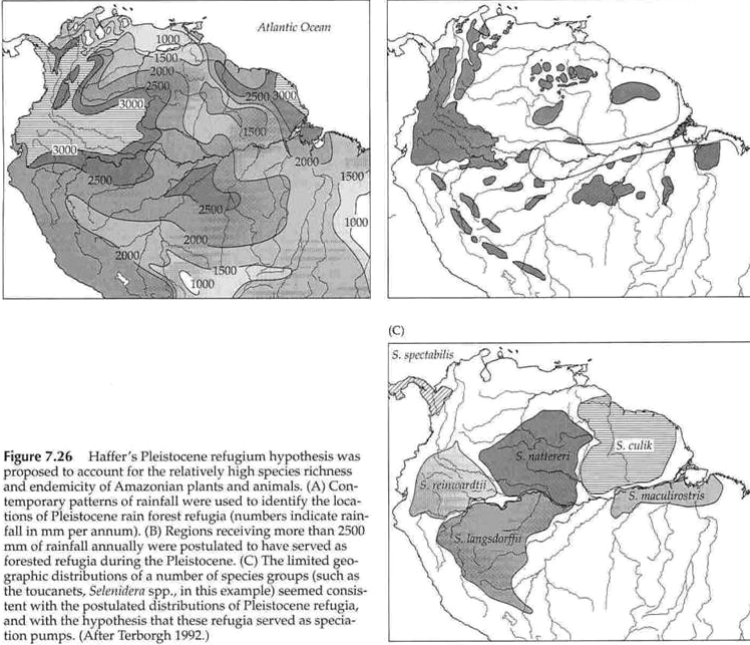


Fig. 6

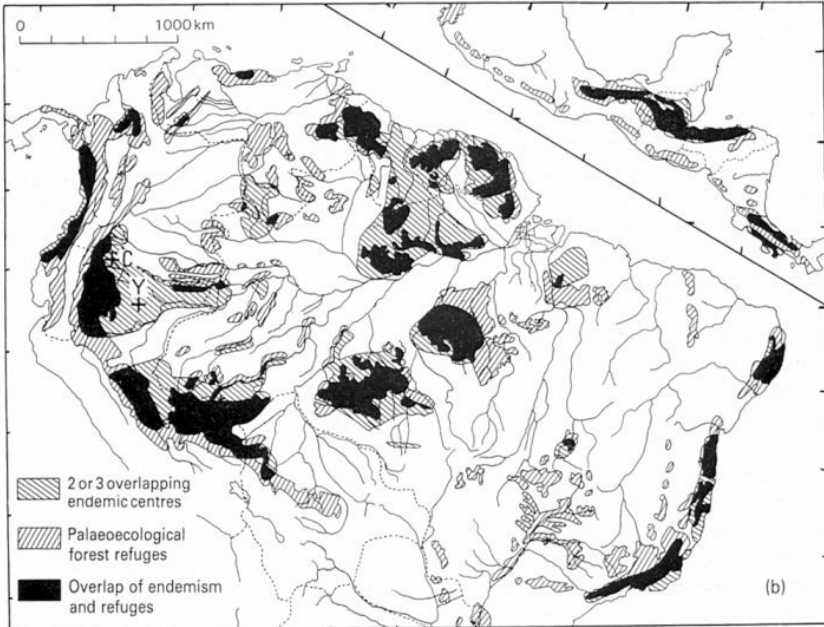
## Centra endemismu – ptáci, motýli, kytky



## Centra endemismu & pleistocénní refugia

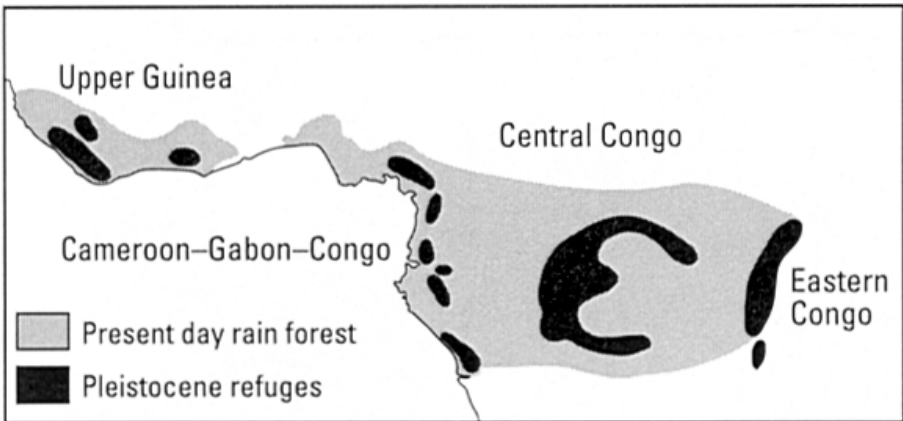


## Centra endemismu & pleistocénní refugia



## Centra endemismu & pleistocénní refugia

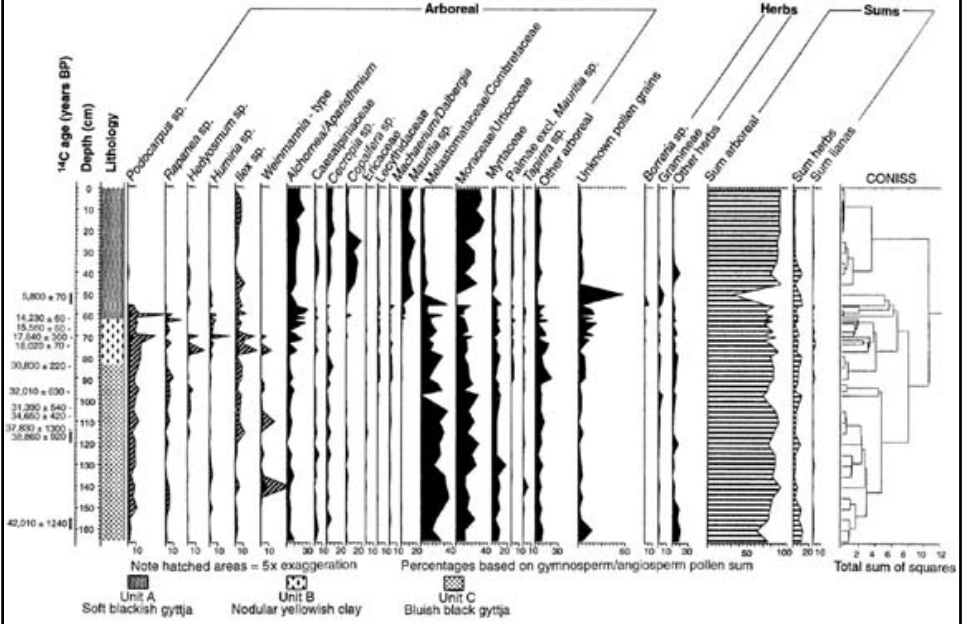
proč je Latinská Amerika druhově tak bohatá a Afrika tak chudá?



## Centra endemismu & pleistocénní refugia

- tradice: tropické deštné lesy = stabilní útočiště biodiverzity
- později: rozsah lesa se masivně měnil (40 000 let)!
- centra endemismu – subspecie (ptáci, plazi, obojživelníci, motýli, stromy)
- Haffer (1969): pleistocénní lesní refugia
- poslední glaciál (18 000 let)
- model cyklické vikariace (*speciation pump model*)
- fragmentace kontinuálních areálů na diskrétní subareály
- vlhký les vs suchá savana (polopoušť)
- alopatriká speciace ⇌ v interglaciálech už mezidruhové bariéry

## Pleistocénní refugia vs. důkazy



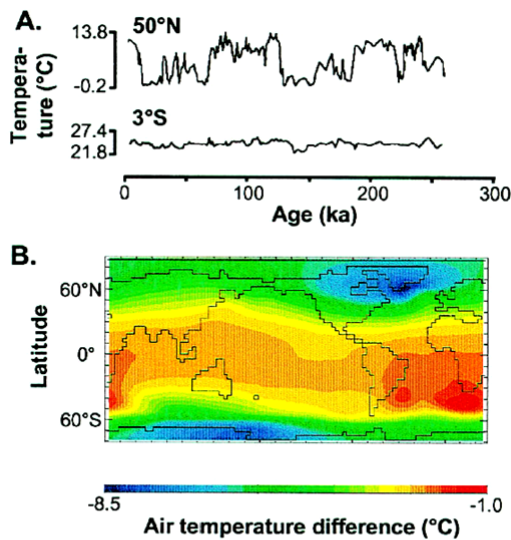
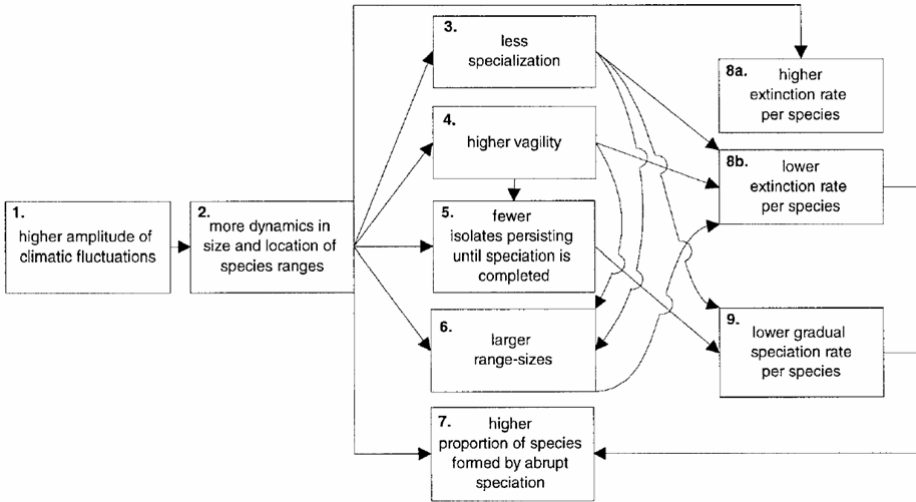
P. Colinvaux – pylový diagram z Amazonie

## Centra endemismu & pleistocénní refugia v tropech: proč je to asi všechno špatně?

- ochlazování jednotně po celé Amazonii
- slabý překryv endemismu mezi taxony
- počet a velikost refugií ~ disperzní schopnosti daného taxonu
- přecenění rozsahu fragmentace (existovala vůbec nějaká refugia?!)
- druhy často mnohem starší než refugia
- ale: starší glaciály drsnější → dostatečná fragmentace → speciace
- ale: pattern tehdejšího endemismu vs dnešní endemismus!
- různé druhy s podobným patternem endemismu – různé stáří!
- rostliny: max. světová diverzita v J. Am. už před 52 000 000 lety!!!
- „refugia“ – vyšší nadmořská výška → heterogenita abiot. podm.
- refugia = místa s nejvyšším výzkumným úsilím! (*sampling artefact*)
- distribuce ptačích areálů je zcela náhodná (*random placement*)!
- jihoamerická diverzita ≠ jen amazonská diverzita!
- ke speciaci stačí parapatriká speciace (obrovská plocha Amazonie!)

## ORD – model oscilační areálové dynamiky

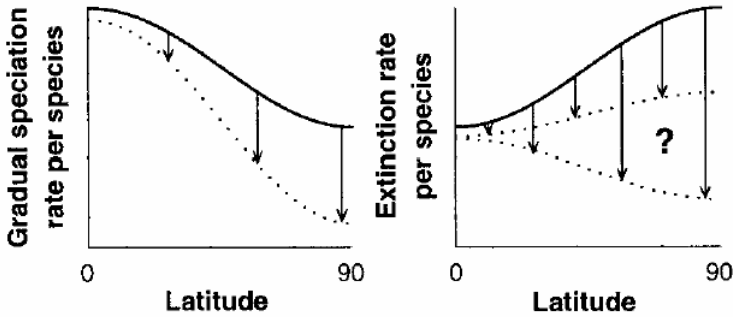
- orbitally forced range dynamics (velikost a umístění areálů)



**Fig. 2.** The amplitude of climatic oscillations is higher toward higher latitudes. (A) Variation in sea-surface temperatures (cold season) at two sites situated 50°N and 3°S in the Atlantic. Adapted from Imbrie *et al.* (6). (B) Difference in the mean annual air temperature between the last glacial maximum and the present, estimated from a recent general circulation model (9).

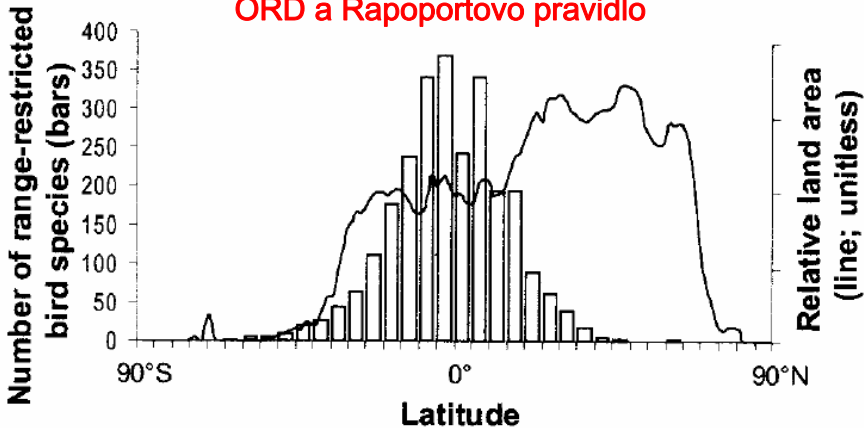


### ORD a latitudinální gradient biodiverzity



**Fig. 3.** Differential degrees of ORD generate a latitudinal gradient in gradual speciation rates. Larger ORD toward the poles reduces the gradual speciation rate but elevates the extinction rate (solid lines). However, ORD selects for vagility and against specialization, thereby lowering both speciation and extinction rates (arrows and dotted lines). Extinction is also lowered by the larger geographical ranges caused by ORD. Stronger rate reductions at high latitudes (longer arrows) accentuate the gradient in speciation rate, whereas the gradient in extinction rate is reduced or may even become reversed.

### ORD a Rapoportovo pravidlo



**Fig. 4.** Larger ORD toward the poles causes a gradient in species' range size. Bird species with small breeding ranges (<50,000 km<sup>2</sup>) are concentrated around the equator and lacking in vast high-latitude land areas in the Northern Hemisphere. Bars show the global number of range-restricted bird species (2,623 or 27% of all bird species) per 5° latitudinal band. Data from Stattersfield *et al.* (63). The line represents the latitudinal distribution of ice-free land, adapted from Rosenzweig (71).

## ORD – model oscilační areálové dynamiky

- orbitally forced range dynamics
- nízká specializace
- vyšší migralita a dispersalita
- genetická homogenita
- *snižování* rychlosti speciace (vs model refugií!)
- velké areály na severu (⇒ Rapoportovo pravidlo!)
- brání extinkci i speciaci
- slabá ORD ⇒ hotspots

Dynesius M. & Jansson R. 2000: Evolutionary consequences of changes in species geographical distributions driven by Milankovitch climate oscillations. Proc. Nat. Acad. USA 97: 9115–9120.

Jansson R. & Dynesius M. 2002: The fate of clades in a world of recurrent climatic change: Milankovitch oscillations and evolution. Annu. Rev. Ecol. Syst. 33: 741–777.

## Glaciace a biogeo dynamika – tradiční model



## Glaciace a biogeodynamika – současný model



*Tradiční představa o vlivu glaciálů na biotu: Klimaticky náročné a lesní prvky teplých úseků přežívají ve vzájemně izolovaných středomořských refugiích, zatímco většinu kontinentu pokrývá drsná periglaciální stepotundra obývaná společenstvy chladnomilných stepních a tundrových forem (vlevo) ♦ Současné poznatky ukazují, že model kompletní výměny fauny v průběhu každého glaciálního cyklu (střídání glaciálních a interglaciálních společenstev) v jižní Evropě neplatí. S výjimkou přílivu pestrůšky r. *Lagurus* zůstávají místní společenstva bez podstatných změn v průběhu celého cyklu. Vůdčí prvky středoevropských glaciálních společenstev (lumíci, hraboš úzkolebý apod.) zde chybí. Přechodová zóna mezi středoevropským a jihoevropským typem faunové dynamiky byla pravděpodobně hlavním refugiem pro většinu náročných středoevropských prvků (vpravo)*

🕒 Tradiční model

🕒 Současný model

## Glaciální refugia byla i severně od Středomoří



norník rudý

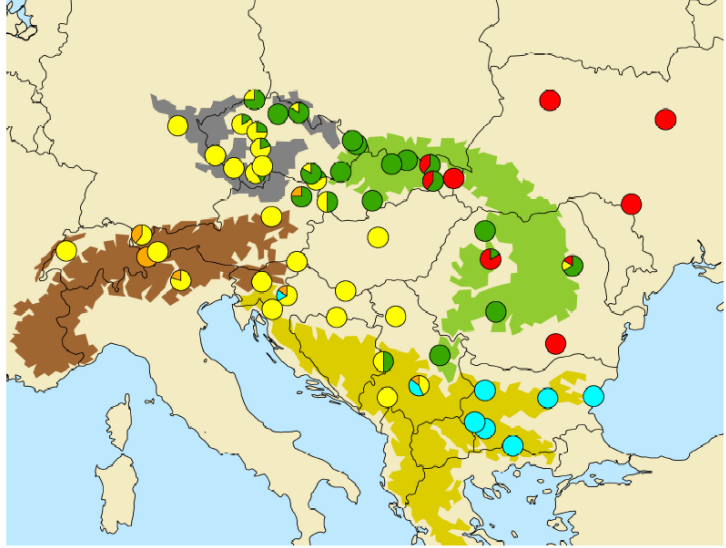


Fig. 1. Map showing the collection sites and the distribution of haplotype lineages. Pie charts show the proportions of haplotypes belonging to each lineage within each population. The colors equate to the clades identified in Fig. 2. Approximate distribution of major mountain regions is shown in green for the Carpathians, in gray for the Bohemian Massif, in brown for Alps, and in yellow for the Balkans.

Kotlík P. et al. 2006: PNAS 103: 14860–14864.

## Význam glaciálů

- změna distribuce a velikosti biotů a areálů (ORD dynamika)
- rozpad společenstev – druhy reagují individuálně
- „poskládání“ nových společenstev
- fragmentace (?) ekosystémů
- extinkce / adaptace / genetická diferenciace
- proč byly glaciály:
  - **externí příčiny:**
  - astronomické (Milankovičovy cykly)
  - **interní příčiny:**
  - oceánská (↔ atmosférická) cirkulace
  - zpětná ekosystémová vazba
  - vulkanické erupce