Ecology I.

- http://zeus.nyf.hu/~szept/kurzusok.htm

- Krebs, C. J. (1985) Ecology, The experimental Analysis of Distribution and Abundance.Harper Int. Ed.

- M. Begon, J.L. Harper & C.R. Townsend (1996) Ecology, Individuals, Population and Communities. Blackwell Sci. Publ.

Topics

1. Introduction to the Science of Ecology

2. Distribution of living organisms, Factors that limit distributions

3. Populations, Population parameters, Demographic Techniques

4. Population growth

5. Evolution and Ecology

6. Species interactions: Competition, Niche

7. Species interactions: Predation, Herbivory, Food Webs

8. Nature of the Community: structure and change

9. Flux of Energy and Matter trough Ecological systems

10. Natural and artificial ecological systems. Biological diversity

11. Climate change and its ecological consequences

1. Introduction to the Science of Ecology

History of Ecology

Ancient Greeks

Aristotle (IV. B.C): high reproductive rate of field mice could produce more mice than natural predators can reduce. Reduce of mouse plagues can be by heavy rain.

Herodotus and Plato: nature is designed to benefit and preserve each species, number of every species essentially constant, outbreak of some population might occur (punishment of evil-doers). Each species had a special place in nature, and extinction did not occur because it would disrupt this balance and harmony of nature

History of Ecology

- Graunt (1662) Father of demography. Importance of measuring in a quantitative way the birth rate, death rate, sex ratio and age structure of human populations. Concluded, that even without immigration, London could double its population in 64 years.

- Leeuwenhoek (1687) studied the reproductive rate of grain beetles, carrion flies and human lice. One pair of carrion flies could produce 746 496 flies in three months. First attempts to calculate theoretical rates of increase for an animal species

History of Ecology

Buffon (1756) Population of man and other living organism subjected to the same processes.

Great fertility of every species was counterbalanced by innumerable agents of destruction.

Plague populations of field mice checked partly by diseases and scarcity of food (biological factors) – not only the heavy rains

He dealt among the first with population regulation.

- Malthus (1798) „The numbers of organisms can increase geometrically, but their food supply may never increase faster than arithmetically."

Reproduction is checked by food production.

Interest in mathematical aspects of demography increased after Malthus

History of Ecology

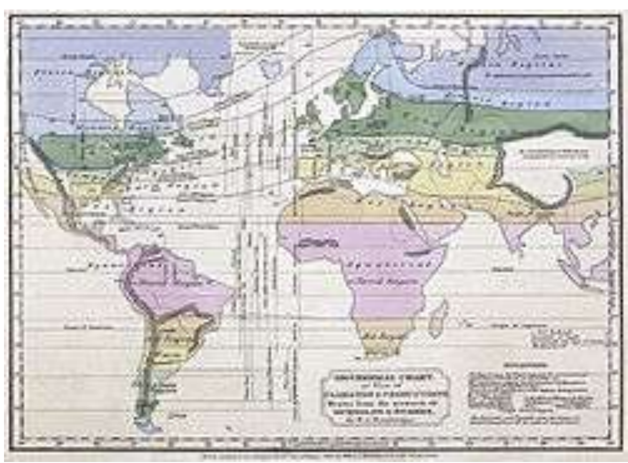
- Farr (1843) Relation between density of population and mortality.

He pointed out that in US the food increased geometrically – against Malthus

- Möbius (1877) Biocoenosis

- Cowles (1899) Plant succession

- Humboldt (XIX century) Relation between climate and vegetation



History of Ecology

- Darwin (1859) Natural selection

Ecology, definition

The roost of ecology lie in natural history.

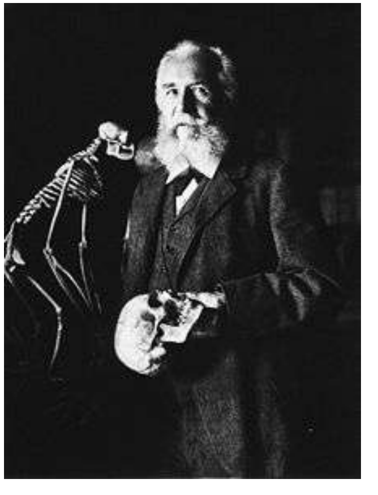
A word used first by Henry Thoreau (1858) without definition

Haeckel (1869) defined first: as the total relations of the animals to both its organic and inorganic environment -> Too wide definition **!**

Physiology

Genetics Ecology Ethology

Evolution



Ecology - definition

Elton (1927): Scientific natural history

Odum (1963): Study of the structure and function of nature

Andrewartha (1961): Ecology is the scientific study of the distribution and abundance of organism – problem: this definition is static and leaves out the importance of relationships

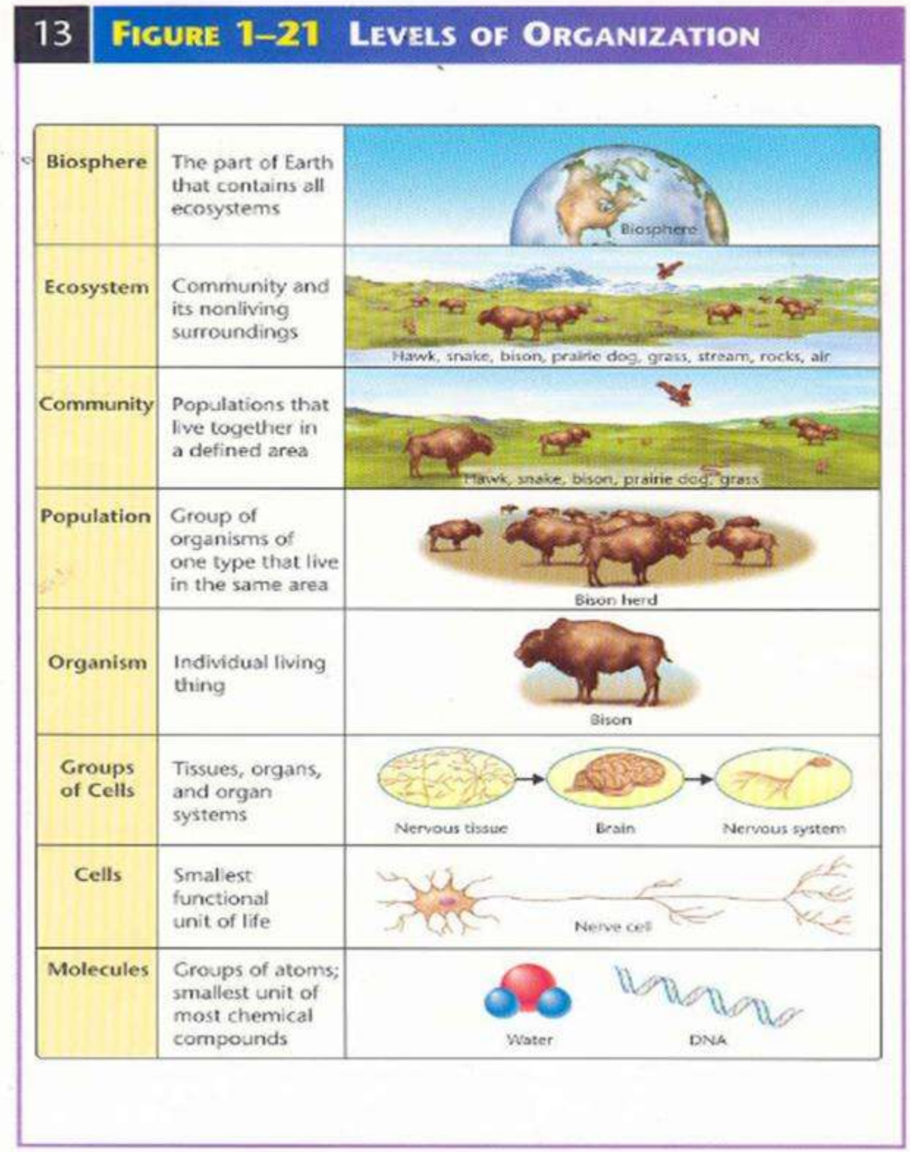
Krebs (1985): Ecology is the scientific study of the interactions that determine the distribution and abundance of organism. Where organisms are found, how many occur there, and why

Hungarian approach

Juhász-Nagy Pál (1970):

Ecology:

- focusing on supraindividual levels of biological organisation
- Population is the basic unit of it



Hungarian approach

Juhász-Nagy Pál (1970): 

Ecology:

- focusing on supraindividual levels of

biological organisation

- Population is the basic unit of it

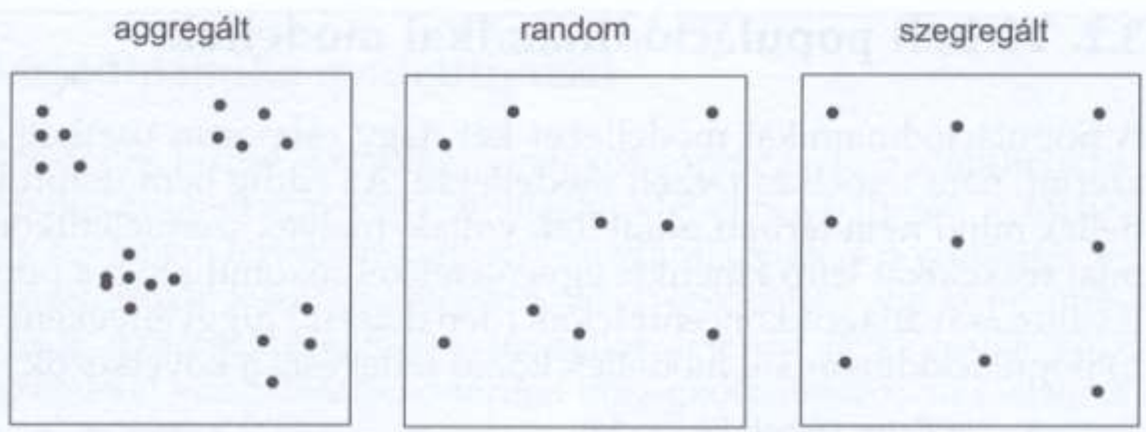
- Central (null) hypothesis (CH): Any population could find any where, any time, any quantity in the nature – occurance in space, time and abundance is random

- Central fact: CH could be faulty
- Central problem: How the CH is faulty and Why?

Example: spatial distribution

Three basic distributions:

aggregated random segregated



2. ábra A populációmintázatok típusai.

In the case of non random distribution there is an chance to find factors responsible for the found pattern.

Ecological principles -
Opportunities to explain difference from the random distribution

1. Indication principle

-indicators (living organisms)

-indicandum, environmental factor which ones the indicator indicates

2. Complementation principle

- Relation of exterior and interior environments – acting factors and perceptive abilities
- exterior-interior complexes, neighbourhood – living organism

-Exterior complexes, all potentially acting factors in the neighbourhood

- Miliö spectrum, potentially acting factors in the neighbourhood on the base of existing experience

- Miliő, effectively acting factors in the neighbourhood responsible for the found distribution – environment

-Interior complexes, all potentially perceptive abilities

- Tolerance spectrum, potentially perceptive abilities on the base of existing experience

- Tolerance, effectively perceptive abilities responsible for the found distribution

.

Ecological environment: all factors in the neighbourhood which directly and effectively act on the biological object

Neighbourhood –> topological environment

Habitat (biotope): area where the supraindividual biological object occur

3. Multiplural environmental principle

There are several ecological environments in the given topological environment in the given time

4. Limitation principle

- Environmental factors acts together, synergy, any of it which reach range of the tolerance became limiter. Liebig limitation.

  „The strength of the chain depend on the weakest chain link”

Type of ecological studies

- Descriptive

Natural history, describing populations, communities and their relationships

- Functional

Investigations of how the ecological system working. Discovering proximal processes.

- Evolutionary

Explanation of how evolution by natural selection has moulded the ecological patterns we observe today.

.

Type of ecological studies

.

Plant and animal ecology

Hydro and terrestrial ecology

Population and Community Ecology

Behavioural ecology

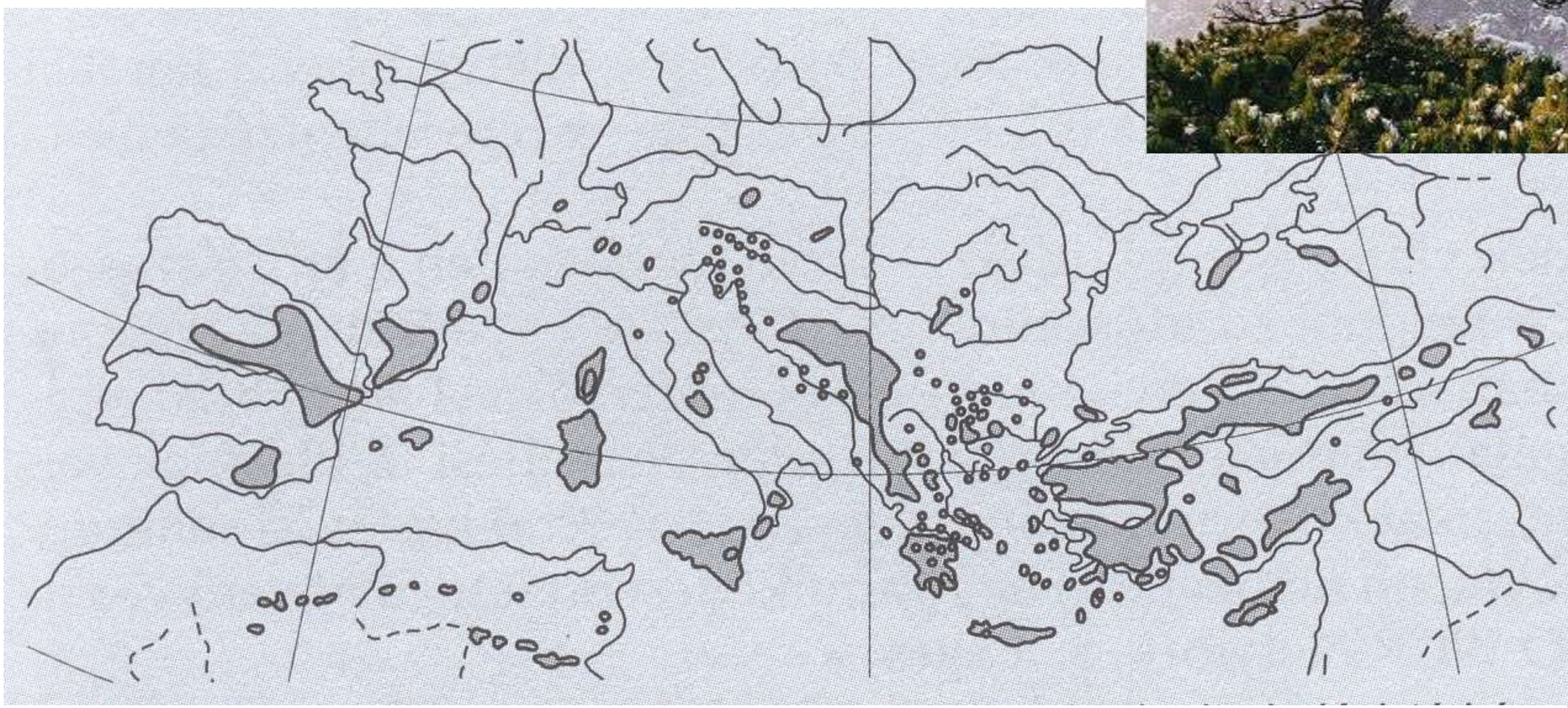
Study methods
- Field observation
- Experiment
- Modeling

Synecology – study of group of organisms

Autecology –> individuals organism –> environmental physiology

Methods for analysing distribution

What explains the occurence of a species in a given place?



Distribution of black pine (Pinus nigra) in Europe

What explains the occurence of a species in a given place?

Area accessible yes← **Dispersal** → no

↓

Dispersal

- Spread of the African honey bee in South America

Dispersal: undirected movement

Migration: directed movement (e.g. bird migration)

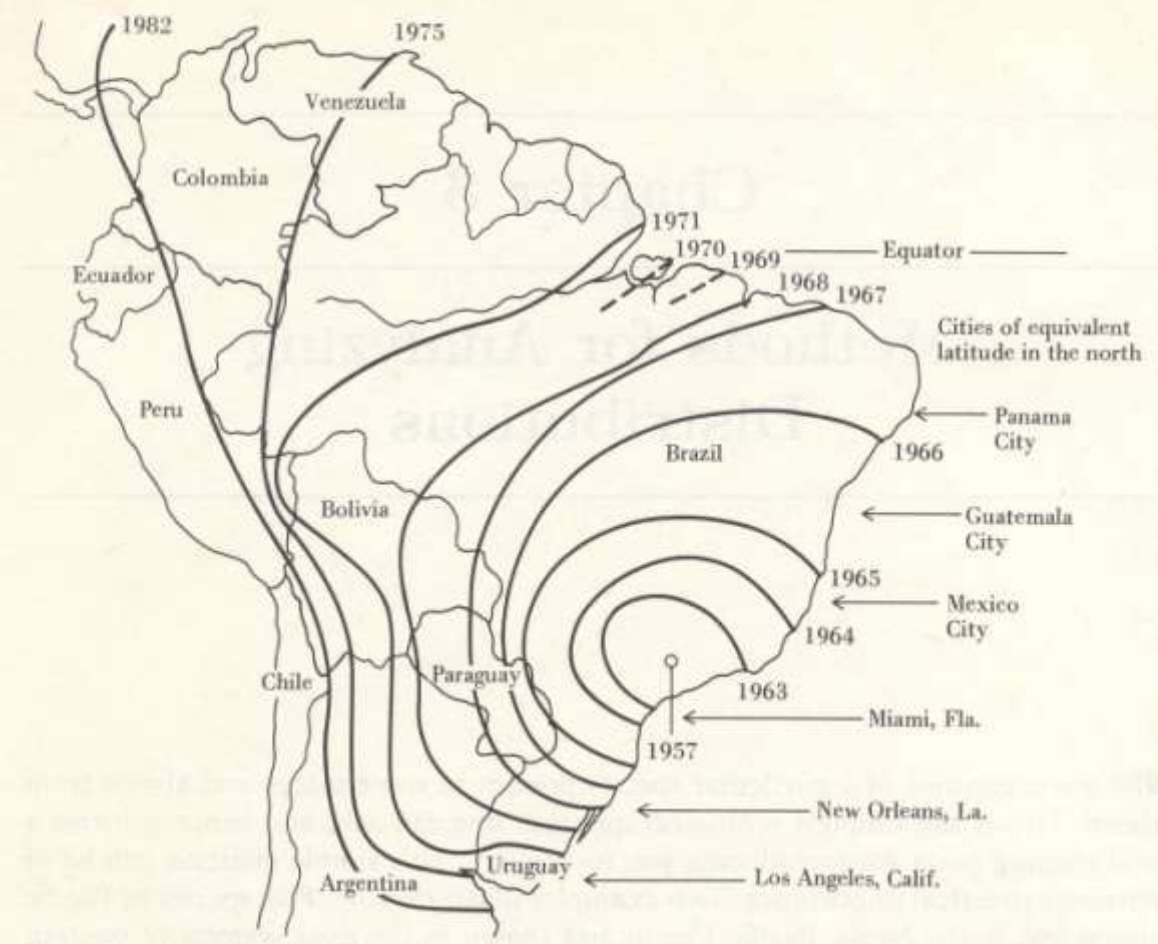


Figure 3.1 Spread of the African honey bee in South America since 1956. Southward and westward expansion has been slight since 1971. Further northward spread is occurring. (After Michener 1975 and personal communication.)

Dispersal

Part of Biogeographia

European starling (Sturnus vulgaris) introduce to USA

Between 1850-1889 at many sites – no success
Introduce in 1918 at New York 80 males and 80 females, slow
Young individuals has the most important role

Types:
- Diffusion
- Jump dispersal
- Secular migration (in evolutionary
Scale) (e.g. opossum

The role of barriers
(Oceans, deserts, high mountans,..e.g.)

Colonisation and extinction -> part of dispersal

What is the function of the dispersal ?
- Option to invade new habitats

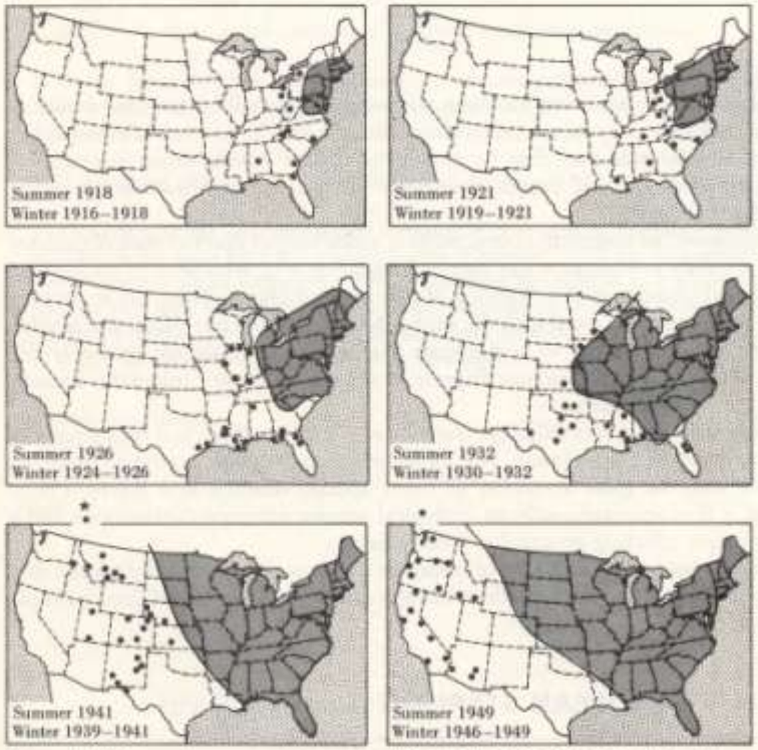
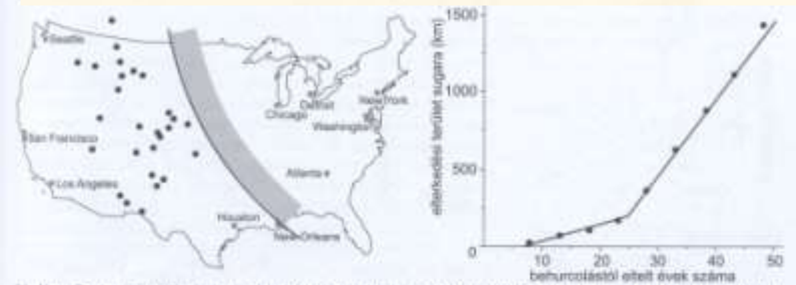
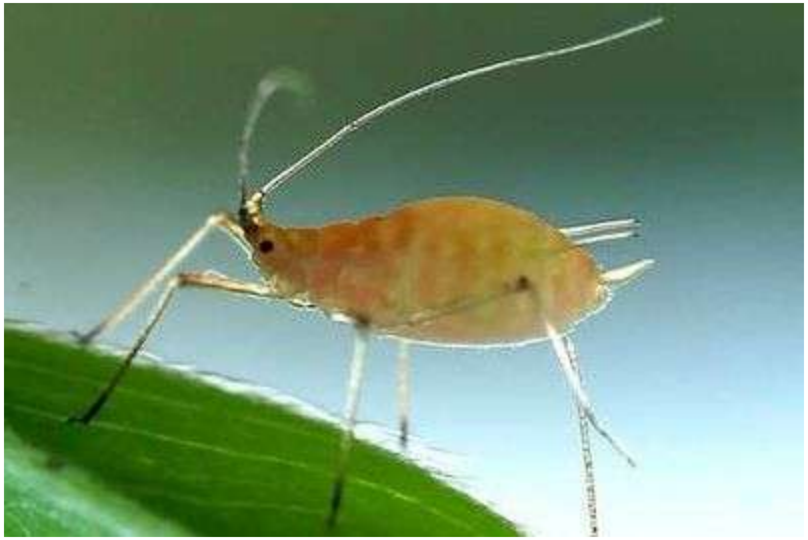


Figure 4.1 Westward expansion of the range of the starling. The shaded area shows the approximate breeding range for a given summer; the dots indicate winter occurrences outside the breeding range for the same year and two or three previous years. The star indicates an unusually advanced breeding record, in 1934, at Camrose, Alberta. (After Kessel 1953.)



21. ábra Európai seregélyek elterjedése (a) terjedési front és szórványos előfordulások (•), (b) elterjedési terület változása az idővel.

Aphids



Aphids

Different forms:

– winged, sexual reproduction, high dispersal

- wingless, partenogenetic reproduction

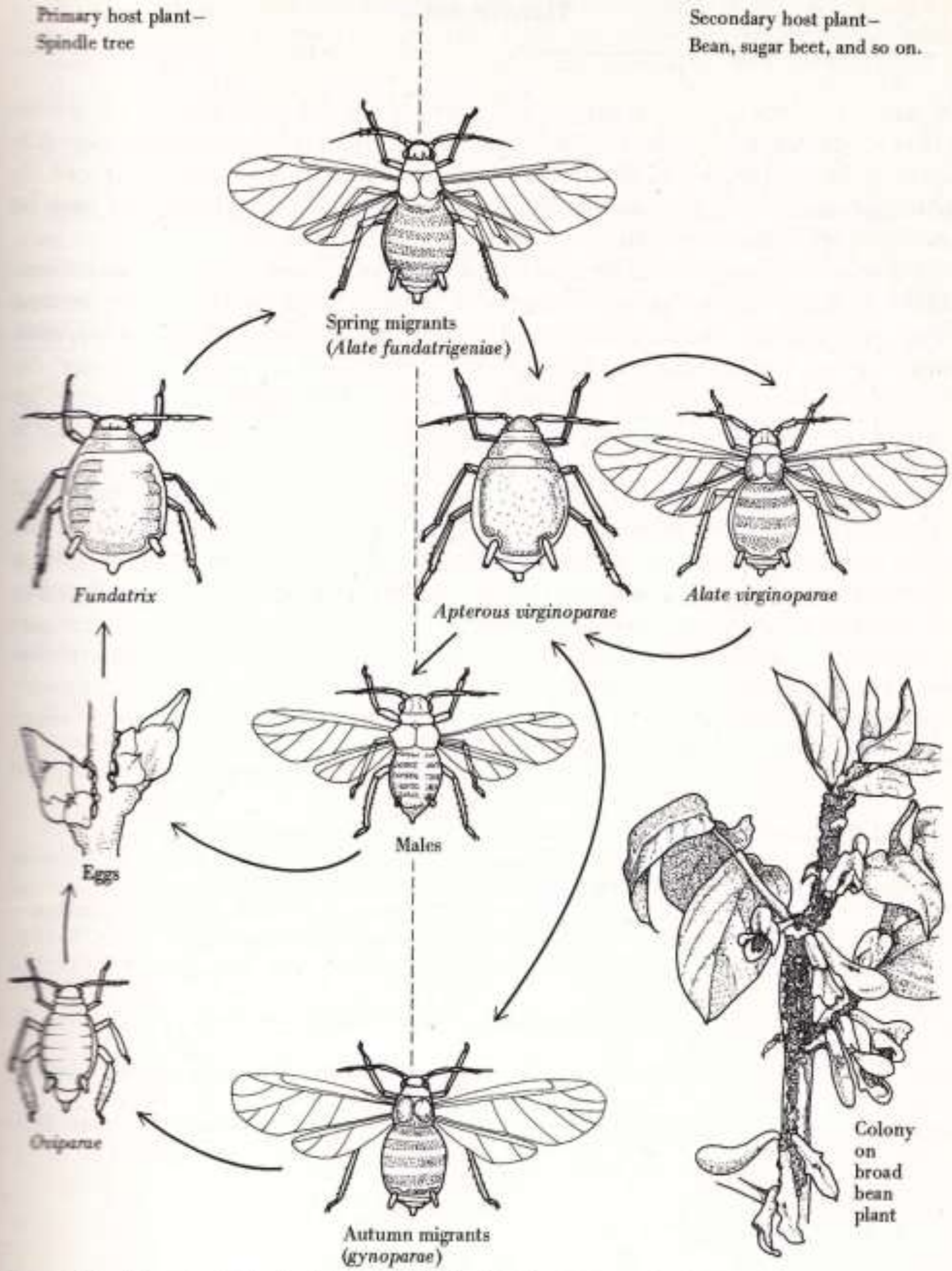


Figure 4.7 Life cycle of the black bean aphid (*Aphis fabae*). (From Blackman 1974.)

Speed of dispersal

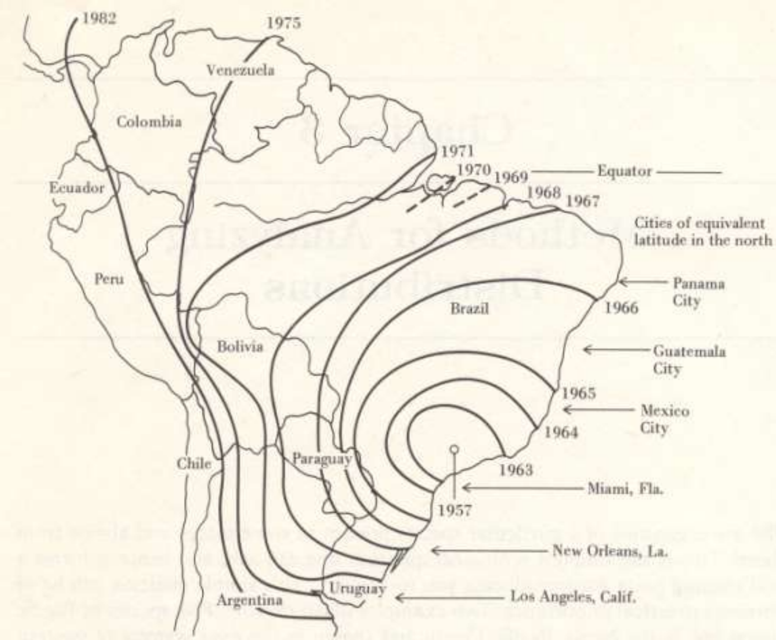
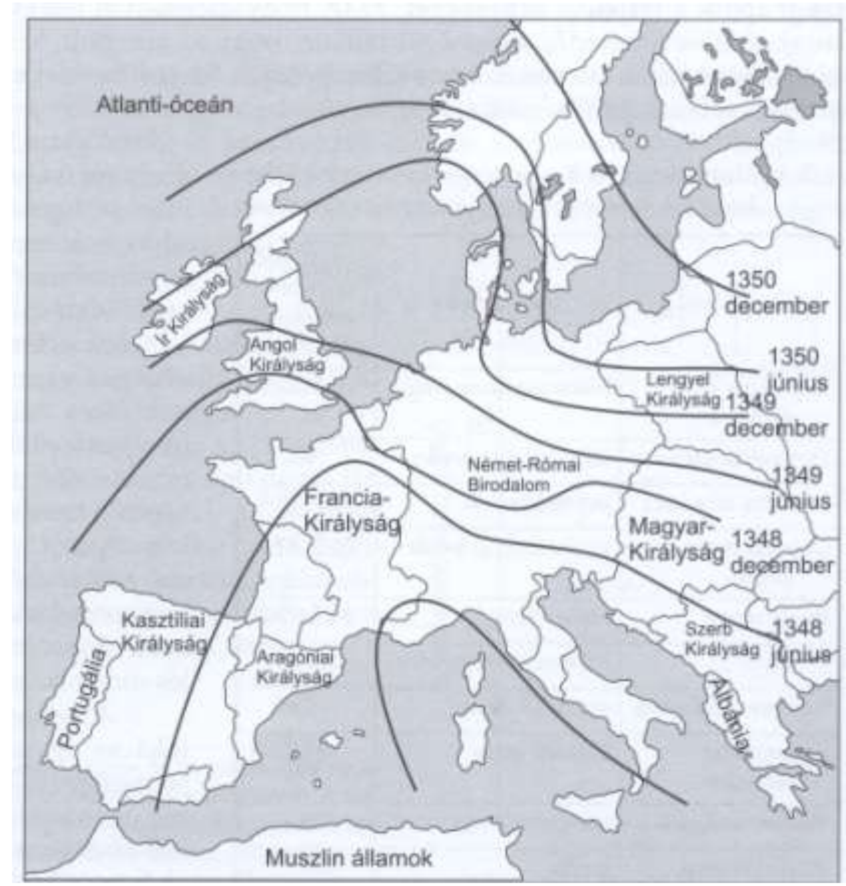


Figure 3.1 Spread of the African honey bee in South America since 1956. Southward and westward expansion has been slight since 1971. Further northward spread is occurring. (After Michener 1975 and personal communication.)

Latin	Hungarian	Megfigyelt speed km/year
Impatiens glandulifera	bíbor nebáncsvirág	9,4–32,9
Lymantria dispar	erdei gyapjaslepke	9,6
Ondatra zibethica	pézsmapocok	0,9–25,4
Oulema melanopus	vetésfehérítő bogár	26,5–89,5
Pieris rapae	répapillangó	14,7–170
	róka veszettség vírus	30–60
Sciurus caroliensis	szürke mókus	7,66
Streptopelia decaocto	balkáni gerle	43,7
Sturnus vulgaris	seregély	200
Yersinia pestis	pestis	400



Spread of pestis (Yersinia pestis) plague in Europe

Dispersal

Invasive species -> economic, health and conservation problems

„10% role”

An average 10% of an introduced alien species survive in the new area

↑ An average 10% of these species could live longer in the new area

↑ An average 10% of these species could reproduce extremly-> invasive species

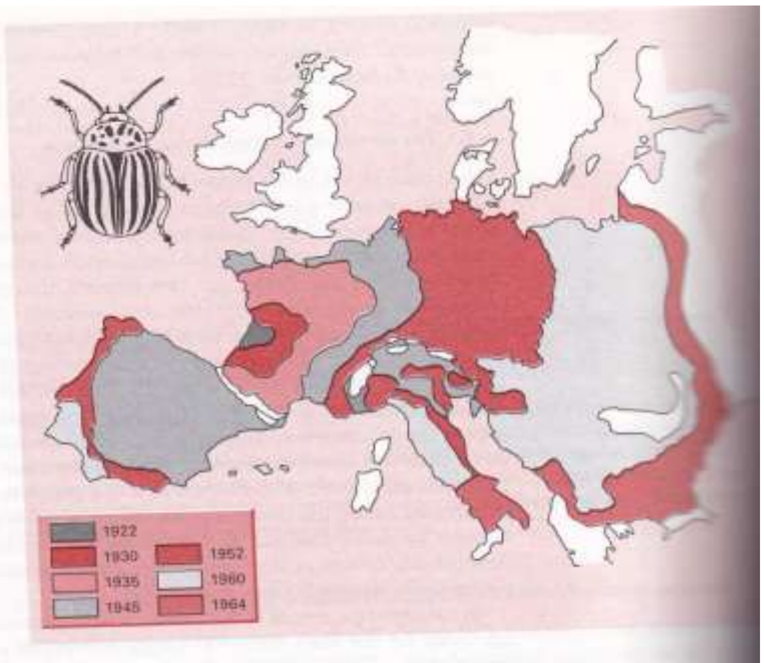
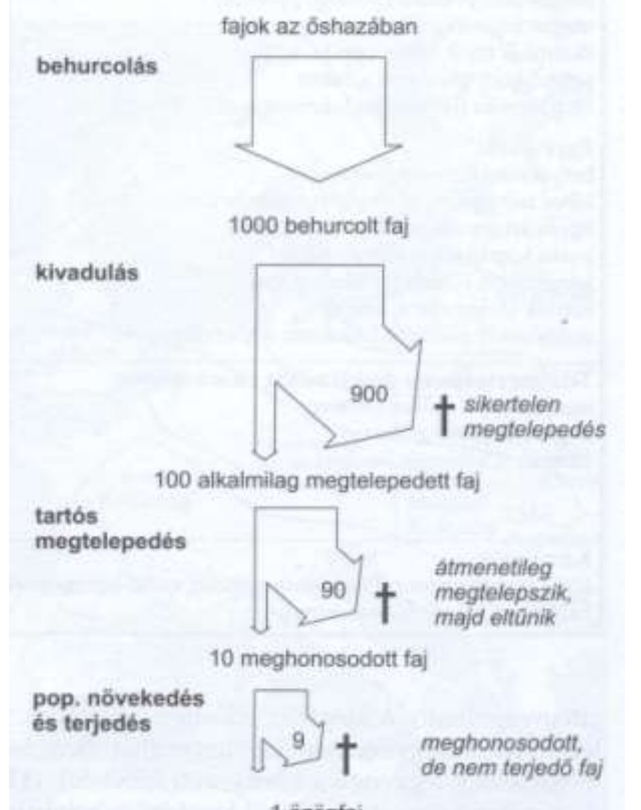


Figure 5.4 Spread of the Colorado beetle (*Leptinotarsa decemlineata*) in Europe. (After Johnson, 1967.)



13. ábra Az özönfajjá válás 10-es szabálya (Williamson és Fitter 1996 nyomán).

Transplantation experiments

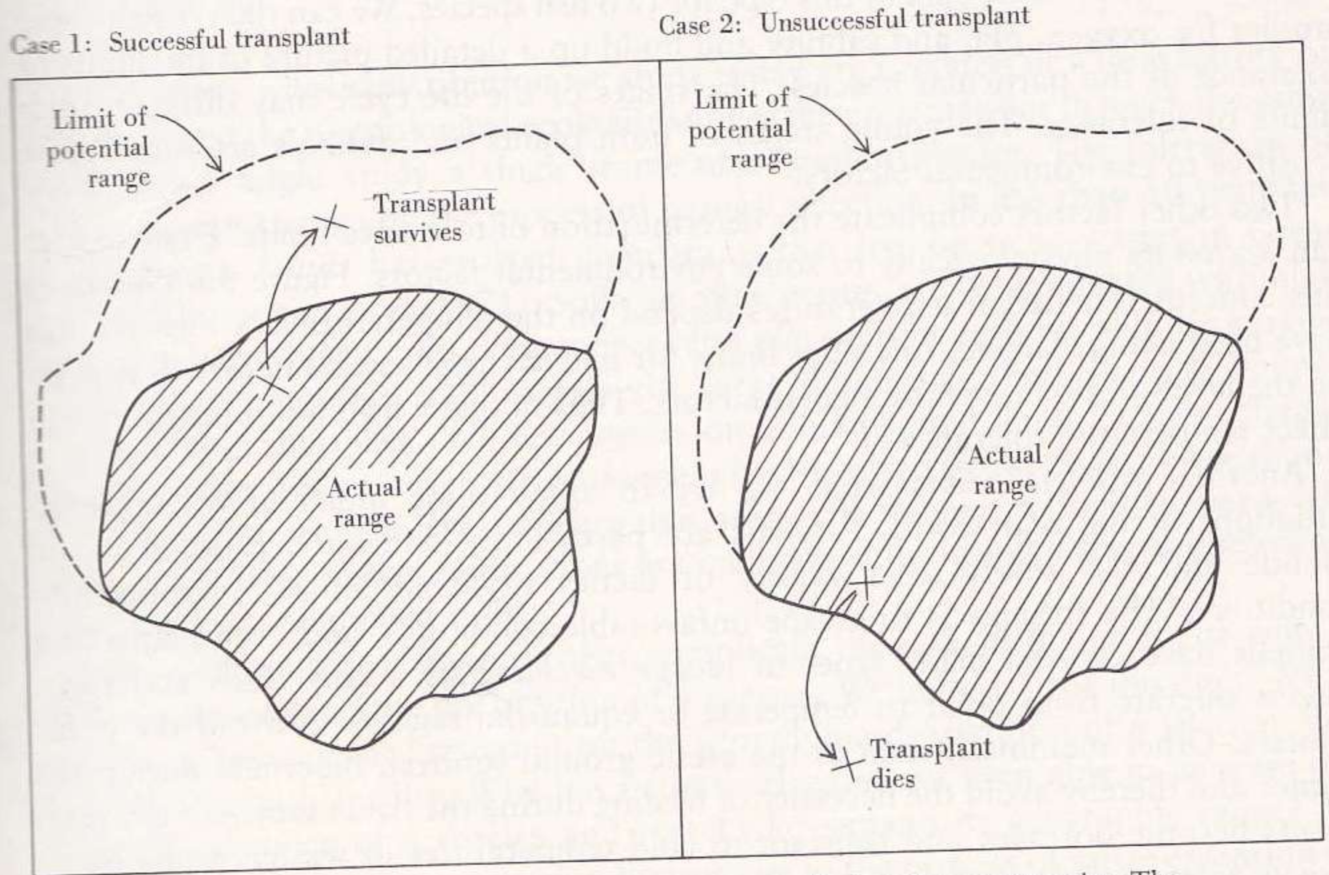


Figure 3.2 Hypothetical pair of transplant experiments applied to the same species. The shaded area represents the actual distribution of the population.

What explains the occurence of a species in a given place?

Area accessible yes← **Dispersal** → no

↓

Habitat selection yes← **Behaviour** → no

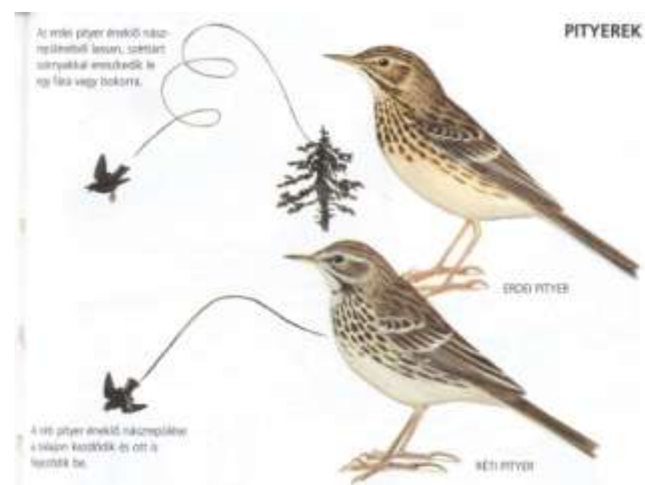
↓

Habitat selection

Several animals do not occupay all their potential range even though they are able to disperse into the unoccupied area

Anopheline mosquitoes – malaria infection – the mosquitoes lay eggs in much smaller areas as they able to do – height of vegetation above the surface of water influence the egglaying habit of the female mosquitoes – they prefer the open surface to during ovipositing dance

Lapwing (Vanellus vanellus) prefer the brown colored grassland in spring against the green one for nesting -> proper height of the vegetation during incubation



Two pipit bird species (Anthus trivialis, Anthus pratensis)

A. trivialis need trees in the habitat – important duirng pair-formation

Habitat selection

Fretwell (1972) Ideal free distribution model

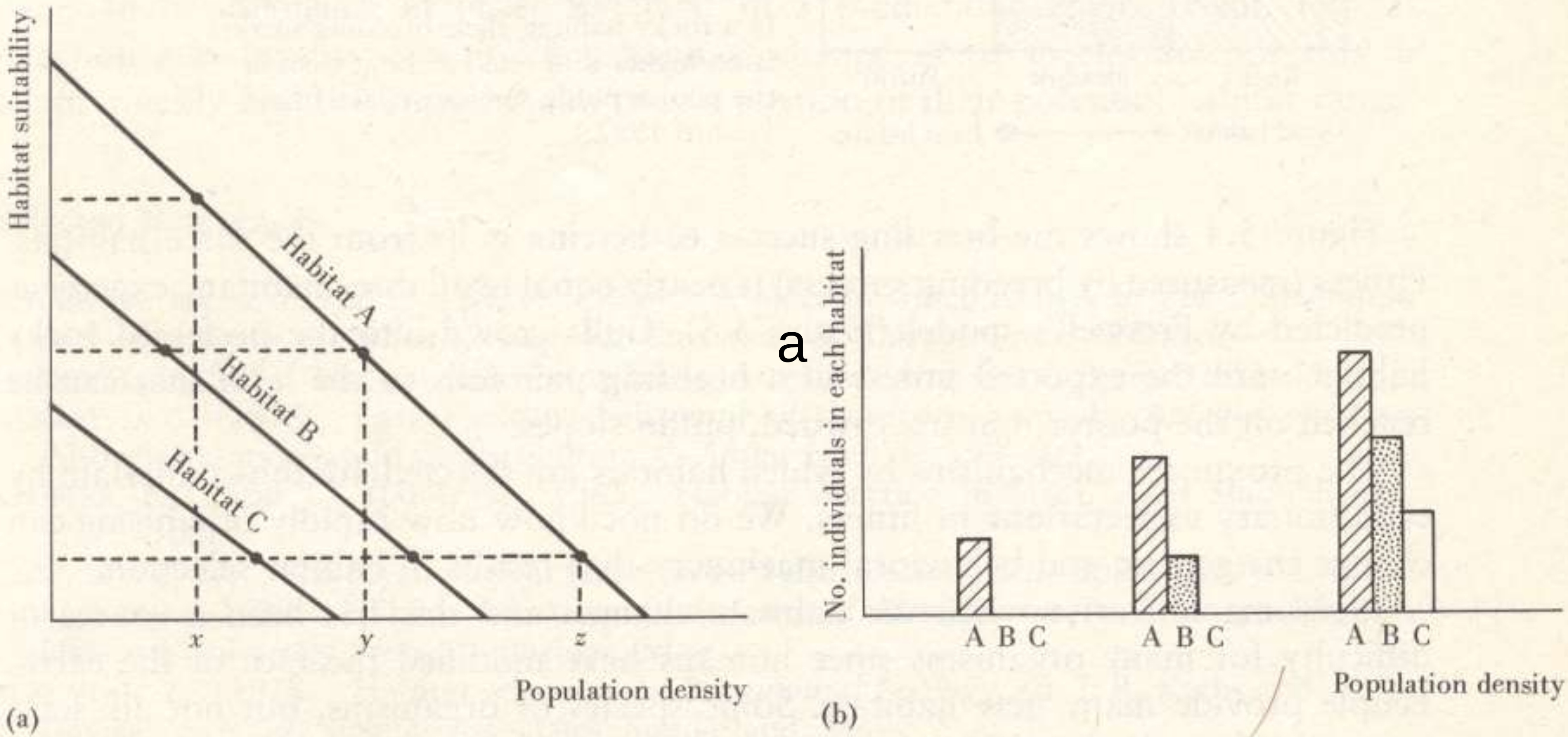


Figure 5.3 A simple model of habitat selection. Three habitats are used for illustration (A = good habitat, C = poor habitat). Habitat suitability is measured by the fitness of individuals living in that habitat. For illustrative purposes, three levels of population density are indicated (*x*, *y*, *z*). At low density *x*, all individuals live in favored habitat A. At high density *z*, all three habitats are occupied. (Modified from Fretwell 1972.)

What explains the occurence of a species in a given place?

Area accessible yes← **Dispersal** → no

↓

Habitat selection yes← **Behaviour** → no

↓

yes← **Other species** → no

Predation

Competition

Parasitism

Mutualism

Interrelations with other organisms

Burrowing rats distribution before discovering by European (grey area) and recently (black dots) – cause: fox (predation) és rabbit (competition)

Figure 6.4 Geographic distribution of the burrowing rat kangaroo (*Bettongia lesueur*) in Australia. This small kangaroo is now extinct on the mainland and survives on only three islands. (From Ovington 1978.)

Interrelations with other organisms

Competition

Redwing territories (upper map) before the Tricolored blakbird arrival in spring and territories of these two species after arrival of Tricolored blakbird (lower map ábra).

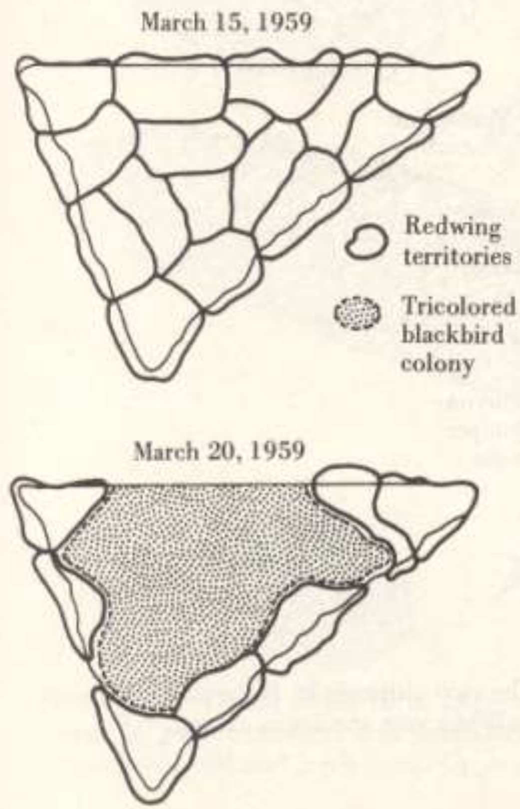


Figure 6.9 Interactions between redwing and tricolored blackbirds at Hidden Valley Marsh, Ventura County, California, in 1959. (After Orians and Collier 1963.)

Interrelations with other organisms

Allelopathy

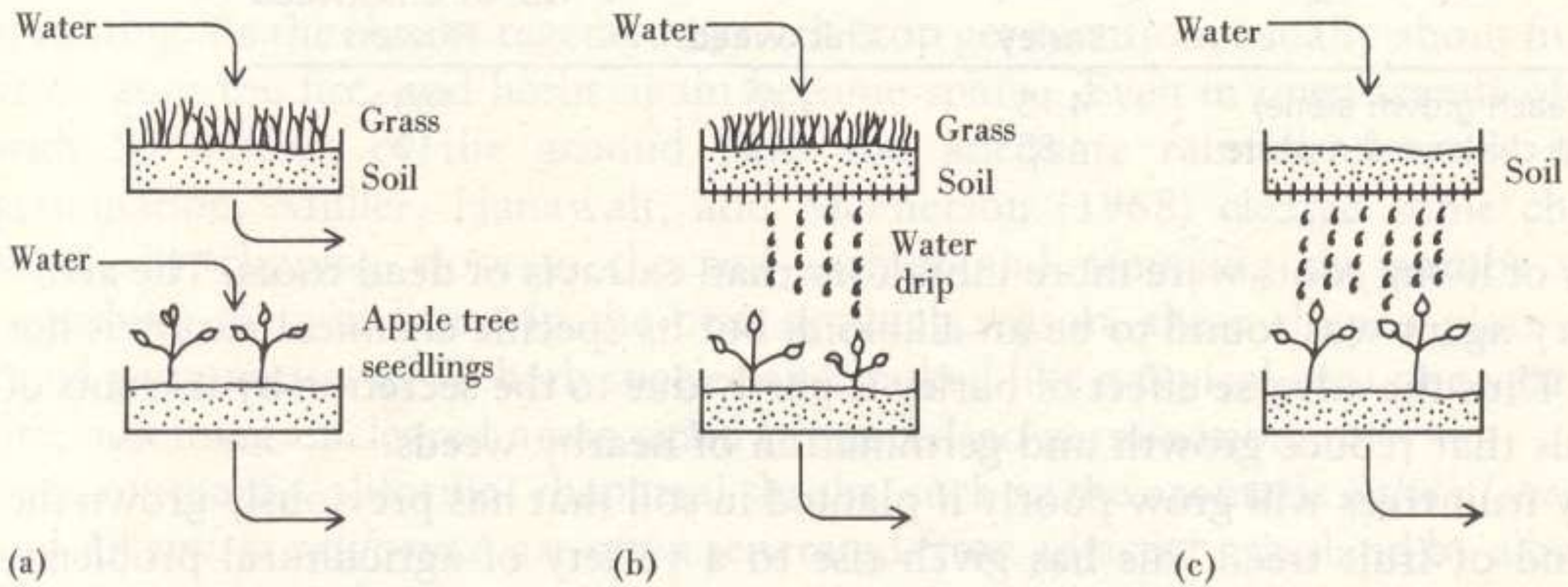


Figure 6.5 Experiments that demonstrated the detrimental effects of grass on apple tree seedlings. Grass and tree seedlings are grown in separate flats in a greenhouse. Water is provided either (a) independently to both grass and trees, (b) as a single source to the grass and soil, or (c) to the soil alone. Water drip provides moisture for the apple seedlings in (b) and (c). Apple tree seedlings do not grow properly when the water has passed through grass first (b).

Interrelations with other organisms

Parasitism

e.g. Mosquitoes and reindeer in the tundra

Mutualism

e.g. Fungies and Pine trees

e.g.

Ant species (Pseudomyrmex triplarinus) and a tree (Triplaris americana) in South America

What explains the occurence of a species in a given place?

Area accessible yes← **Dispersal** → no

↓

Habitat selection yes← **Behaviour** → no

↓

yes← **Other species** → no

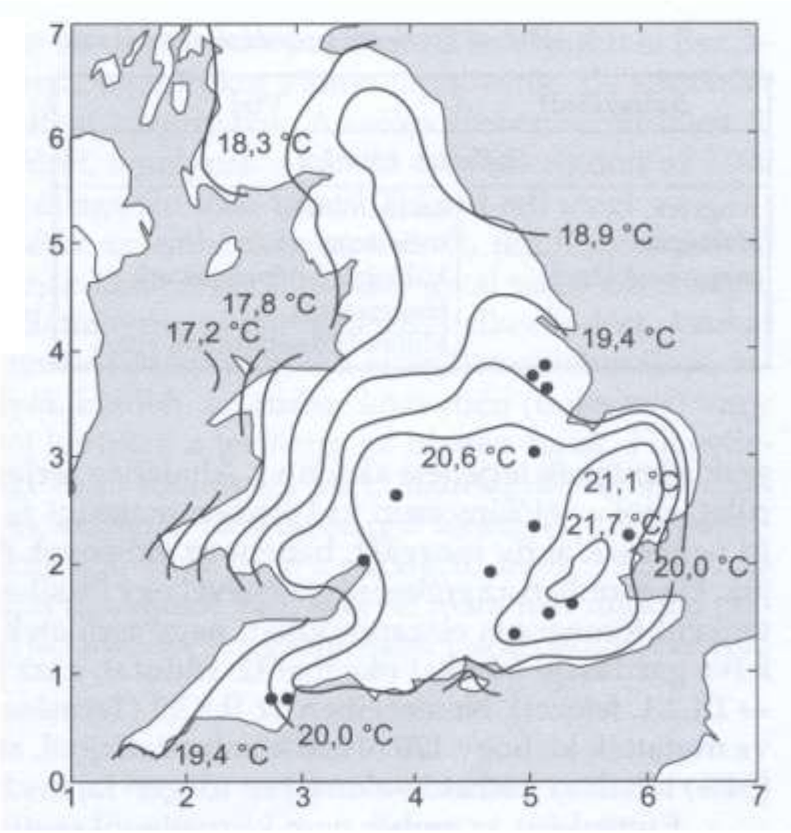
Predation
Competition
Parasitism
Mutualism

Physical and Chemical factors

Temperature	Water
Light	Oxygen
Soil structure	Salinity
Fire	pH
Currents	Soil nutrients
etc.	Etc.

Physical and Chemical factors

Tree species (Tilia cordata) distribution in UK
Lines- daily maximum temperature in August
Points – occurrence of the tree species



Effects:
- Survival
- Reproduction
- Development of young organisms
- Competition

Temperature

e.g. Mynah (Sturnus cristattellus) – not able to breed in (Vancouver, USA) because of the very low hatching rate of eggs

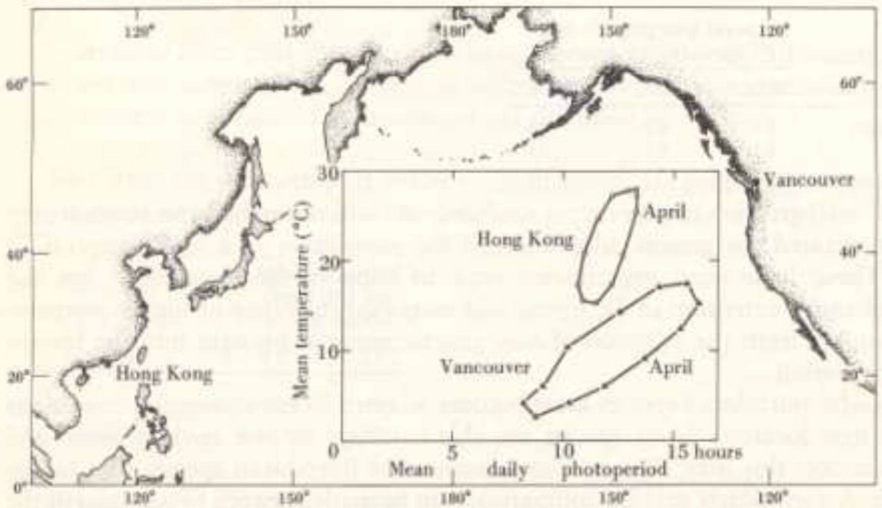


Figure 7.15 Comparison of native (Hong Kong) and introduced (Vancouver) home of the crested mynah (*Sturnus cristatellus*). The climatograms are constructed by connecting means (air temperature and photoperiod) for succeeding calendar months. Egg laying starts in April at both localities. (After Johnson 1971.)

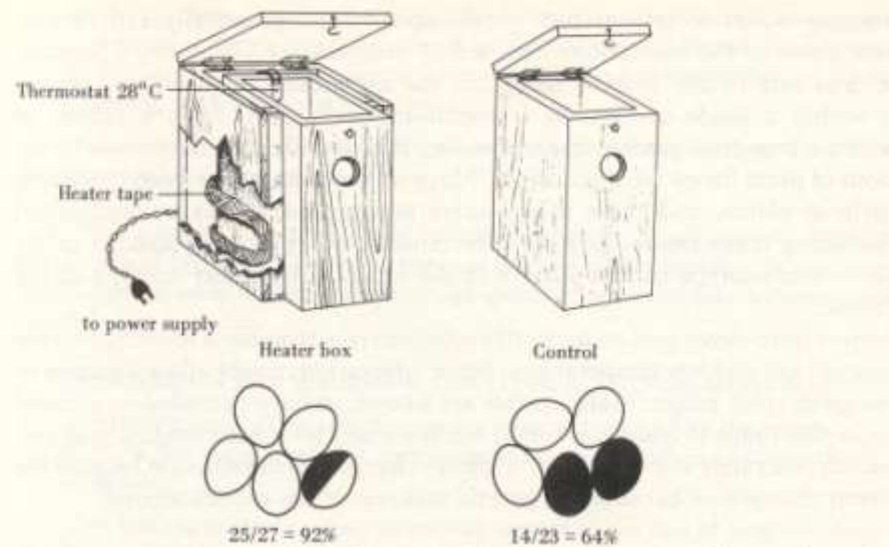
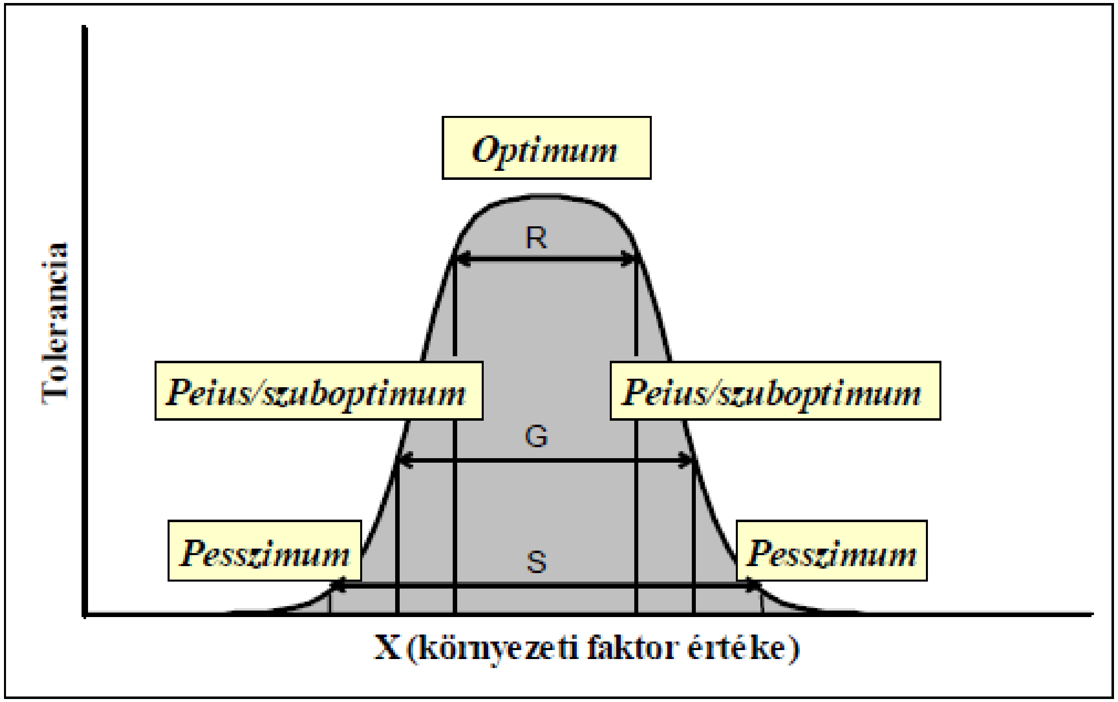


Figure 7.16 Experiment with altered nest microclimate in Vancouver; at five crested mynah nests, a heater was installed and nest temperature was maintained at Hong Kong levels (28°C). Hatching success at these nests is contrasted with the controls exposed to natural temperature fluctuations. (After Johnson 1971.)

Physical and Chemical factors

.



Tolerance curve and intervalls in relation to an X environmental factors

optimum (reproduction)

peius – suboptimum (only growing without reproduction)

pessium (only surviving)

Physical and Chemical factors

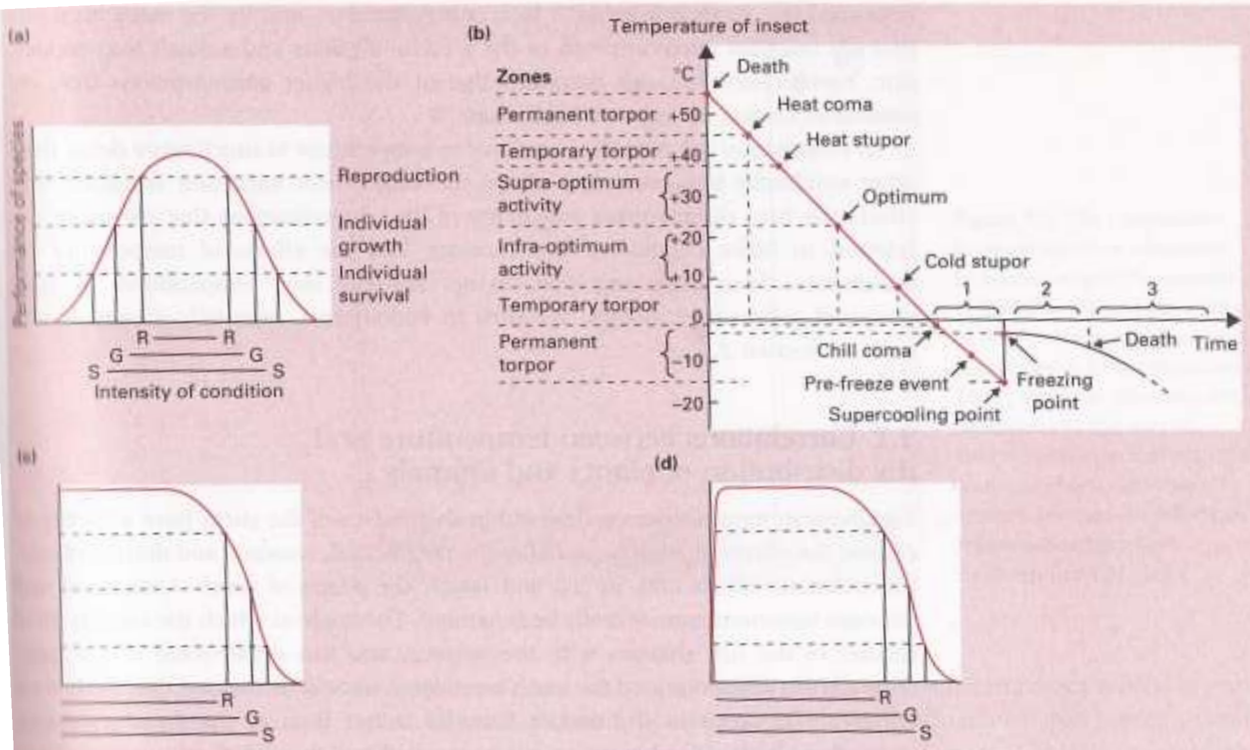
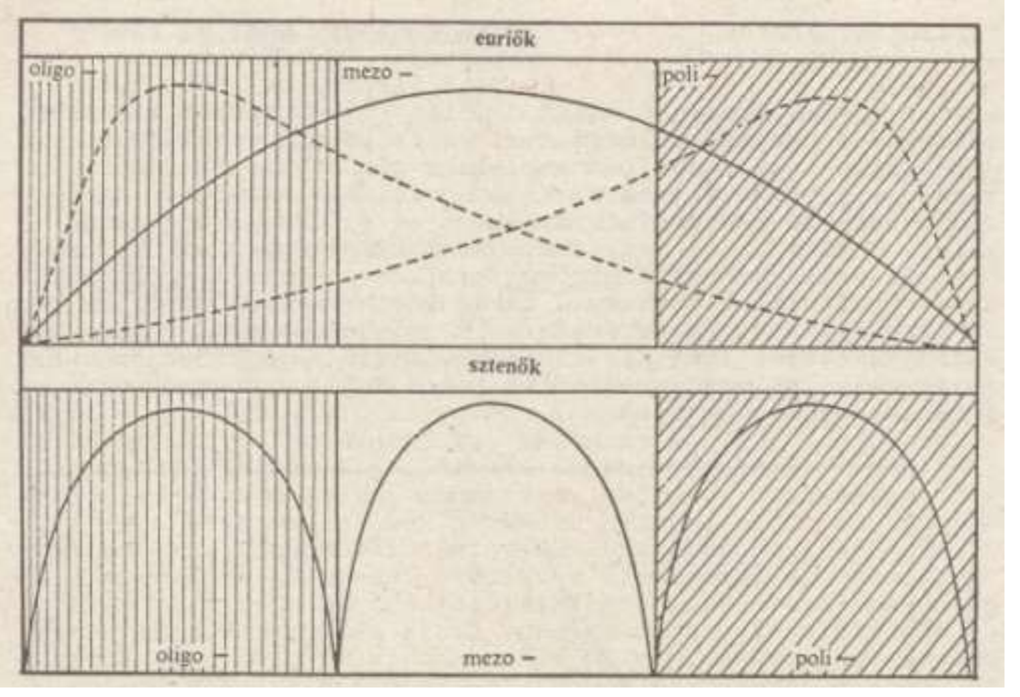


Figure 2.1 (a) A generalized graphical representation of the manner in which the activities of an organism may relate to the intensity of an environmental condition, such as temperature or pH. The narrow range over which reproduction can occur (R–R) usually dictates where continued existence of the species is possible (although the patterns of distribution of some species may be maintained by the repeated dispersal and recruitment of individuals into areas where they could not otherwise maintain themselves). (b) The thermobiology of an arthropod which does not tolerate freezing. Note that a symmetrical sequence of physiological states is recognized passing through stupor into temporary torpor and coma to permanent torpor and death as conditions become much hotter or cooler than the optimum. (After Vannier, 1987; Block, 1990.) (c) A generalized response curve of the form that relates the activities of an organism to the level, concentration or intensity of a condition (e.g. toxin, radioactive emission or pollutant which is harmful only at high levels). (d) As (c) but as the level, concentration or intensity of a condition is increased it changes from being an essential resource for growth at low levels to becoming damaging or lethal at higher concentrations (e.g. micronutrients such as copper and zinc).

Physical and Chemical factors

.growing

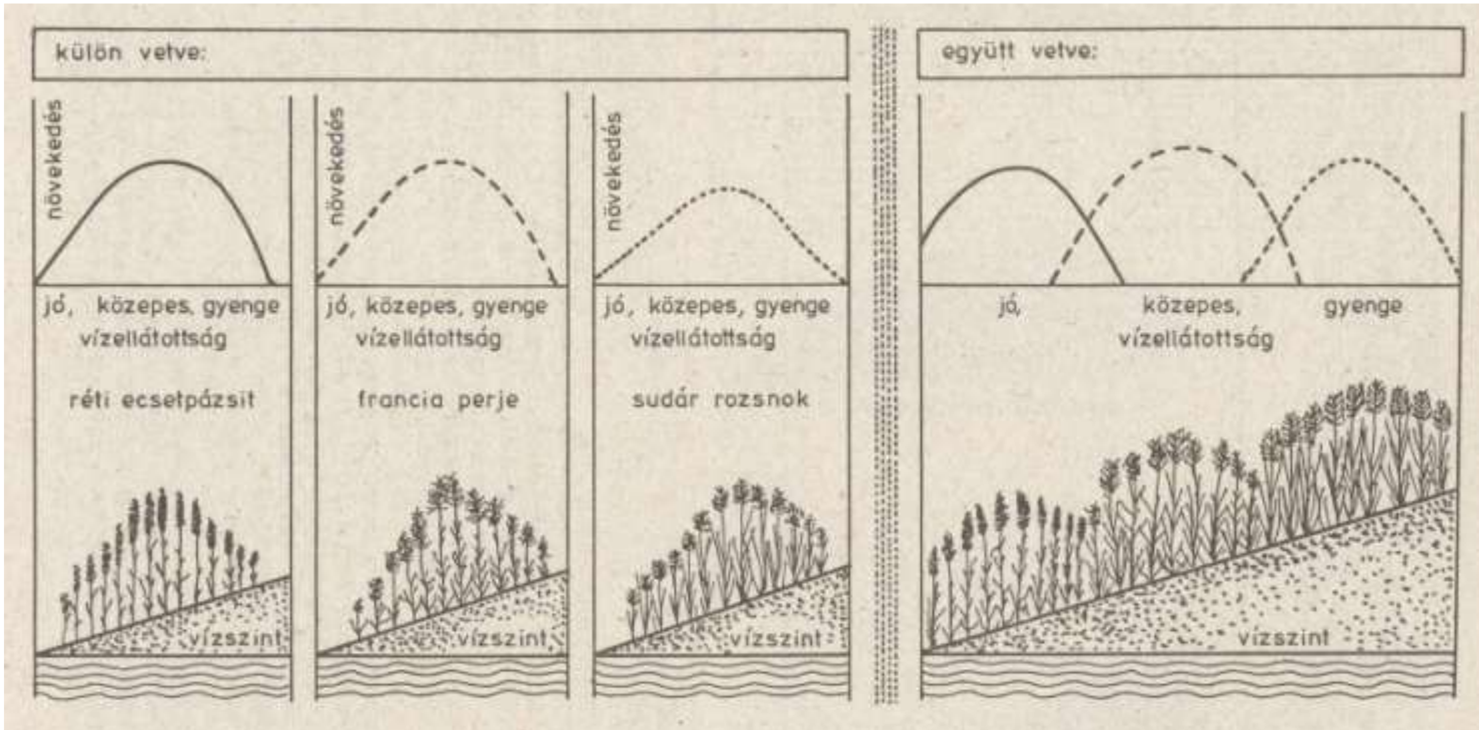


quantity of an environmental factor

Euriök - generalist

sztenők - specialist

Physical and Chemical factors



Growth of three grass species in relation to water availability when it was seeding separatelly (left part) and mixed way (right part).

physiological – ecological optimum

Climatic, edafic (soil), and hydrological factors

.

Light

Photoperiodism

-long-day plants, wheat

-short-day plants, rice

- spektrum

Light intensity

-heliophile, Maize

-sciophilous, leaf frogs

-scotophil, earthworm

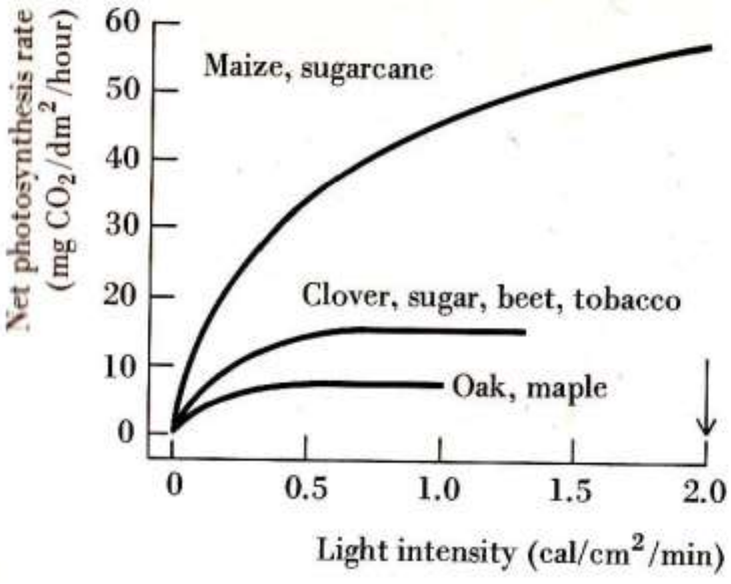


Figure 9.1 The effect of light intensity on the rate of photosynthesis in several species of plants. Photosynthesis was measured by CO_2 uptake at 30°C and 300 ppm CO_2 in air. The arrow on the light axis marks the approximate equivalent of full summer sunlight. (After Zelitch 1971.)

Water

- hydrophytes, lemna
- heliophytes, reed
- mezophytes, violet
- xerophytes, succulent
- halophytes, sea lavender

Soil

- Structure
- Nutrients

Salinity

pH

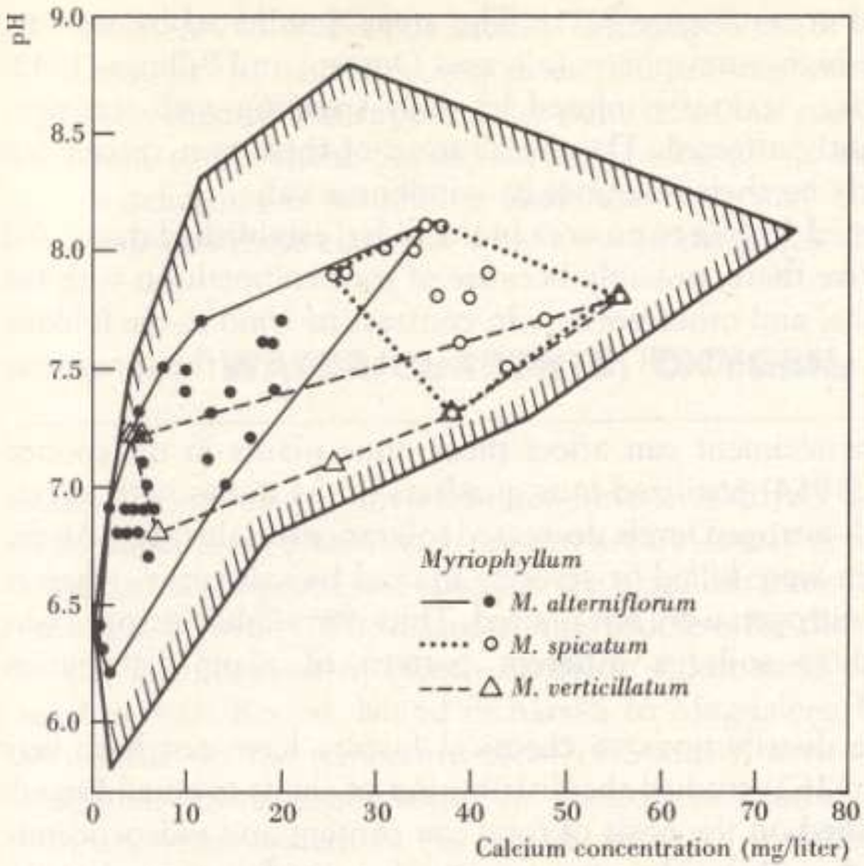


Figure 9.10 Occurrences of the three species of *Myriophyllum* in the lakes of central Sweden in relation to calcium concentration and pH. The shaded envelope encloses the points for all the lakes studied in the region. (After Hutchinson 1970.)

Water currents

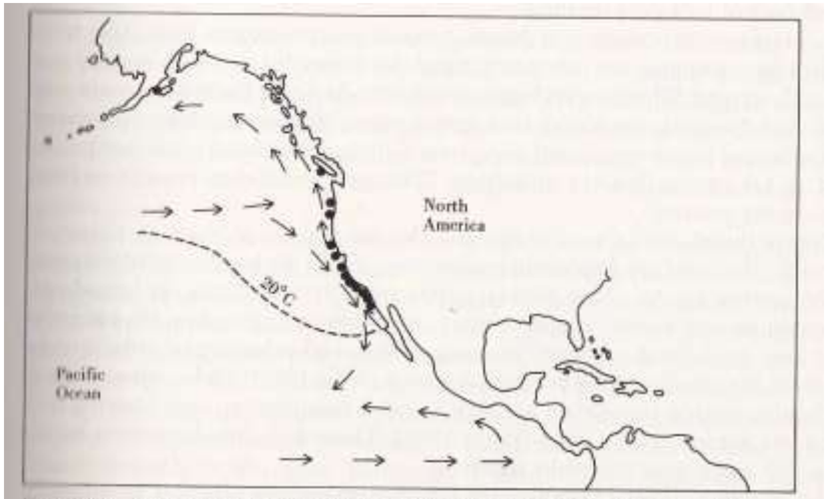


Figure 9.12 Distribution of the sand crab *Emerita analoga* in North America and the surface currents of the North Pacific. Dashed line marks approximate position of average annual sea-surface temperature of 20°C. (After Efford 1969.)

Oxygen

- Its level vary hardly in freshwaters

Fire

- Occurence is important for several Species/communities

What explains the occurence of a species in a given place?

Area accessible yes← **Dispersal** → no

↓

Habitat selection yes← **Behaviour** → no

↓

yes← **Other species** → no

Predation

Competition

Parasitism

Mutualism

Physical and Chemical factors

Temperature	Water
Light	Oxygen
Soil structure	Salinity
Fire	pH
Currents	Soil nutrients
etc.	Etc.

Populations, Population parameters, Demographic Techniques

Population ecology

- Biological and statistical definitions

Biological: A population is the number of organisms of the same species that live in a particular geographic area at the same time, with the capability of interbreeding

Statistical: A group of organisms of the same species occupying a particular space at a particular time

- Abundance (N)

individuals, pairs, biomass (genet-clonal plants), colonies (eusocial insects)

- Density (D)
  - Abundance/Area, Abundance/Volume

Estimation Abundance/Density

Absolute methods

- total counts (census)

  Count all individuals of the population

  (human, rare or very low density species)

Sampling methods

- estimation of density in sampling area

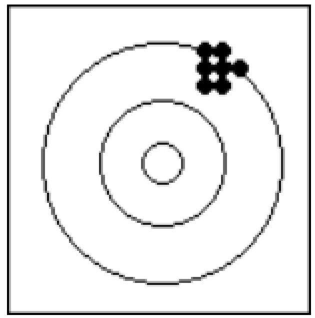
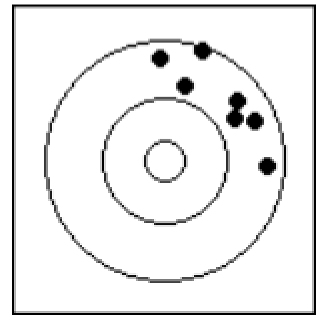
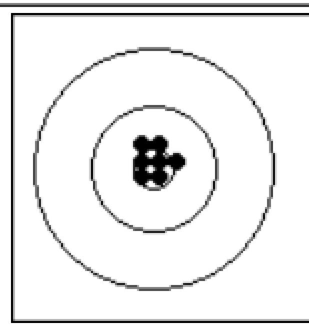
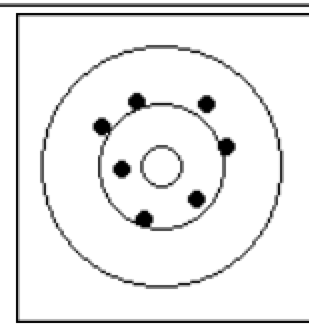
  Count all individuas in the sampled areas (quadrats), estimate the density and estimate the abundance for the entire area of the population

  Condition:

  - Total counts in the samples area
  - Known the size of the sampled area
  - Sampled areas must be representative to the entire area of the population -> proper sampling strategy to minimase the bias and precision

Accuracy of an Estimation

Accuracy, Precision, and Bias

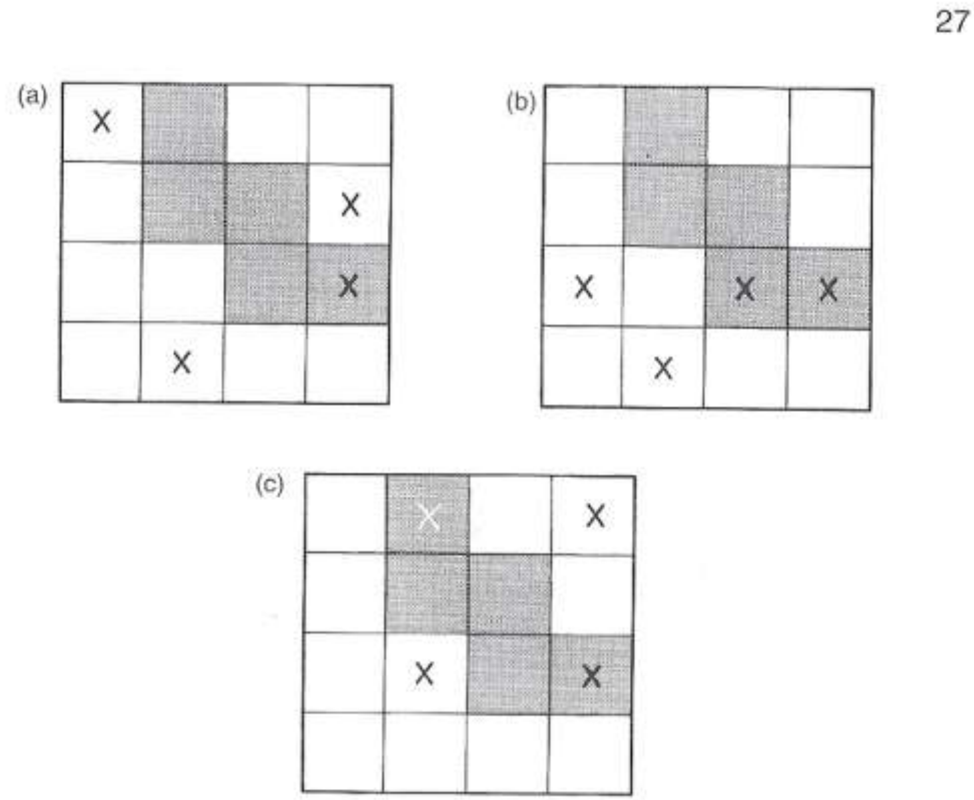
	Precise	Imprecise
Biased		
Unbiased		

Sampling strategy

Random (a)

Stratified random (b)

Regular (c)



Estimation Abundance/Density

Sampling methods

- Capture-recapture method

e.g. Lincoln index:

$$\frac{m_2}{n_2} = \frac{n_1}{N}$$

N: abundance of the population

n_1: # of caught and marked individuals during the first capture, released back to the population

n_2: # of caught and marked individuals during the second capture, released back to the population

m_2: # of marked individuals among individuals caught in the second capture

N': estimated abundance of the population

$$N' = \frac{n_1 * n_2}{m_2}$$

Estimation Abundance/Density

Relative methods – Population indeces

- # of trapped individuals
- # of fecal pellets
- Vocalisation frequency
- Pelt records
- # of artifacts
- Questionnaires
- Cover
- Feeding capacity
- Roadside counts

Hungarian Common Bird Monitoring scheme since 1999

Mindennapi Madaraink Monitoringja (MMM)

Started with the help of RSPB and EBCC

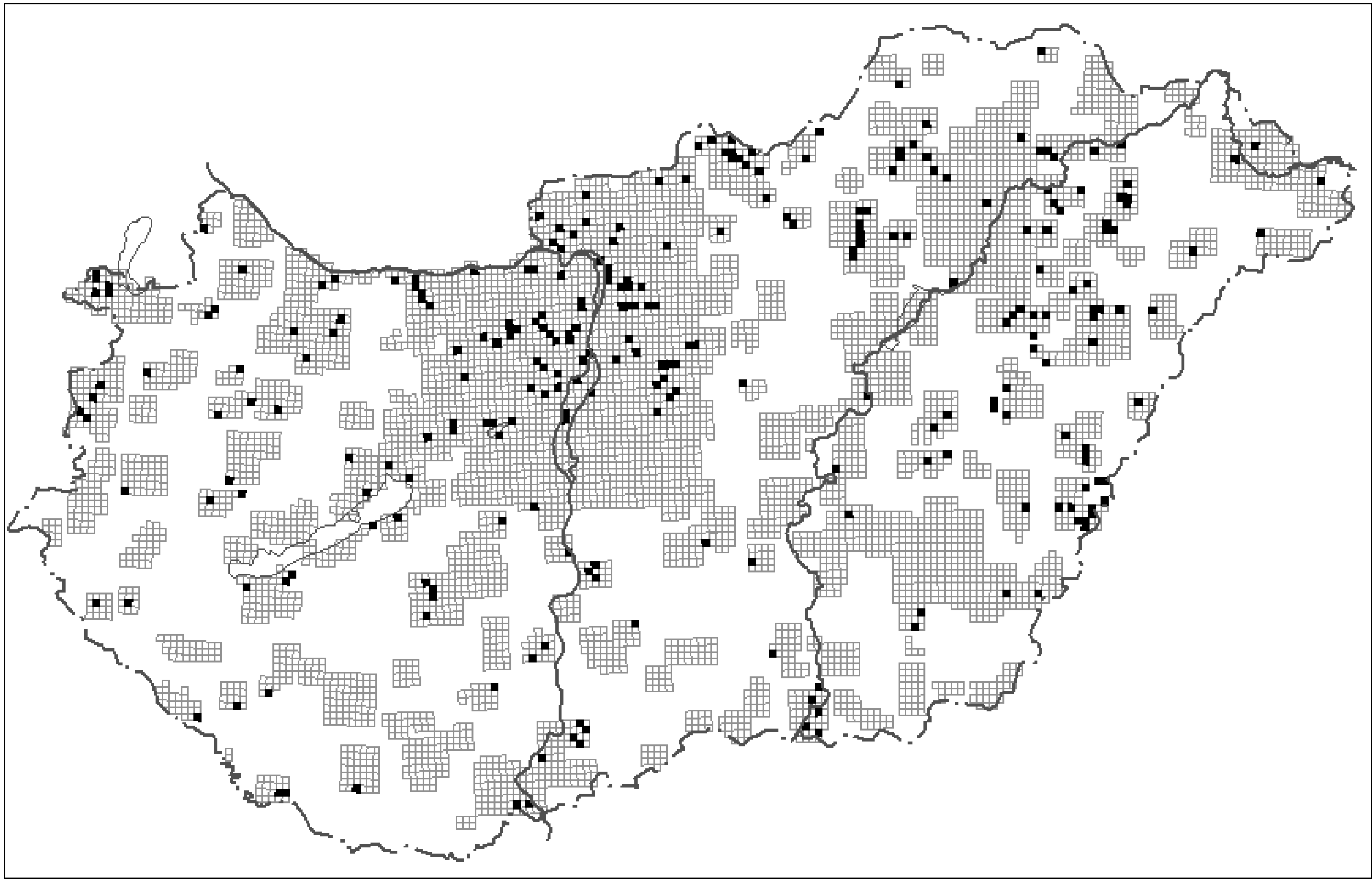
- Szép, T. and Gibbons, D. 2000. Monitoring of common breeding birds in Hungary using a randomised sampling design. The Ring 22: 45-55.

- **http://mmm.mme.hu**

Sampling design

Semi-random selection of the surveyed 2.5*2.5km UTM squares

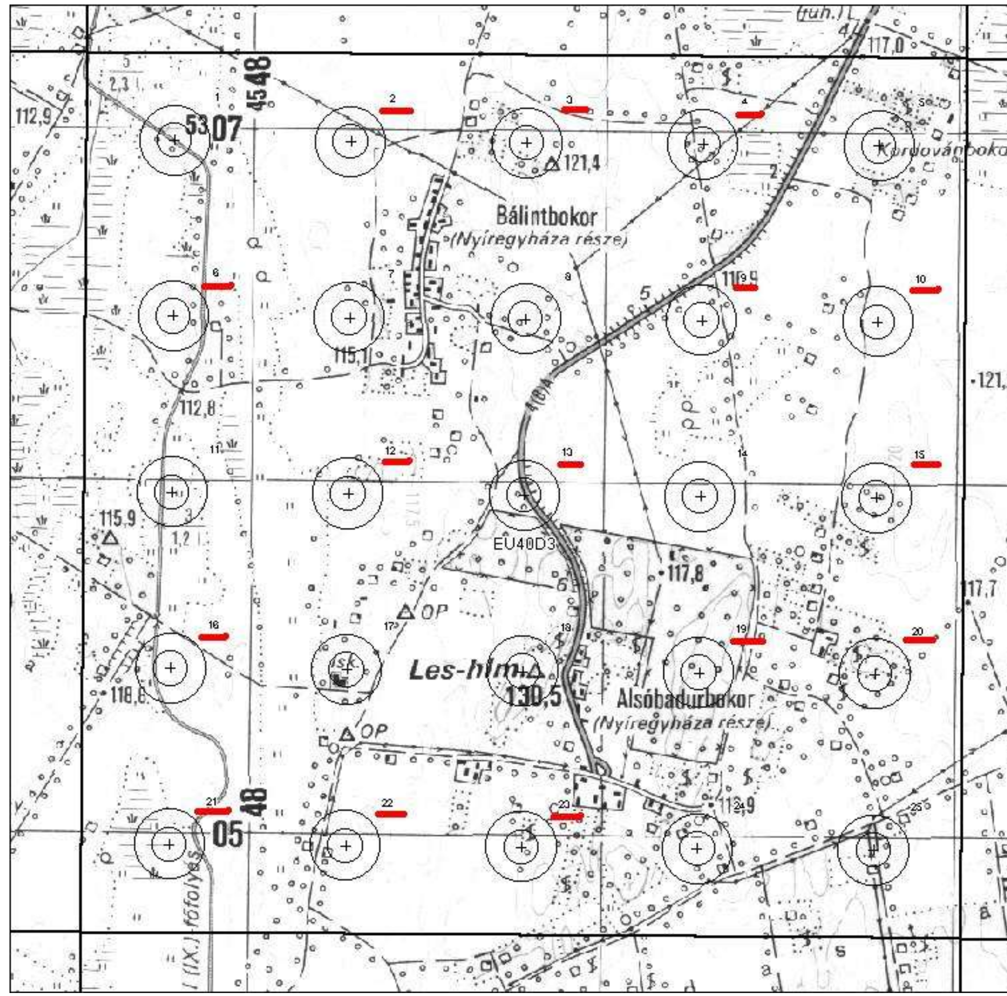
- Unit: 2.5*2.5 km UTM square
- randomly selected within the minimum 100 km^2 large area indicated by the observers



Sampling design

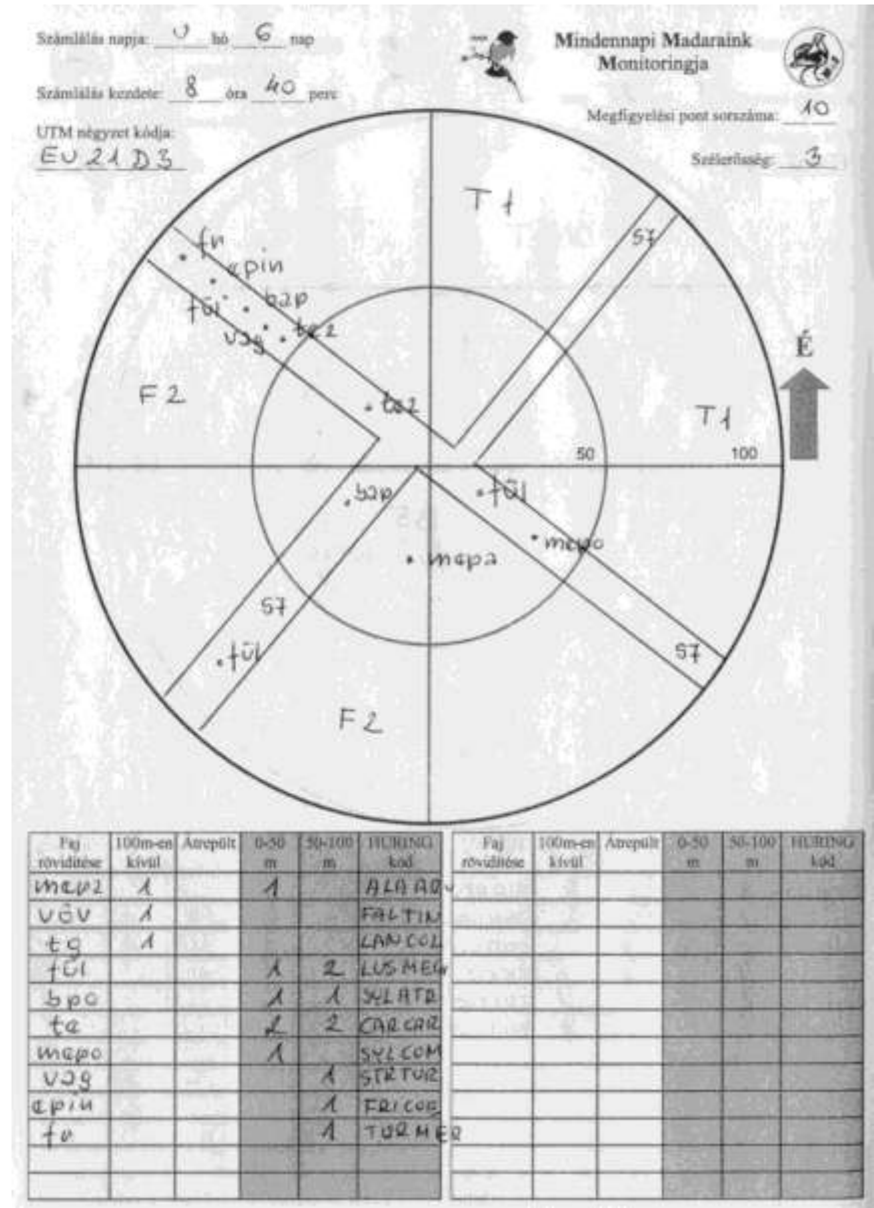
- Randomly selected 15 observation points within the selected 2.5*2.5 km UTM squares

- Map (coordinates) with exact position of the observation points provided



Standard Method

- 5 minutes point counts two times per breeding season (early, late) between 5-10 am
- Distance (0-50m, 51-100m,101-200m, fly over), habitat and wind recorded



Identification skill of the observers

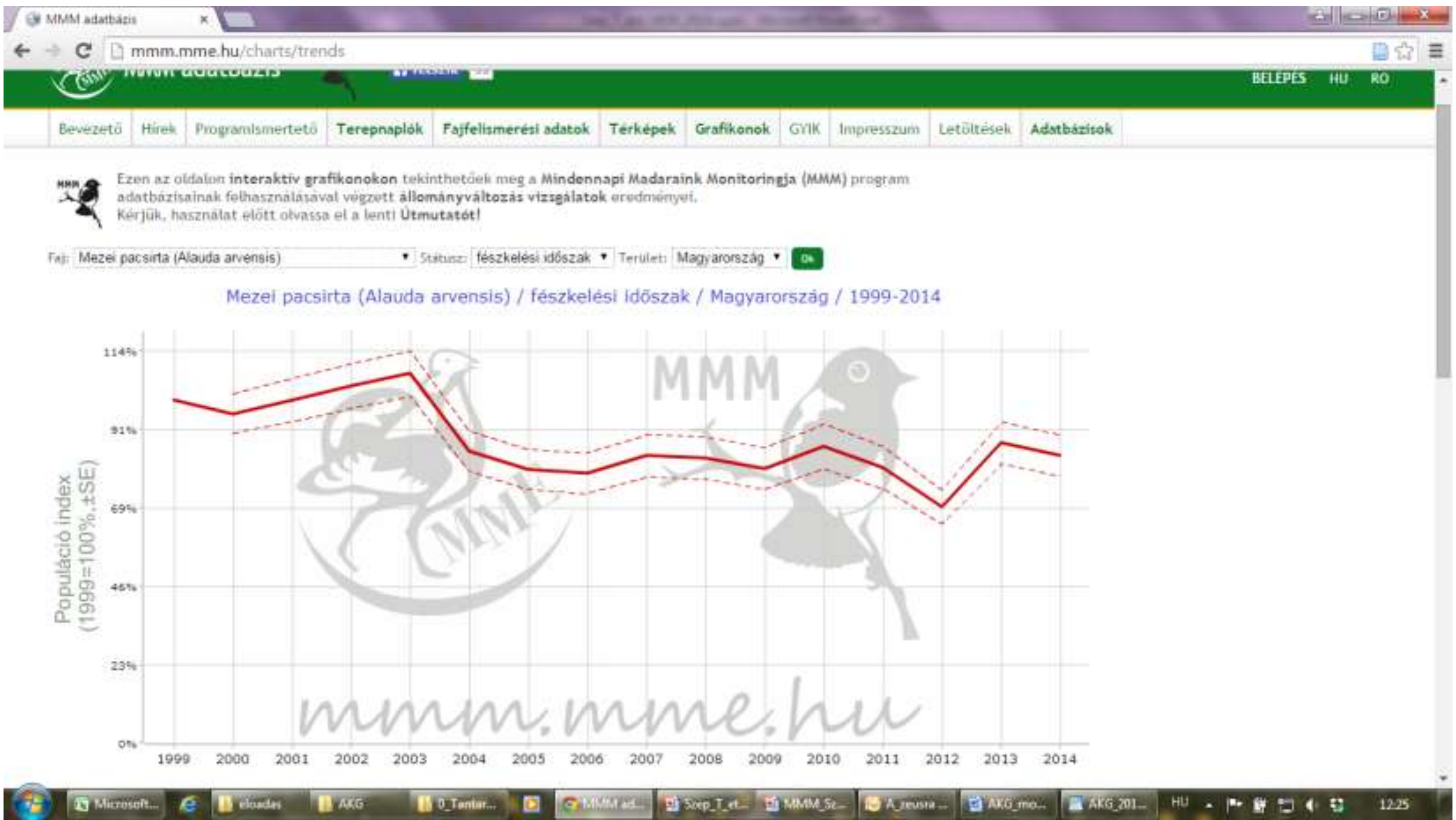
- Annual survey of the species identification skill of the observers for each species occurring in Hungary
  - „How can you identify the given species?”
    - only by view
    - only by sound
    - by view and sound
    - I’m uncertain to identify

  - Control the cause of the absence of the given species in the given squares – real absence or identification problems of the observers

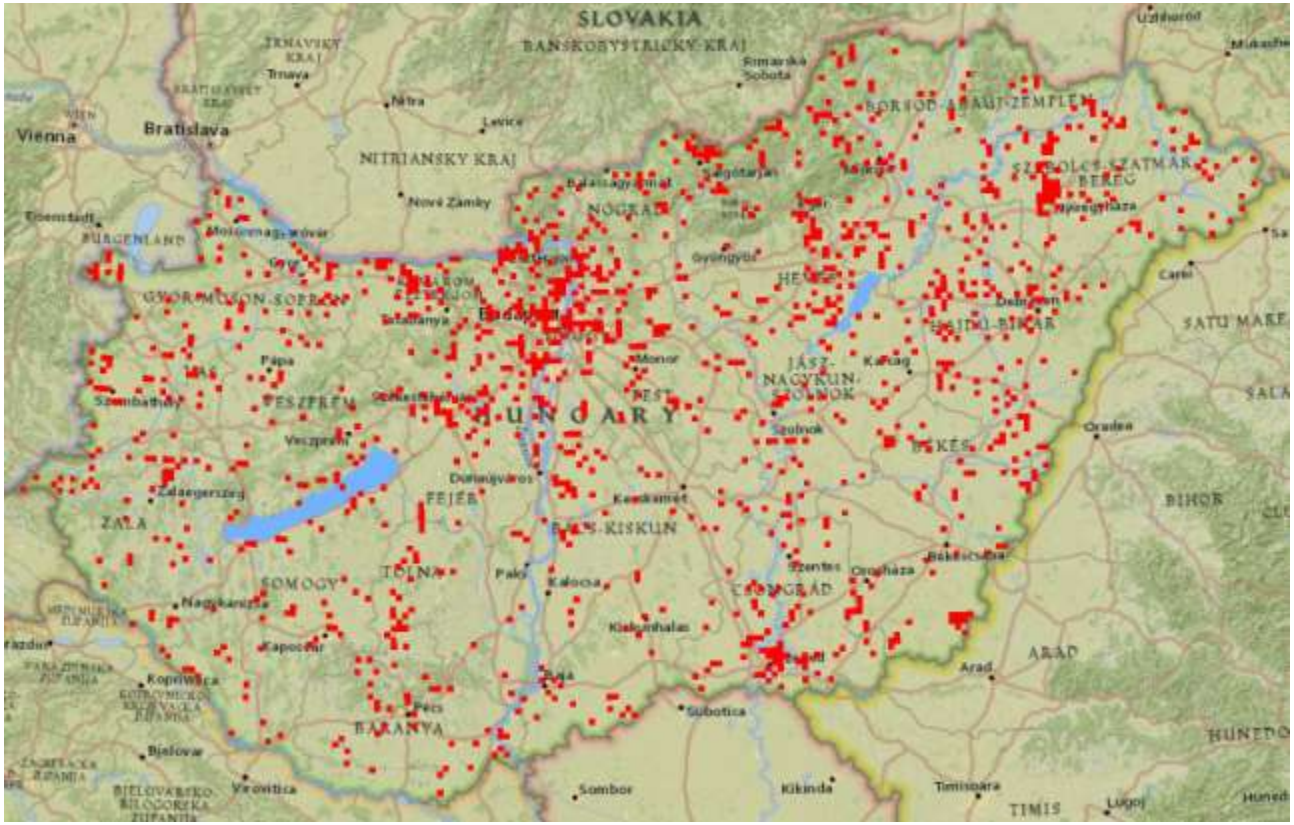
On-line database

http://mmm.mme.hu

- Input and verification of field data
- Maps, Results, Additional information for observers



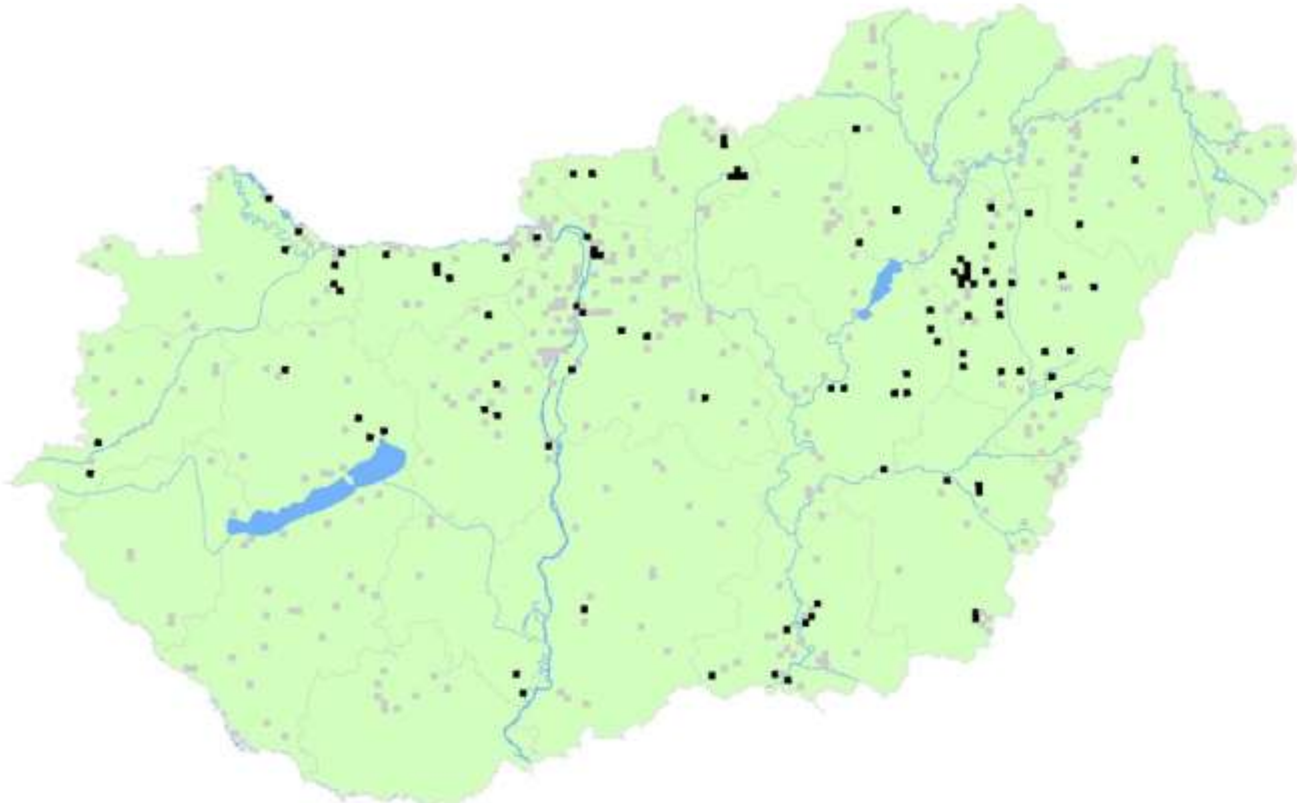
Surveyed UTM squares between 1999-2021 during the breeding season



Surveyed UTM squares

- More than 1000 squares surveyed minimum in two years
- More than 1000 participating observers
- One of the largest database on common birds in Central-Eastern Europe, based on random sampling desing, 44,5 million records (UTM, point, species, date, number)
- 200-300 UTM surveyed annually (~2% of the country territory)

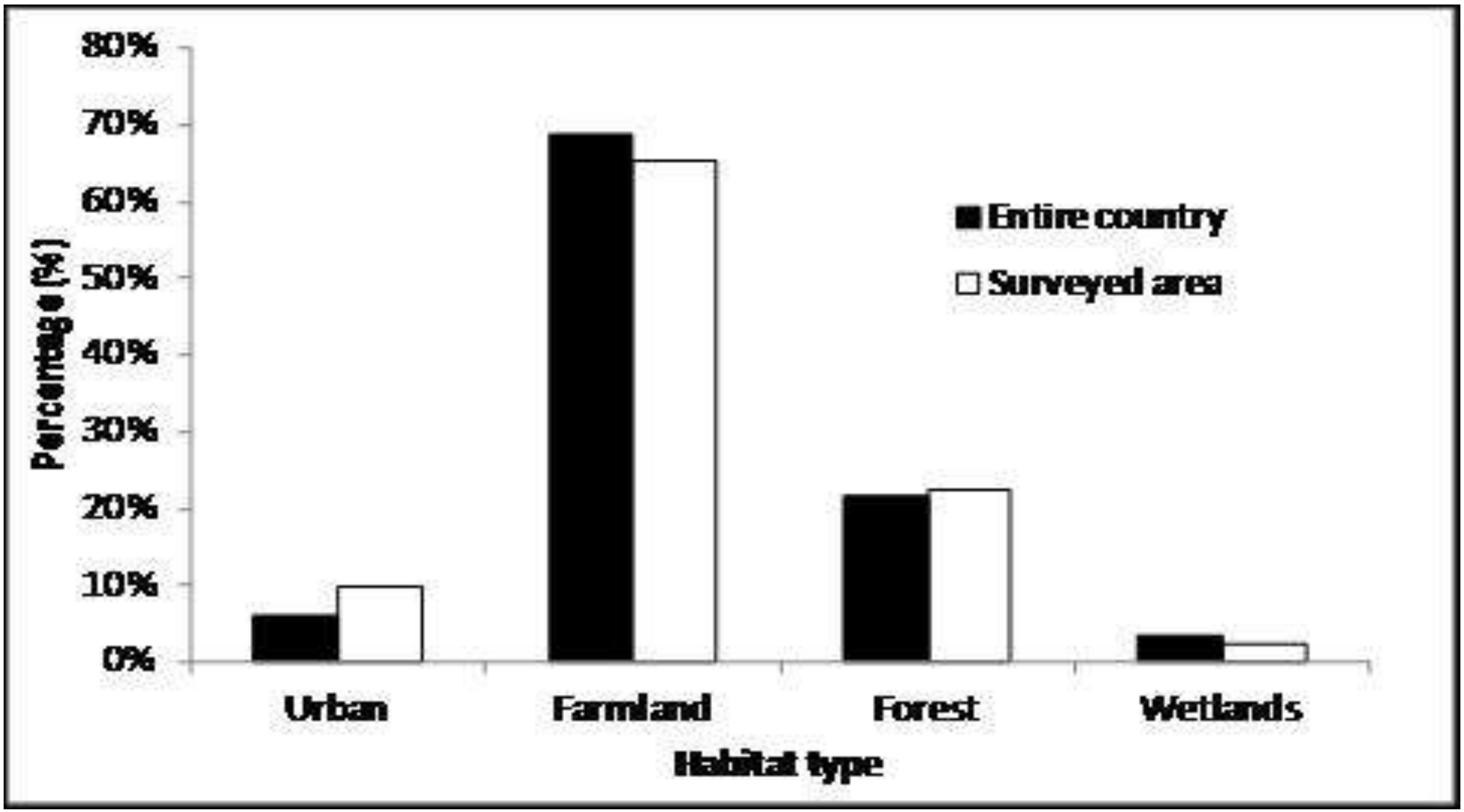
Surveyed UTM squares between 2000-2021 during the wintering season (January)



Colors of the UTM squares indicate the number of surveyed years

- Standard survey during the wintering season for monitoring occurence and abundance of species
- Use of similar field protocol as during the breeding season (but: only one visit in January, during daylight period)

Distribution of habitats in Hungary and in the area surveyed (Corine)



Size of the country: 93 000 km^2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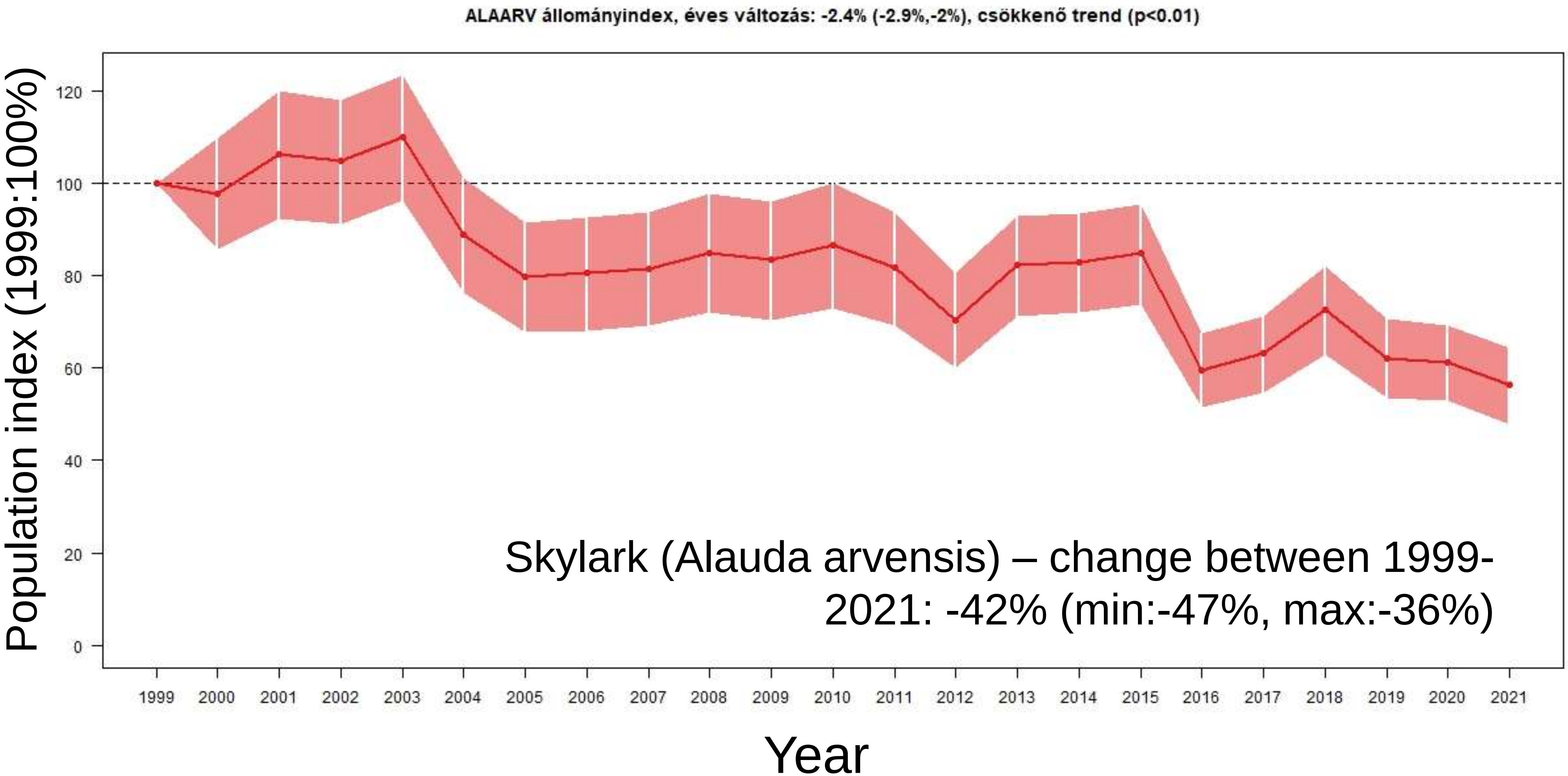
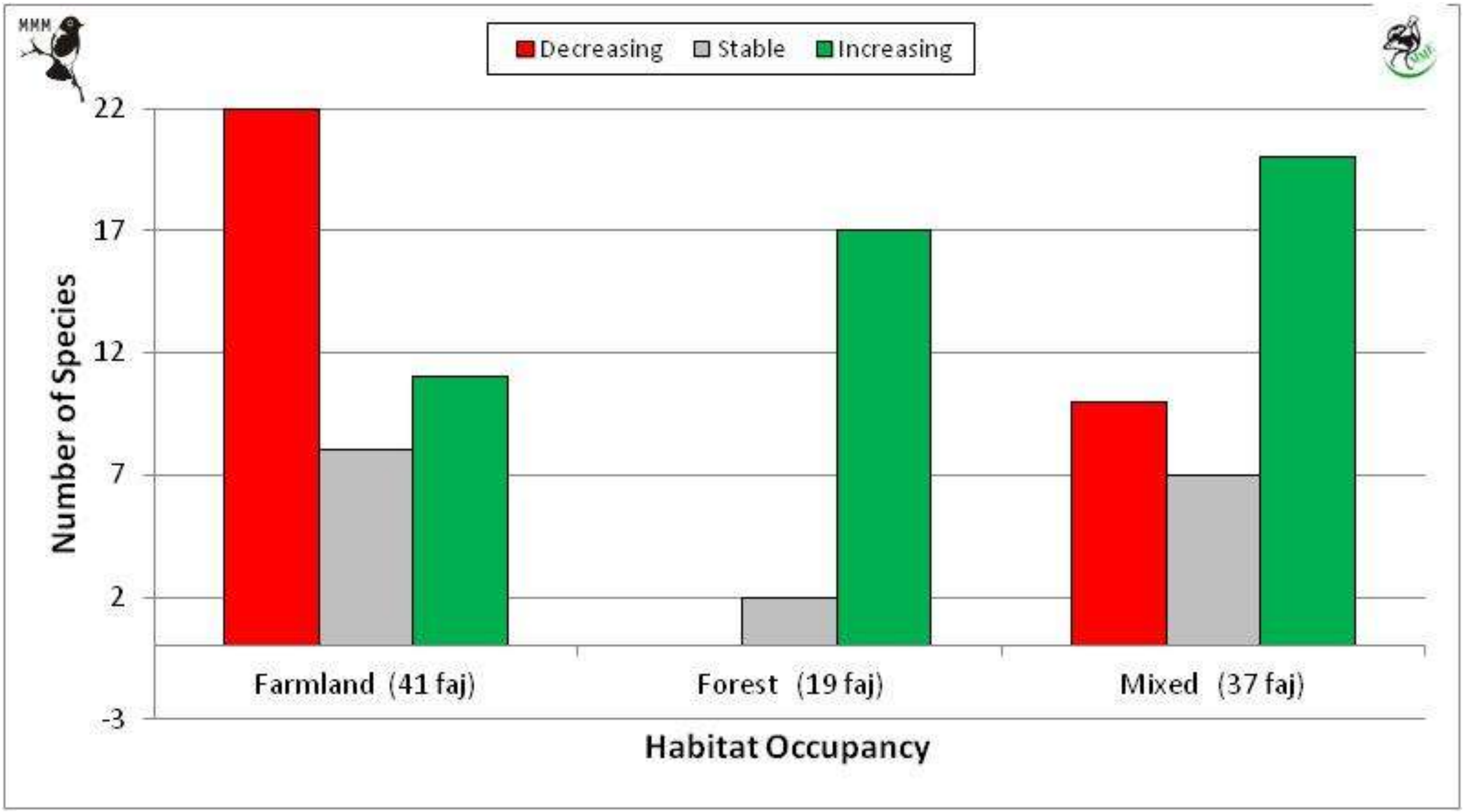
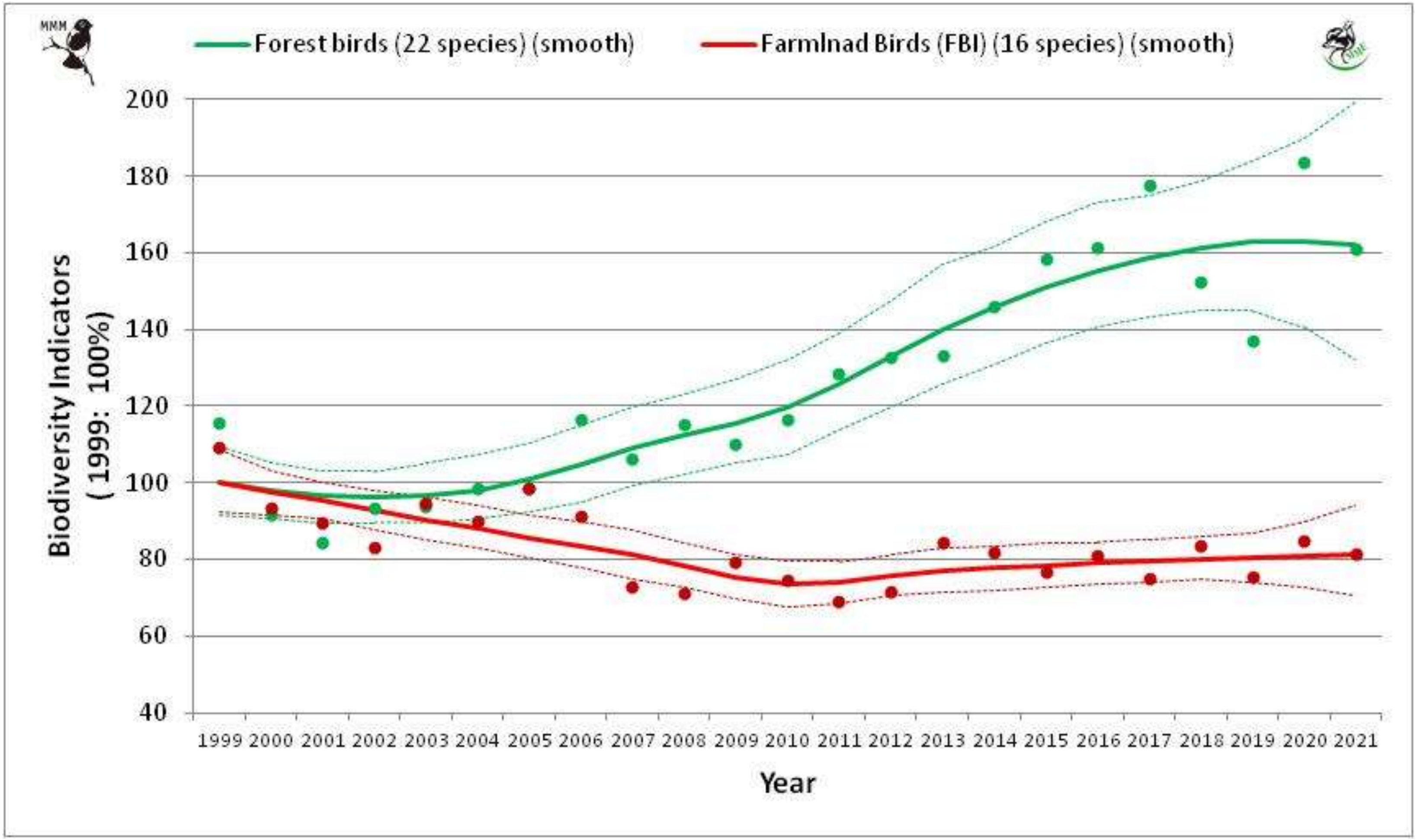

ALAARV állományindex, éves változás: -2.4% (-2.9%,-2%), csökkenő trend (p<0.01)
Population index (1999:100%)
0
20
40
60
80
100
120
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
Year
Skylark (Alauda arvensis) – change between 1999-2021: -42% (min:-47%, max:-36%)

Trends of 100 breeding species were identified by TRIM between 1999-2021, habitats



54% of farmland bird species has significant declining trend during 1999-2021

Recent trends of Bird Indicators in Hungary, habitat



Farmland biodiversity (FBI) show a marked decline between 1999-2021 (slope: -0.9% (SE=0.3%, P<0.01)

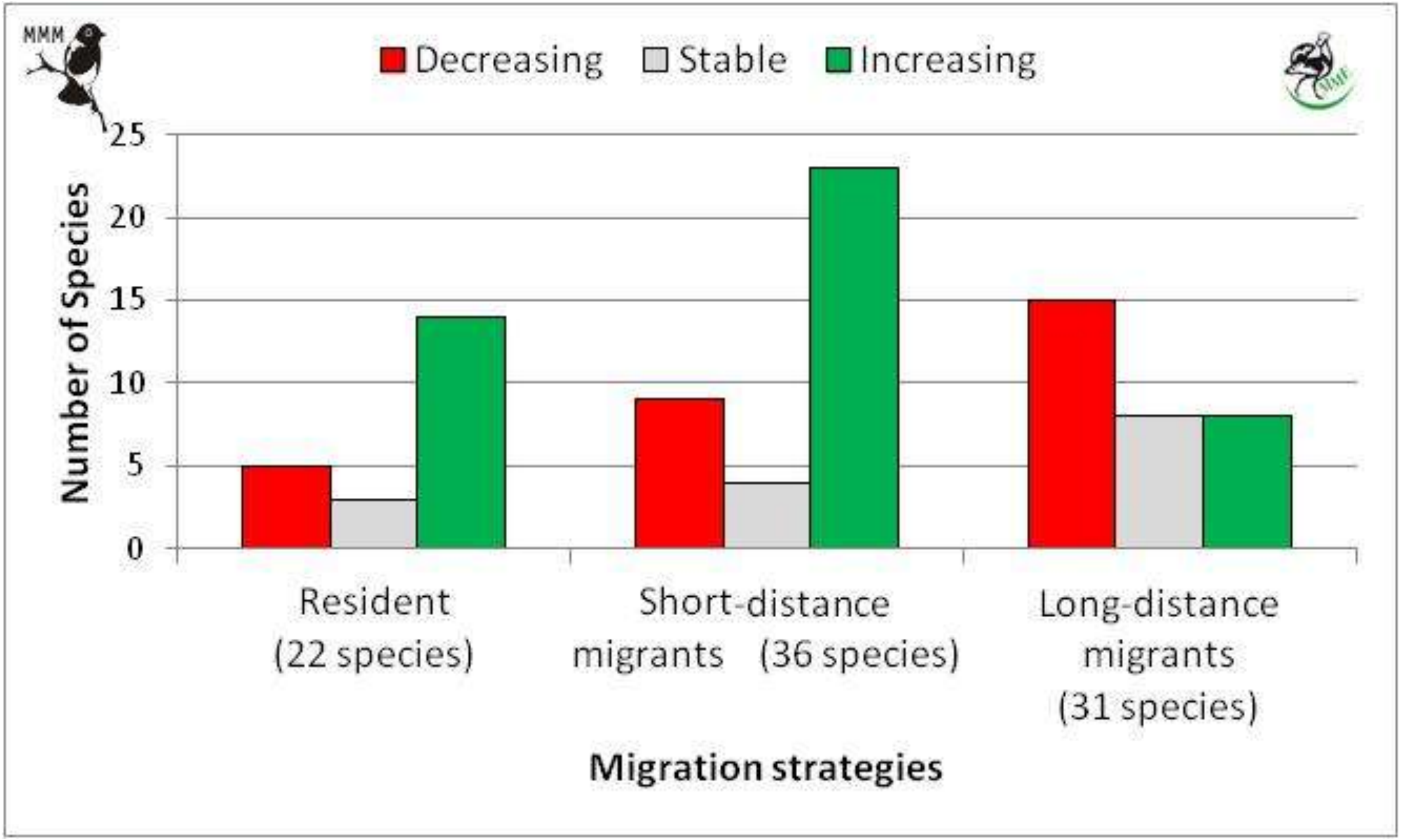
There is an opposite trend for the forest (slope=3.1%, SE=0.4, P<0.01)

Classification species on migration strategy

Breeding species in Hungary was classified on the base of recent Hungarian Bird Migration Atlas (Csörgő et al. 2009)

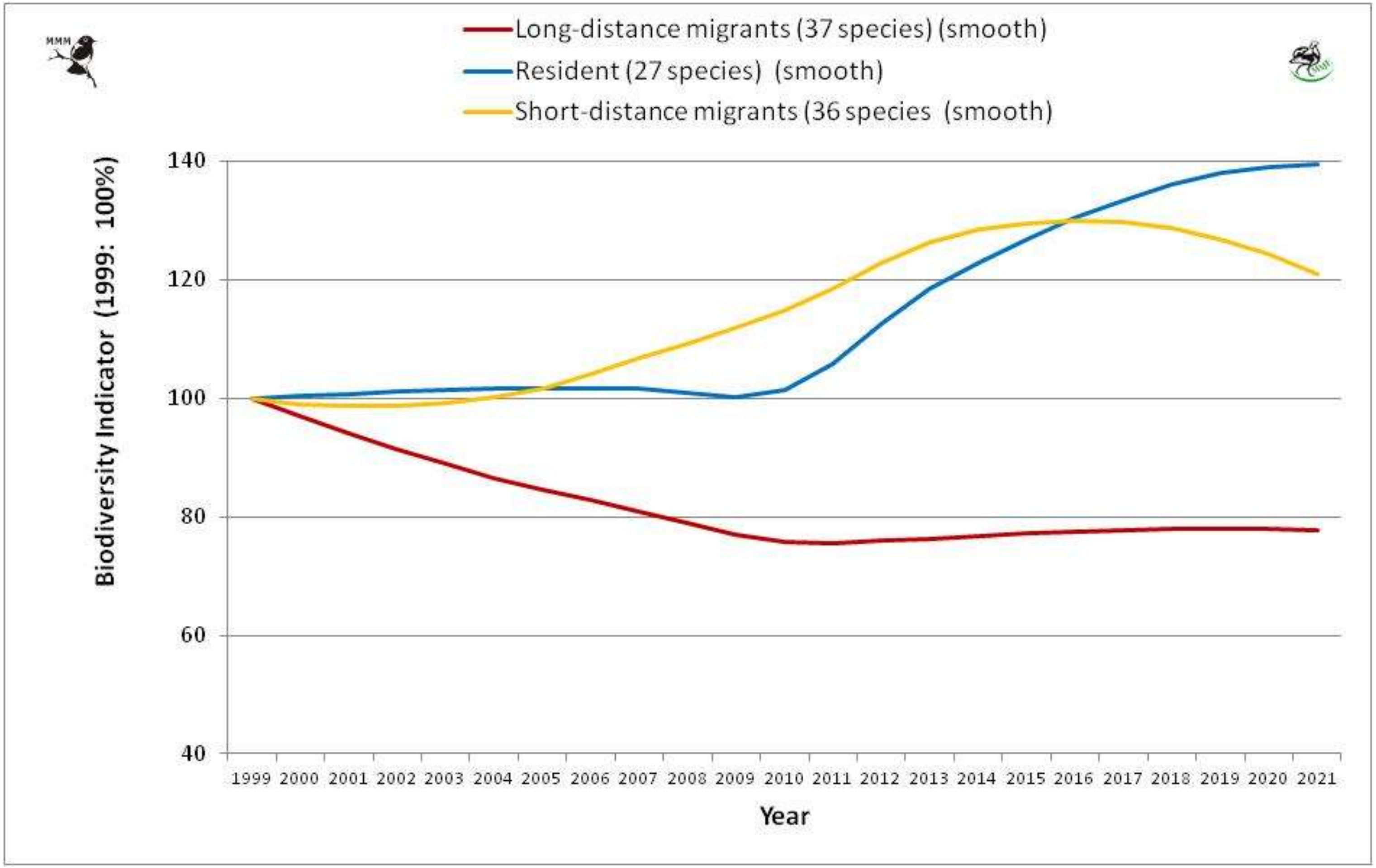
- Resident – spend entire year in the breeding area
- Partial and/or short-distance migrants – migrate only until the Mediterranean region
- Long-distance migrants – migrate over the Sahara

Trends of 100 breeding species were identified by TRIM between 1999-2021



48% of long-distance migrants bird species has significant declining trends, while other two groups has increasing trends during 1999-2021

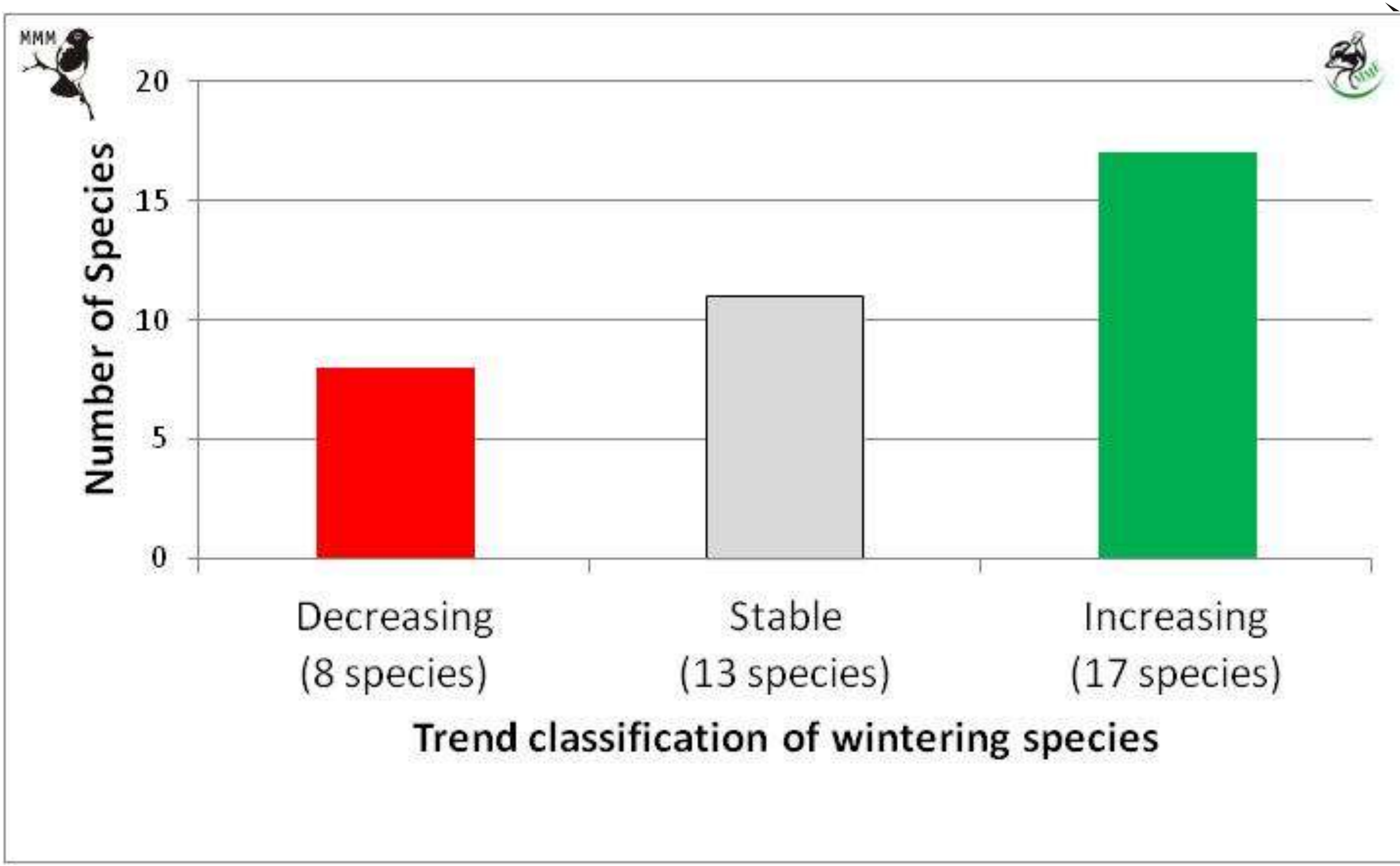
Recent trends of Bird Indicators in Hungary, migration strategy



Long-distance migrant species show decline between 1999-2021 (slope= -1.0%, (SE=0.3%, P<0.01)

In constrast, short-distance migrants (slope=1.5%, SE=0.3%, P<0.05) and resident (slope=1.8%, SE=0.4%, P<0.01) has increasing trends

Recent trends of wintering common species in Hungary



44% of common wintering species in Hungary has significant increasing wintering population size

Recent tendencies in the biodiversity, based on common birds in Hungary

• Farmland biodiversity show marked decline since EU CAP has implemented in Hungary!

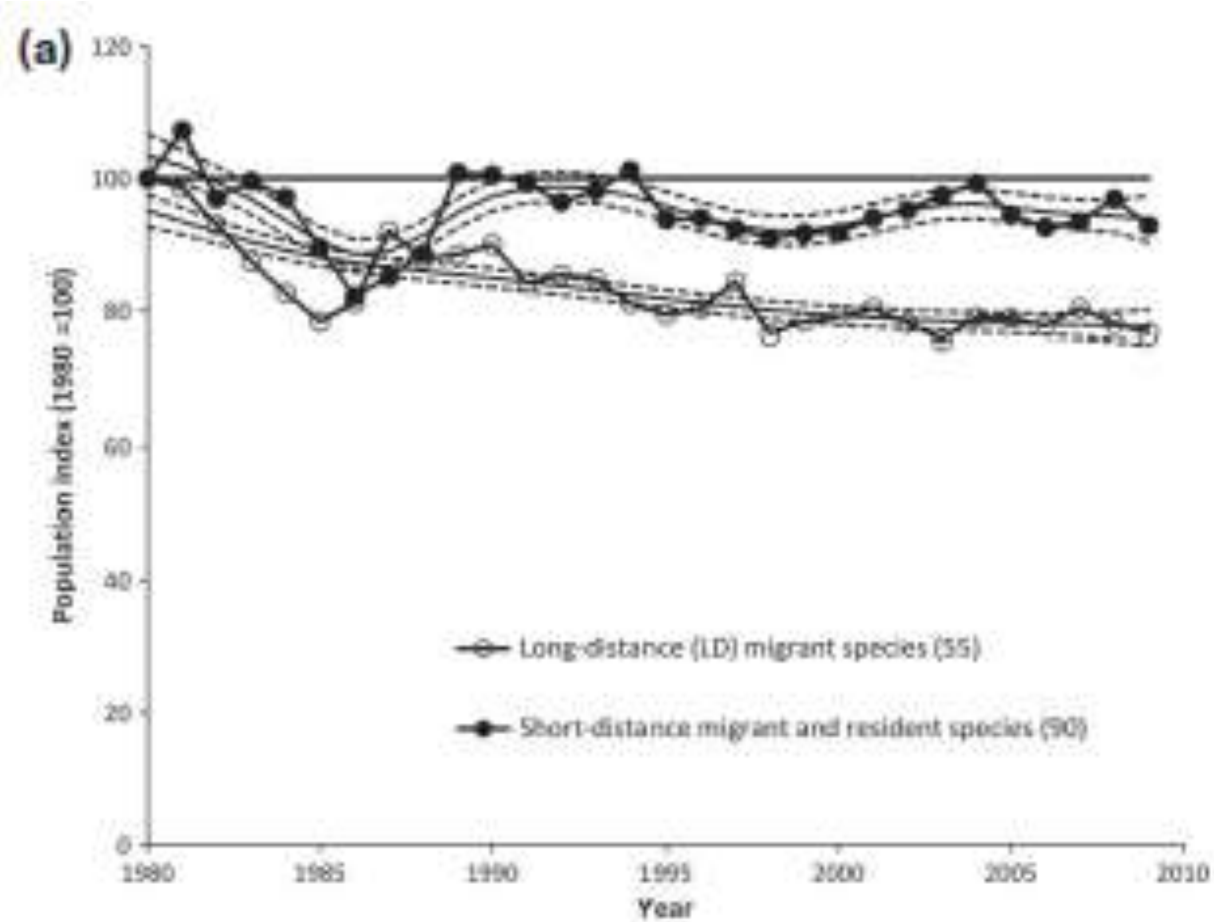
• Contrasting population trends of long distance migrants versus resident and partially/short migrants since start of the monitoring indicate climate related processes (Stephens et al. 2016, Science)

• Increasing trends of wintering populations indicate climate related processes as well (warmer winter, lower mortality)

• Behind the increasing trends of forest birds, climate change could have important influence because dominant part of this species resident and/or partially or short distance migrants

Long distance migrants in Europe

- There is growing evidence that long distance (Afro-Palaearctic, (A-P)) migrants are in decline throughout Europe, with declines often being more pronounced than those of either short-distance migrants or sedentary (Sanderson et al. 2006, Vickery et al. 2014)
- These declines are of growing conservation concern in both scientific and political arenas



Study of Bird Migration, long-term study of Sand Martin in Hungary

Tibor Szép
Environmental Institute, University of Nyíregyháza & MME/BirdLife Hungary

Why Sand Martin?

Weight 12-13 g

Socially monogamous

Insectivorous

Wintering areas, south from the Sahara

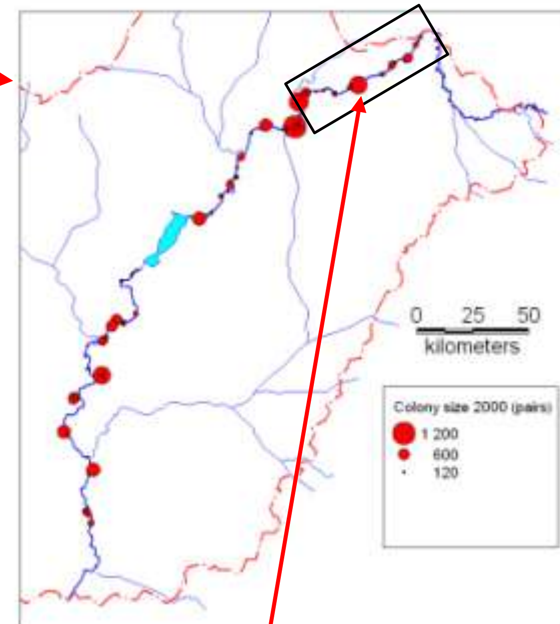
Long-distance migratory species

Bre(e)d in large colonies in Hungary in natural habitat

Easy to catch in large numbers without adverse effect – usage of capture-recapture methods

Easy to survey breeding habitats and populations

Start of integrated monitoring of Sand Martin along Tisza river, Eastern Hungary, 1986-1994



- Annual survey of

  breeding habitat, perpendicular walls

  breeding colonies along the 70km long section of the river

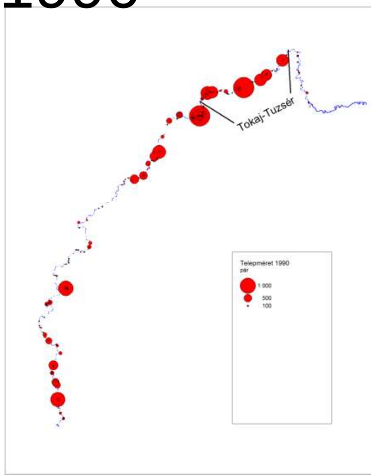
- **Ringing adult and fledged juveniles** at the largest colony at Tiszatelek colony during the fledging period (June-July)

  ~ 1000-2000 ind./year

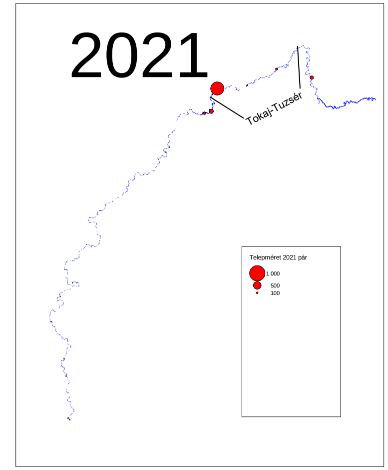
Opportunity for censusing breeding habitats, colonies and its sizes along the river

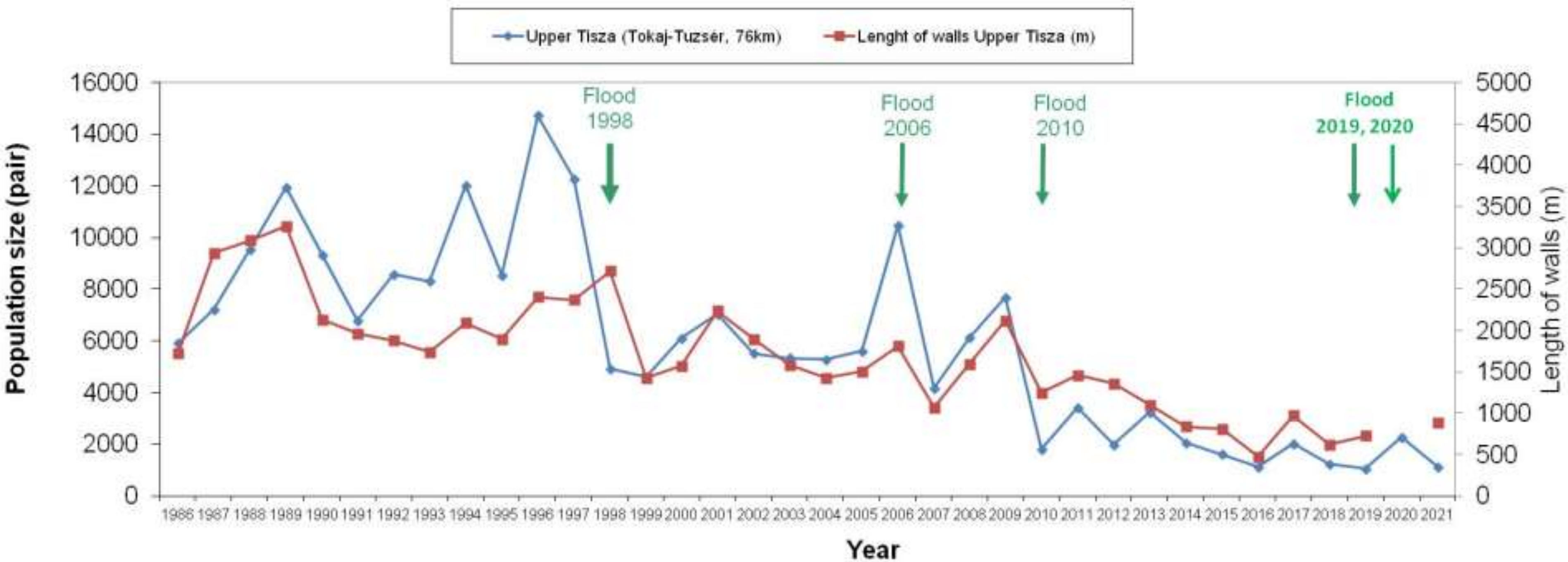
Population along the Hungarian section of river Tisza (600 km)
Strong decline, in 2021 only 6% of the population of 1990 remained

1990



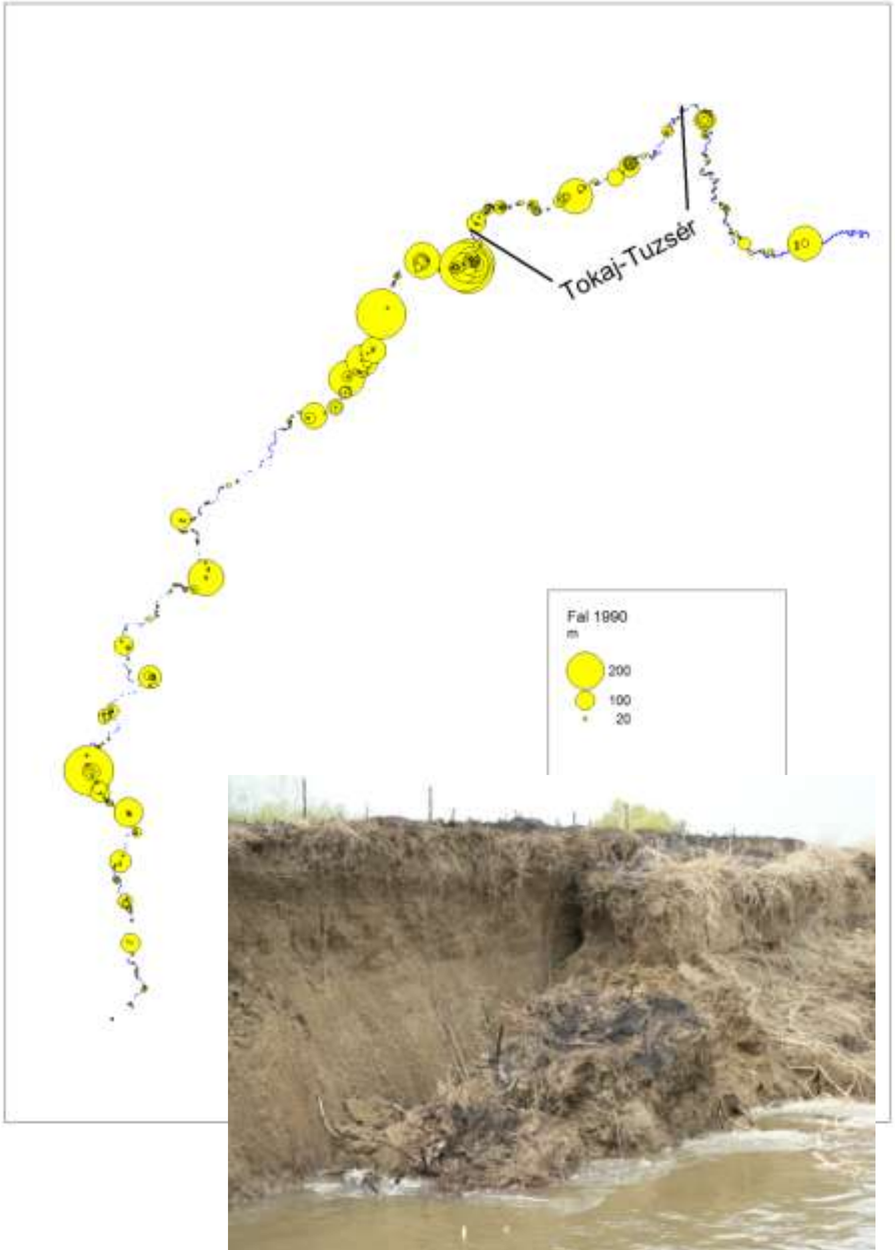
2021



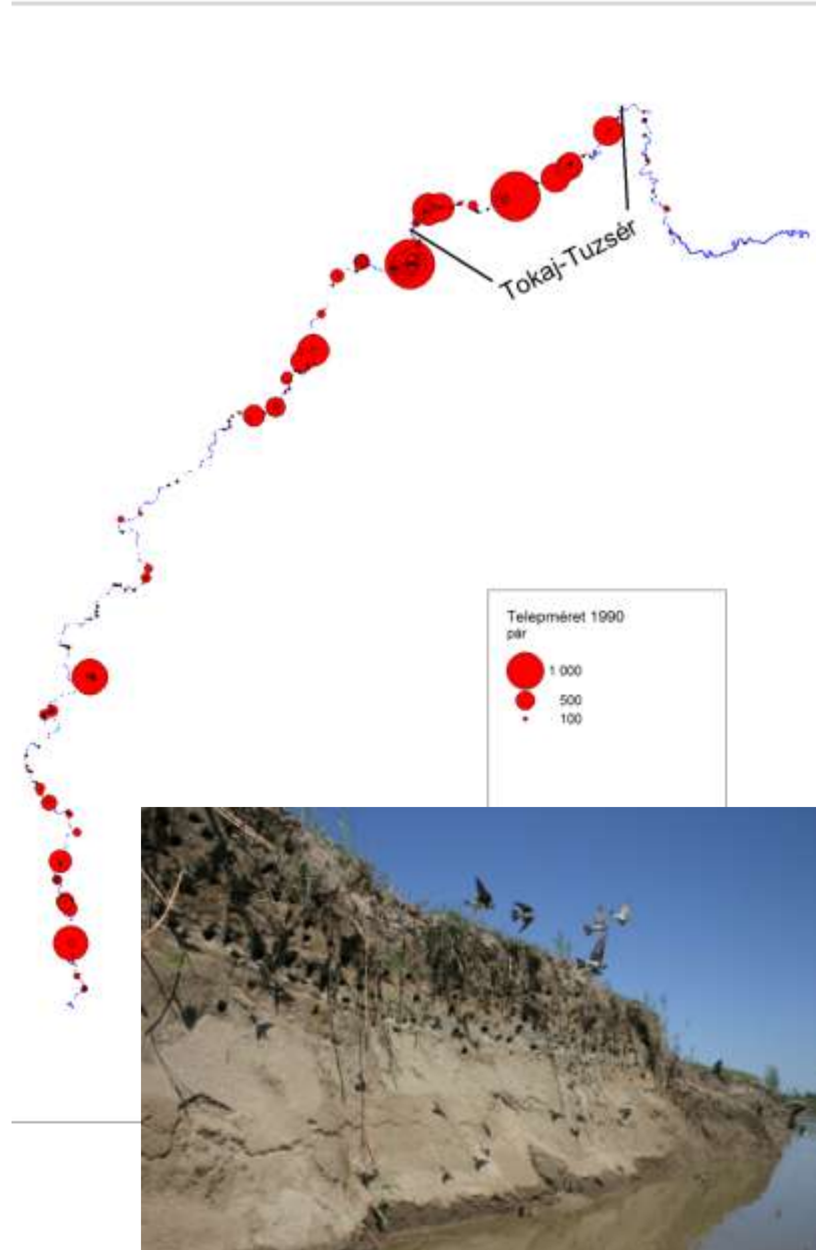


1990

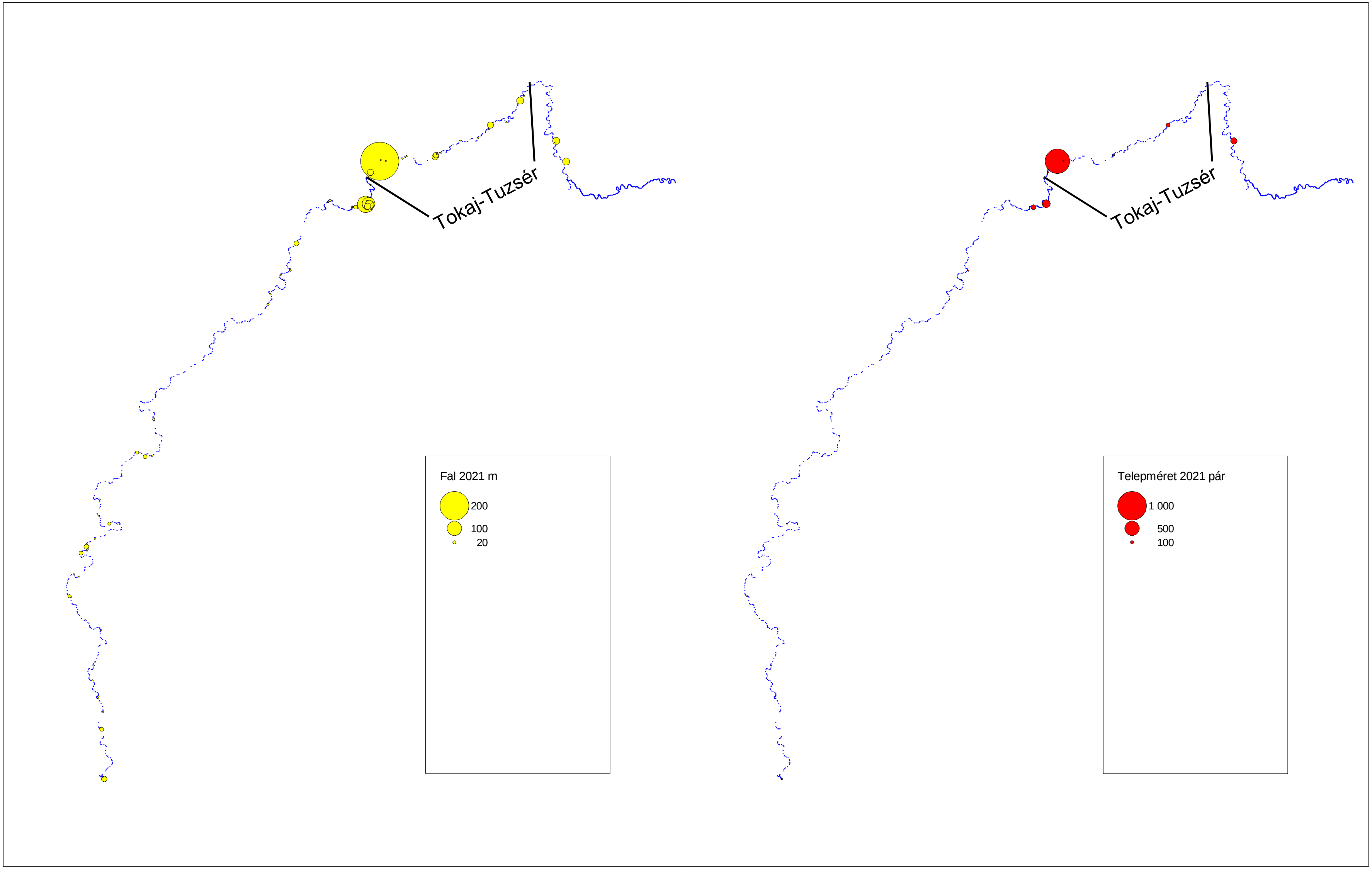
Potential breeding walls and its sizes



Breeding colonies and its sizes



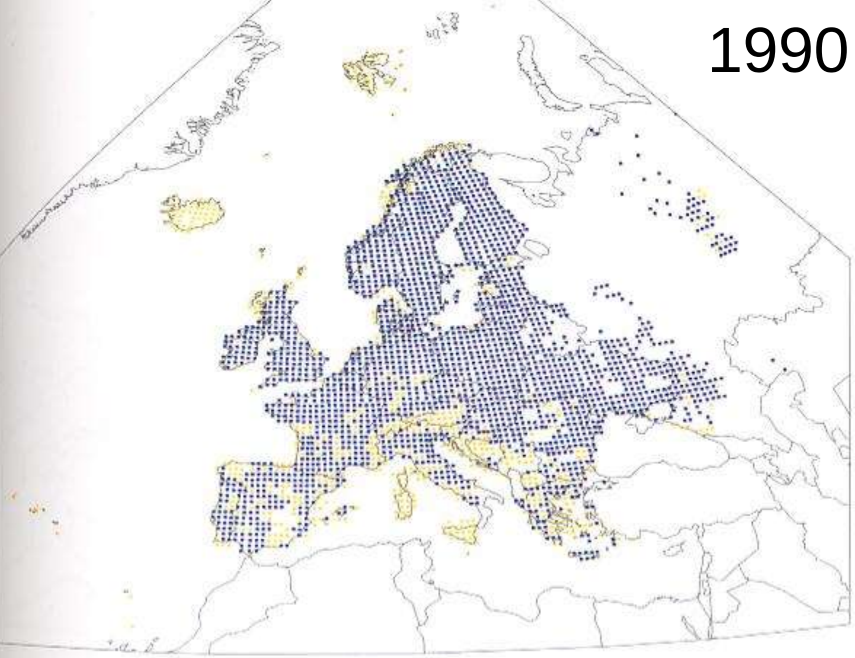
2021


Tokaj-Tuzsér
Fal 2021 m
200
100
20
Tokaj-Tuzsér
Telepméret 2021 pár
1 000
500
100

Marked change is predicted within Hungary for Sand Martin - mainly in the southern part

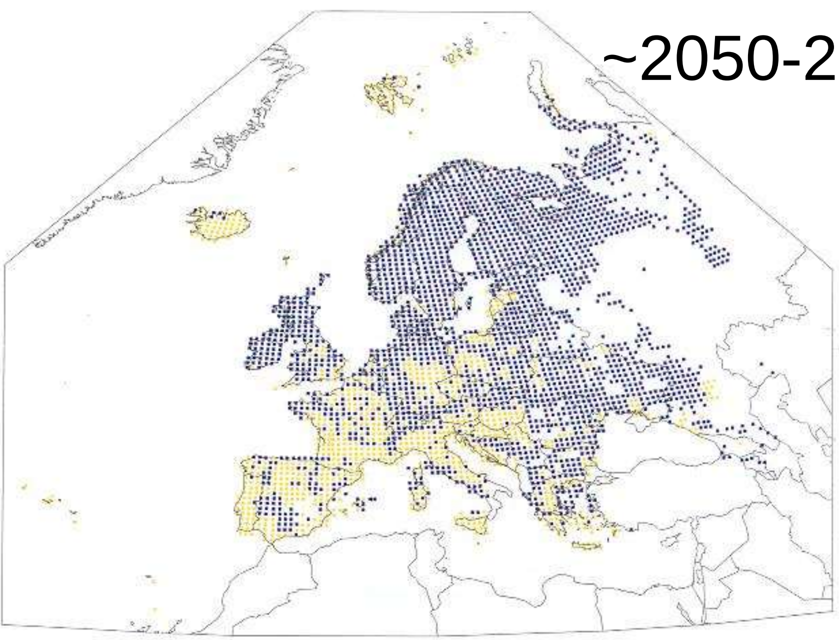
Huntley et al. 2007. A Climatic Atlas of European Breeding Birds.

1990



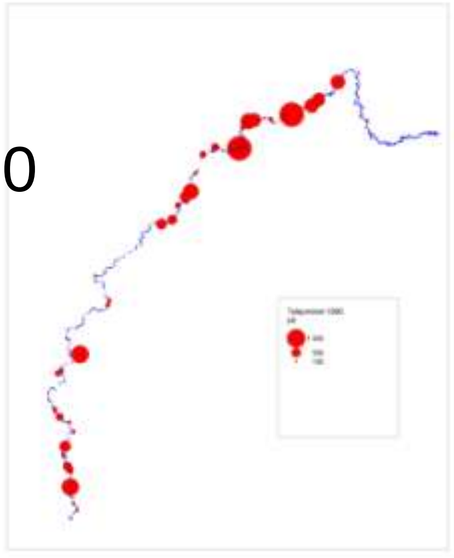
Present recorded distribution

~2050-2100

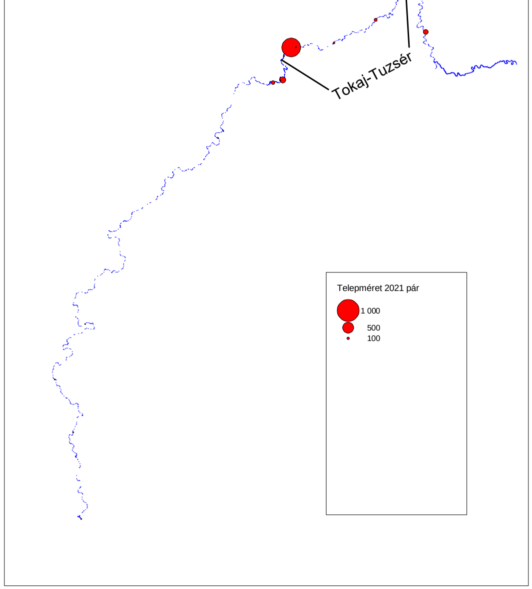


Simulated potential late 21st century distribution (R = 0·81; O = 0·73)

1990



2021



Long-distance migrants – birds of several worlds

- 4 months breeding (May.-Aug.)

- 0.5 months migration in autumn (Aug.-Sept.) 4-6 thousands km

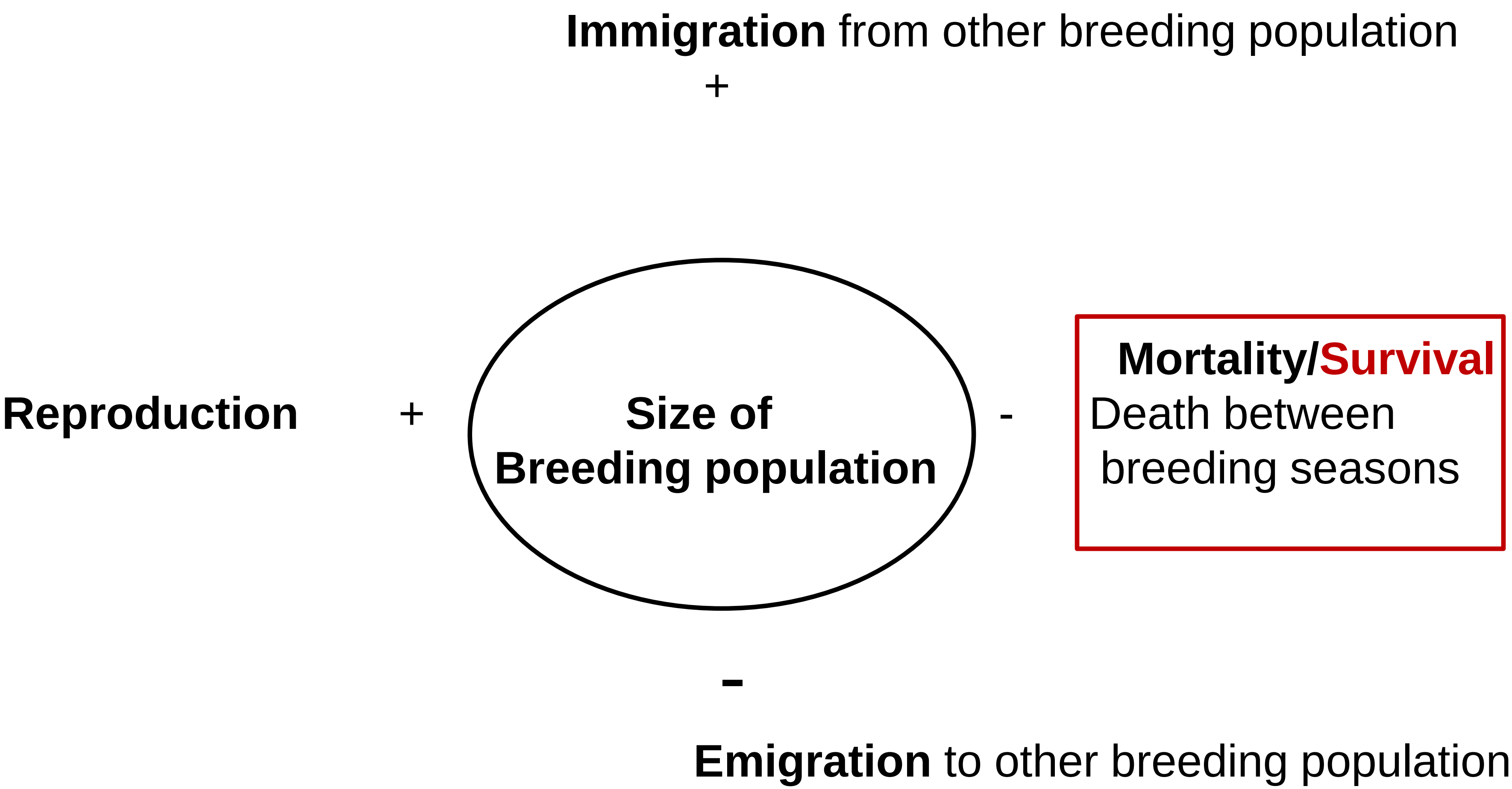
- 7 months wintering (Oct.-April.)

- 0.5 months spring migrations (Apr.-May) 4-8 thousands km

Why the Sand Martin population size is decreasing ?

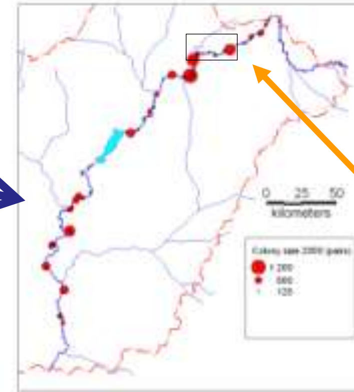
- Higher mortality during migration and/or wintering ?
- Lower reproduction in the breeding area?
- Higher emigration toward North?

Survival rate – most direct proxy to detect influence of migration/wintering event



Development of integrated monitoring of Sand Martin 1994-

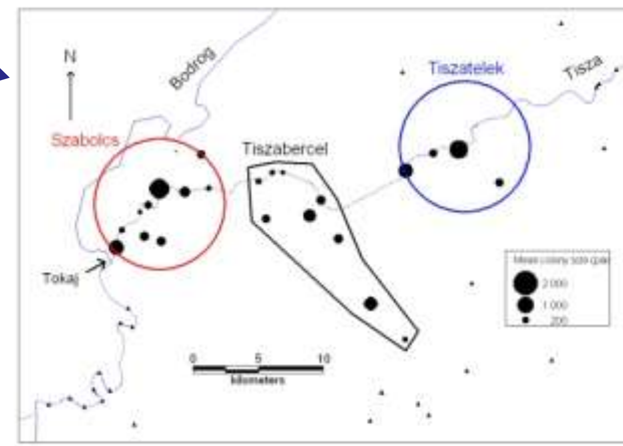
Annual survey of the ~600 km long Hungarian section of the river, since 1990



Regular ringing of all riverside and sand pit colonies in an standard studied area, along a 40km section of the river (Tokaj-Tiszatelek), since 1994

~2000-6000 ringed ind./year

~260-1300 recaptures/year ringed during former years



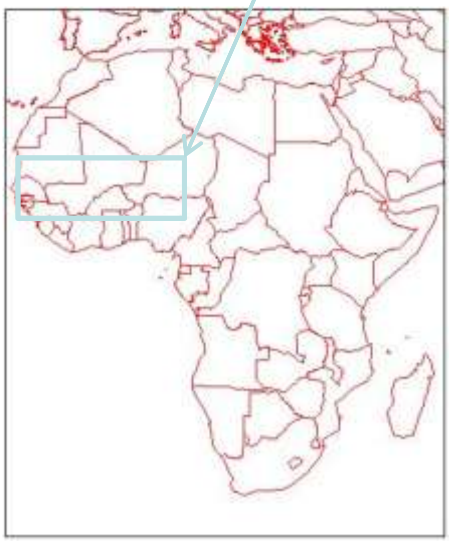
Regular survey of breeding success at randomly selected section(s) of colonies in the studied area using videoendoscope, since 1995

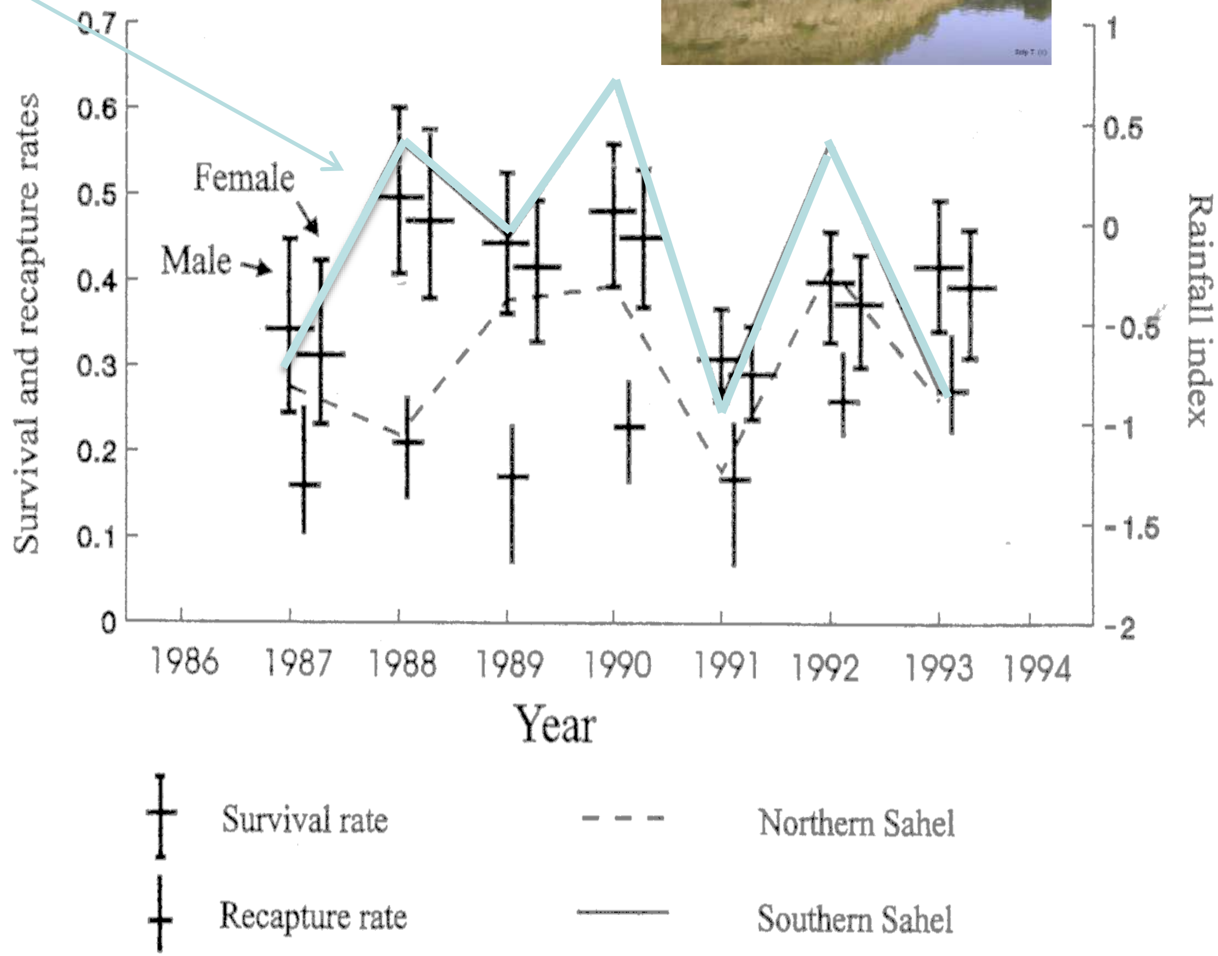
(~800-2000 burrows/year)



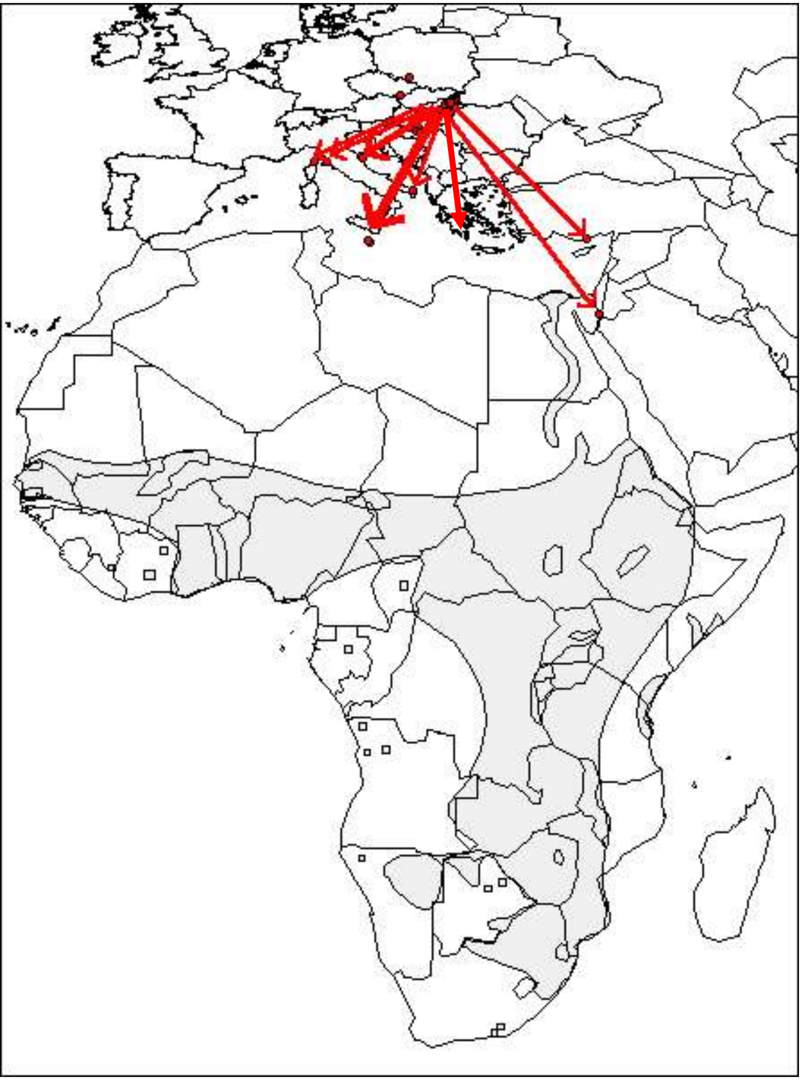

- Survival rate highly depend on the rainfall (Sahel, Western part) condition in Africa (*Szép 1995, Ibis*), one could model the survival rate with Sahelian rainfall for short term (1986-1994, Tiszatelek colony)

Sahelian rainfall index

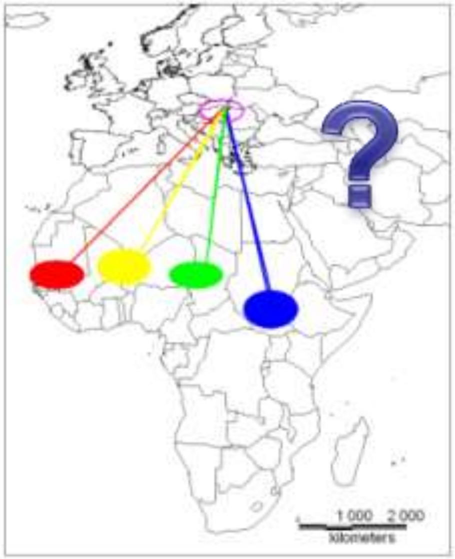




Limited or no information about the all migration and wintering areas of sand martin breeding in Eastern Hungary until 2013



- ~190 thousand ringed breeding birds since 1985,
  - No any African recoveries/recaptures !



Application of geolocators in cooperation with Swiss Ornithological Institutes (2012/13) – first success !!!

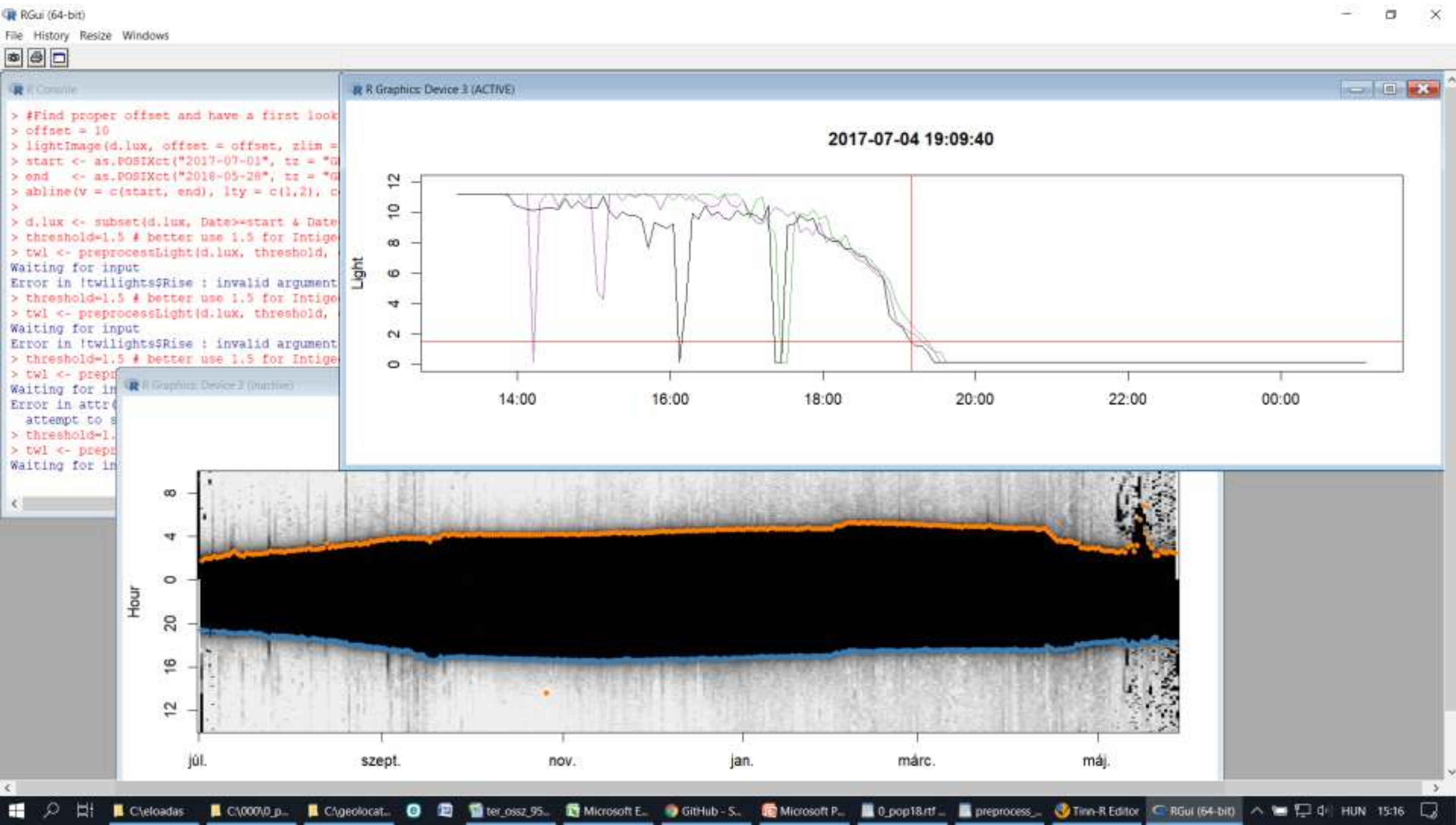
Szép, T., Liechti, F., Nagy, K., Nagy, Zs., Hahn, S. 2017. Discovering the migration and non-breeding areas of Sand Martins and House Martins breeding in the Pannonian basin (central-eastern Europe). Journal of Avian Biology 48: 114-122

Recent project using geolocators, 2017-2020

- 100-100 geolocators deployed in 2017 and in 2018
  (Migratech, 14 months lifespan, measure light in wide range – option to use template fit)

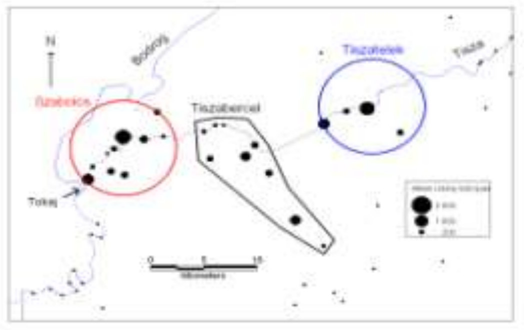
-Opportunity to investigate in details the entire non-breeding period

Geolocation - Flight_R - template fit method, more detailed information about post breeding/autumn migration period , less sensitivity to equinox



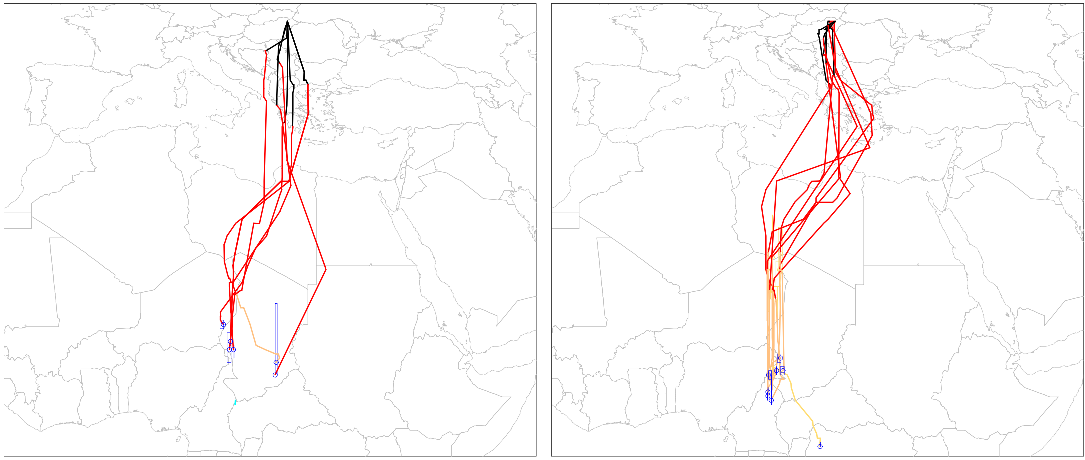
Sand Martin is a long-distance migrant species

Study area in Hungary

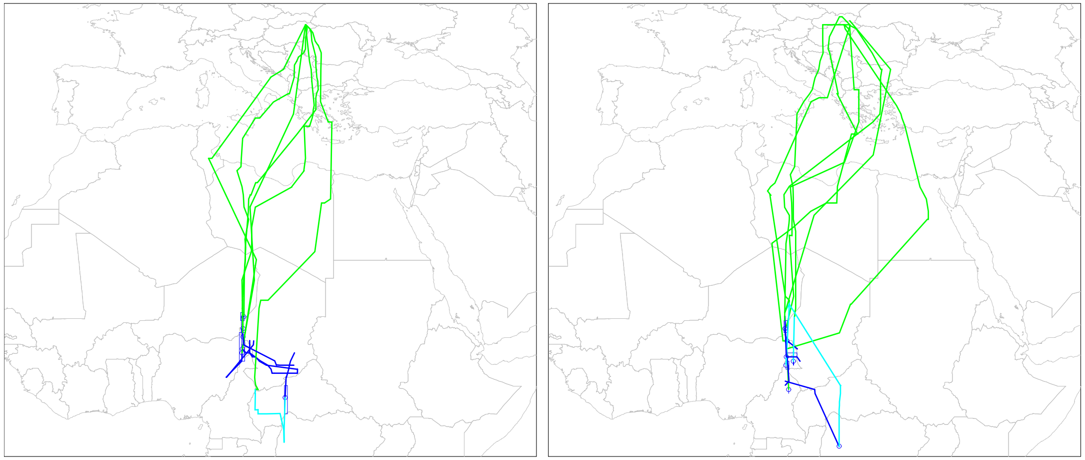


- 6 recaptured individuals in 2018
- 8 recaptured individuals in 2019

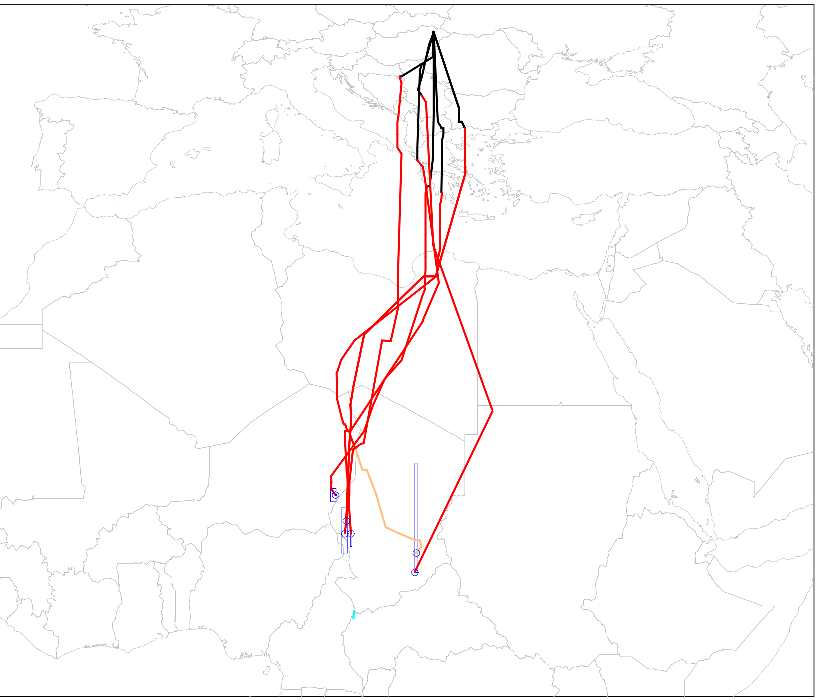
Autumn migration in 2017 and 2018 by geolocators

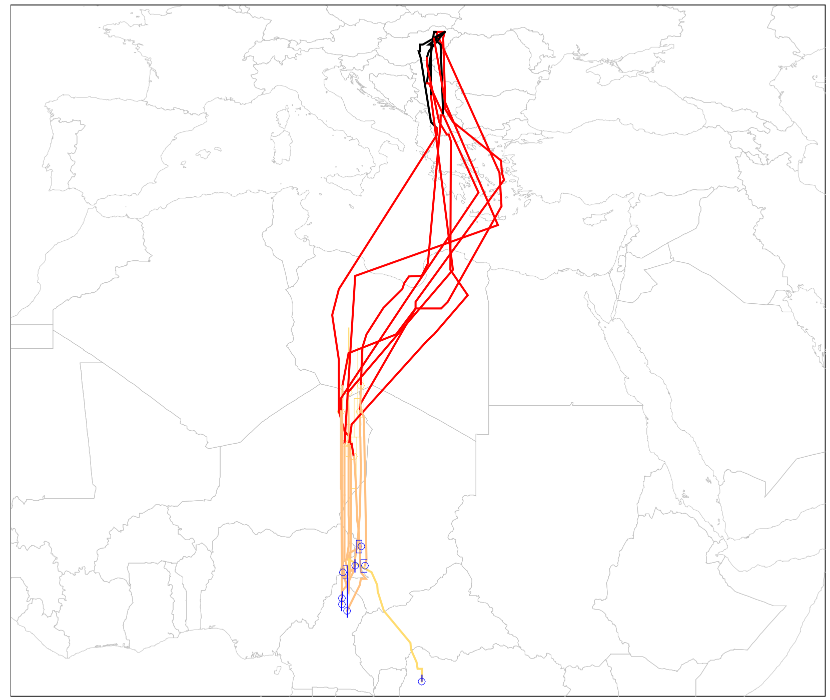


Spring migration in 2018 and 2019



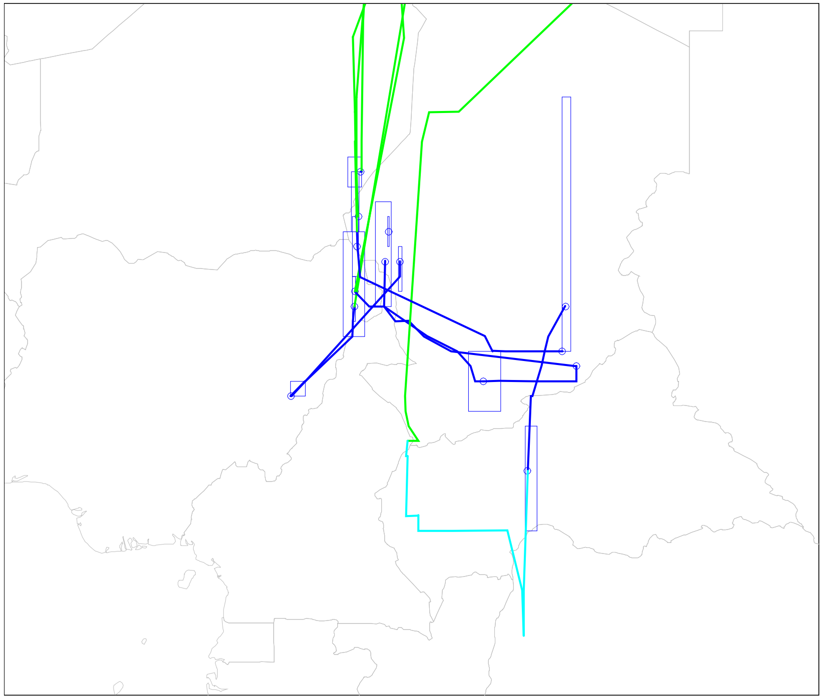
Autumn migratory period

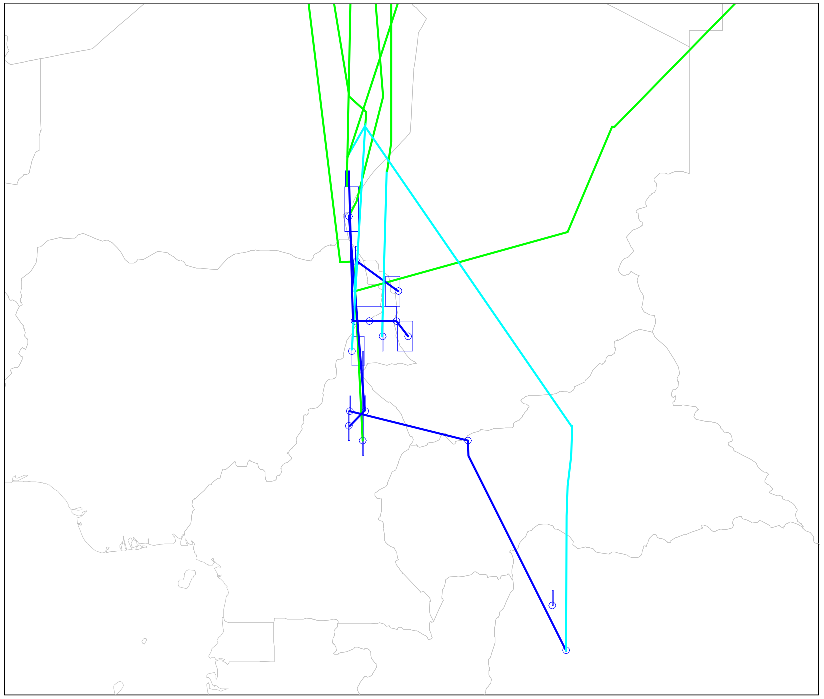




The average speed of movement during autumn migration until reaching the first stationary area used for at least one week in the sub-Saharan non-breeding region was 470 km/day (SE = 129, range 216-745 km/day), it was significantly higher than during the autumnal pre-migration period (Wilcoxon = 6, P < 0.001).

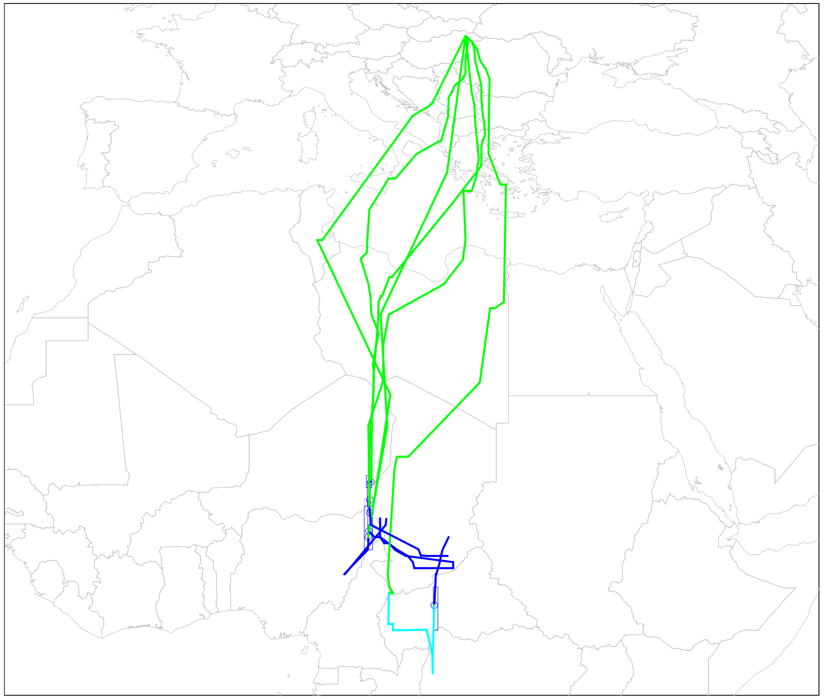
Wintering period

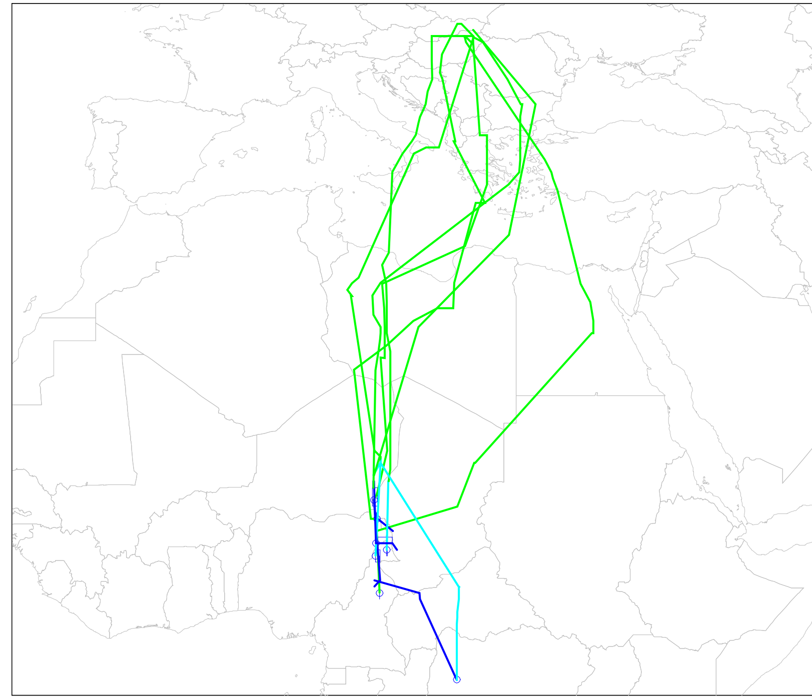




The studied individuals dominantly used the Lake Chad basin as the main non-breeding residence area (Fig. 5), similar to the other two former studies of this population (Szép et al. 2017, Hahn et al. 2021), there were only four individuals (29%) which used different areas in eastern direction (two in SE Chad/Central African Republic) and southern east direction (two in NW Congo).

Spring migration period

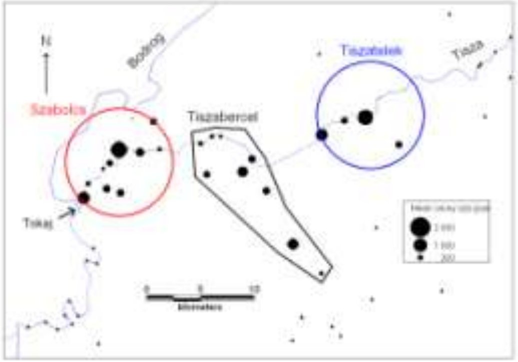




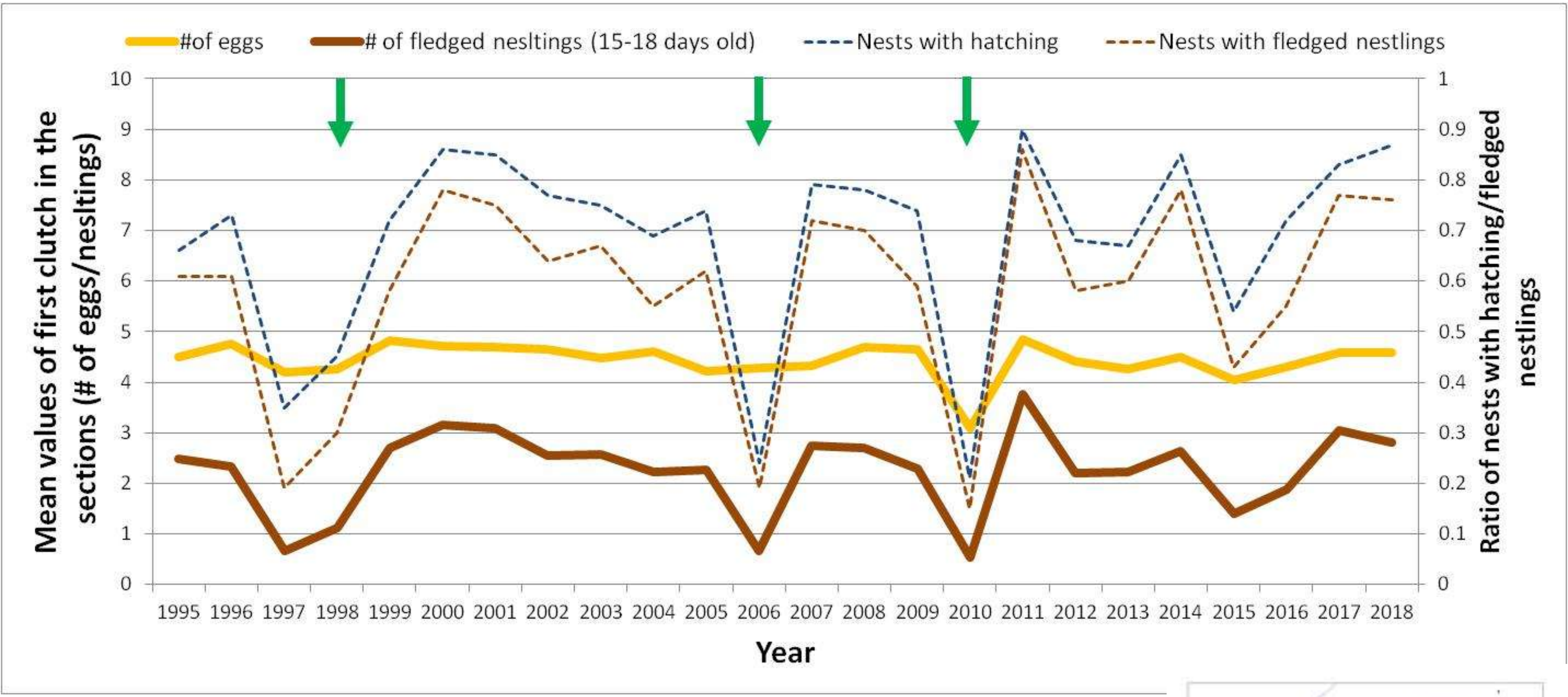
The length of the season until arrival to the final breeding area where the pairing detected was an average 14.3 days (SD = 4.858, range 7.6-23.9 days, n = 13), the birds stayed in stationary areas in total an average 4.731 days (SD=2.623, range 1-9.7 days, n =13), used an average 2.85 stationary areas (SD=1.068, range 2-5) and moved an average 4,136 km among stationary areas (SD = 437, range 3395-4136 km) in this period with an average 484 km/day speed (SD = 182, range 245-763 km/day) which speed did not differ significantly from the speed of the autumn migration across barriers (Wilcoxon = 81, P = 0.878)

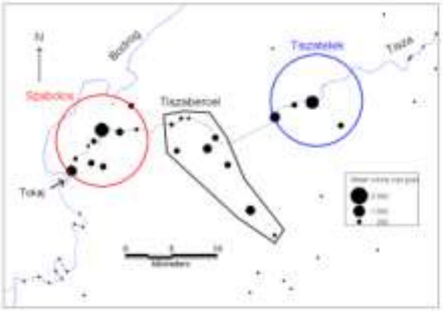
Regular survey of breeding since 1995

- Annually control 800-2000 burrows, at least once a week, since 1995 in the studied area with videoendoscope (~ 10% of all burrows)
- All burrows in randonly selected 2 meters wide section(s) of colonies
  - 478 sections
  - 29 753 burrows
  - 18 691 nests

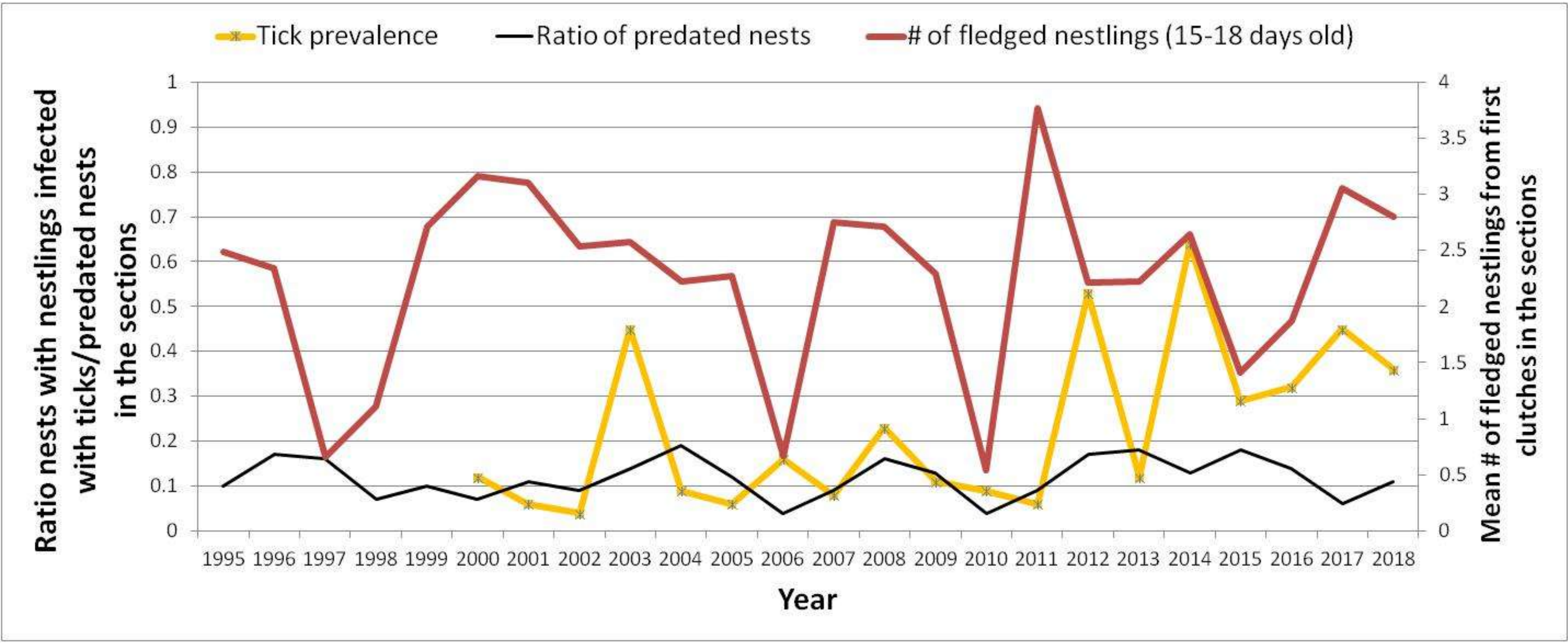


There is no declining trends in the annual breeding values





Only the tick prevalance showing increasing tendecy during the last decade



Host specific tick species, Ixodes lividus, – live and breed only in the Sand Martin nest and individuals and has significant effect on condition of nestlings Szép & Møller (1999, 2000 Oecologia)

Which factors potentially responsible behind the decline ?

- Changing intensity of flood intensity – changing quantity and quality breeding habitats?
- Increasing parasite pressure?
- Changing quantity and quality postbreeding/premigratory/wintering habitats by seasonal/transseasonal (carry-over) effects?
- Phenological mismatch?

- Importance to identify used nonbreeding areas, spatial/temporal characteristics
- Investigation of postfledging condition/survival
- Investigation of natal/breeding dispersals, direction/level of emigration/immigration – other populations
- Investigation on levels of individual/population, IPM

- Opportunity to use new methods for difficult to measure parameters, geolocators, MOTUS network with traditional radiotransmitters, LifeTags, Icarus project
- Opportunity to use remote sensing data, chemical/physical characteristics of feathers

Primary population parameters

Immigration

+

natality + N - mortality

-

Emigration

- **natality**
  - potential fecundity, human (9-11 months)
  - realized - " –, human (8 per years)

  natality rate – offspring/unit time
- **mortality**
  - potential longevity
  - realized - " -
  - human girls (Rome 21 years, 1780 UK 39 years, 1976 USA 77 years
- **immigration-emigration**

Secondary population parameters

- Sex ratio

- Age composition

- Distribution

- Genetical composition

Population demography

– Examines and measures the dimensions and dynamics of populations

Life table

Life Table for the Barnacle *Balanus glandula* at the Upper Shore Level on Pile Point, San Juan Island, Washington[a]

Age (yr)(x)	Observed No. Barnacles Alive Each Year (n_x)	Proportion Surviving at Start of Age Interval x (l_x)	No. Dying Within Age Interval x to $x+1$ (d_x)	Rate of Mortality (q_x)	Mean Expectation of Further Life for Animals Alive at Start of Age x (e_x)
0	142	1.000	80	0.563	1.58
1	62	0.437	28	0.452	1.97
2	34	0.239	14	0.412	2.18
3	20	0.141	(4.5)	0.225	2.35
4	(15.5)[b]	0.109	(4.5)	0.290	1.89
5	11	0.077	(4.5)	0.409	1.45
6	(6.5)[b]	0.046	(4.5)	0.692	1.12
7	2	0.014	0	0.000	1.50
8	2	0.014	2	1.000	0.50
9	0	0.0	—	—	—

[a] Data are from the 1959 year-class and begin 1–2 months after settlement. Individuals were counted each year until 1968, by which time all had died. This is an example of a cohort life table as defined on page 179.
[b] Estimated number alive.
Source: After Connell (1970).

Life table (mortality) of women in Canada

.

TABLE 11.2
Static Life-Table Data for the Human Female Population of Canada, 1980

Age Group (yr)	No. in Each Age Group	Deaths in Each Age Group	Mortality Rate per 1000 Persons (1000 q_x)
0–1	173,400	1651	9.52
1–4	685,900	340	0.50
5–9	876,600	218	0.25
10–14	980,300	234	0.24
15–19	1,164,100	568	0.49
20–24	1,136,100	619	0.54
25–29	1,029,300	578	0.56
30–34	933,000	662	0.71
35–39	739,200	818	1.11
40–44	627,000	1039	1.66
45–49	622,400	1664	2.67
50–54	615,100	2574	4.18
55–59	596,000	3878	6.51
60–64	481,200	4853	10.09
65–69	423,400	6803	16.07
70–74	325,600	8421	25.86
75–79	235,100	10,029	42.66
80–84	149,300	10,824	72.50
85 and above	119,200	18,085	151.70

Note. These data were obtained by tallying the number of females in each age group by their 1980 birthdays and by tallying the number of deaths in 1980 for the same age groups.
Source: *Statistics Canada* (1982).

Survivorship curve

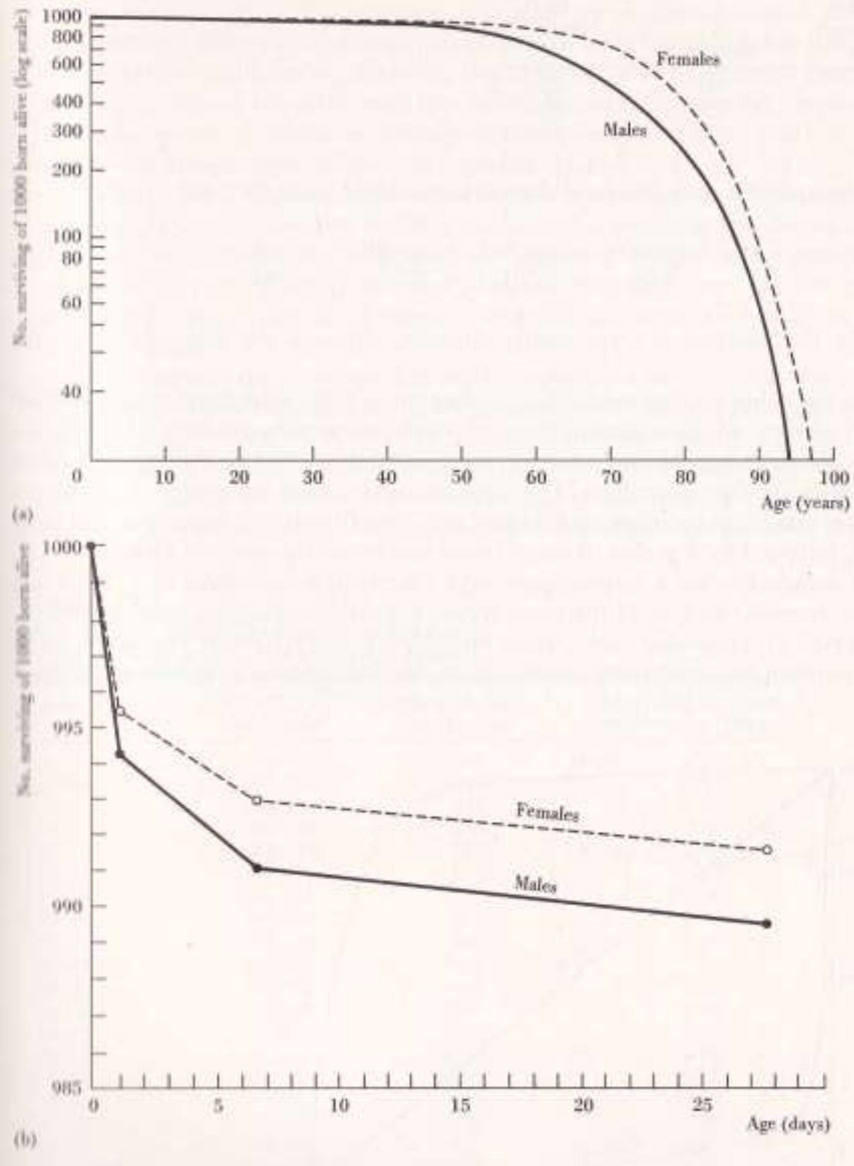


Figure 11.1 (a) Survivorship curve for all males and females in the United States, 1978. (b) Infant survival during the first month. (Data from Demographic Yearbook 1980.)

Survivorship curve

Type I- large mortality in the old age (e.g. humans)
Type II- similar mortality among different age groups (e.g. birds)
Type III- large mortality in the young age (e.g. insects)

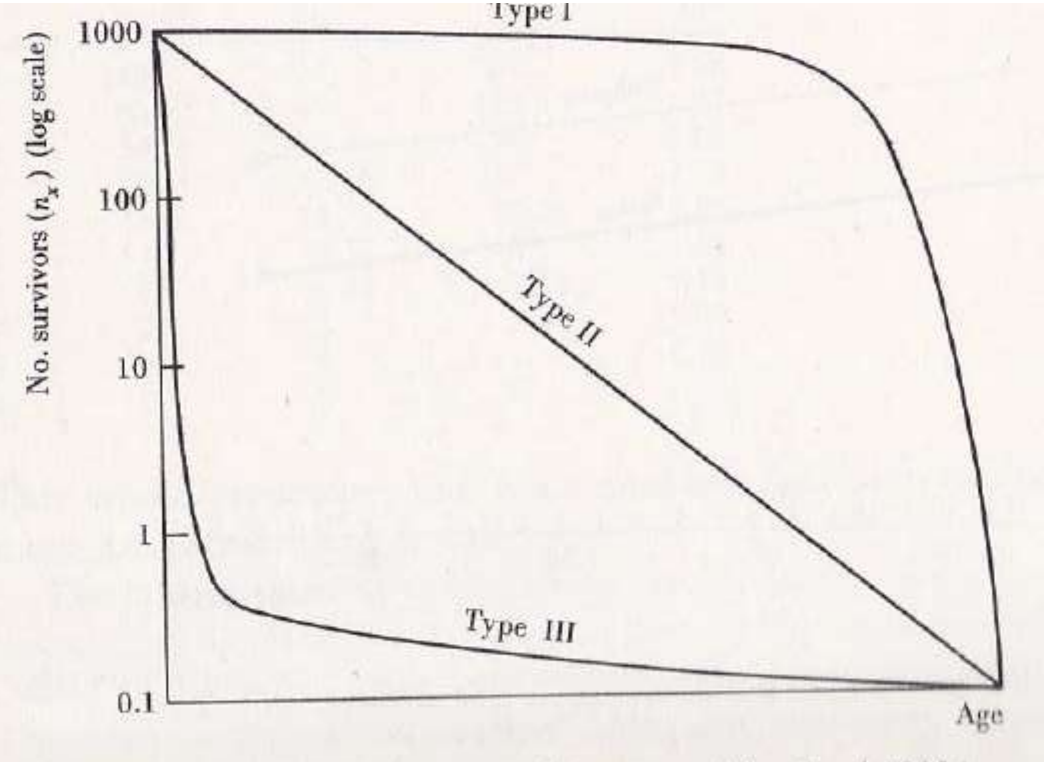


Figure 11.2 Hypothetical survivorship curves. (After Pearl 1928.)

Fertility

l_x: proportion of the population surviving to age x.

a_x/a_0 (a_0: # of young individuals, a_x: # of individuals surviving x. age)

m_x: x korban létrehozott nőstények utódok száma (a táblázatban b_x-el jelölve)

Net reproductive rate (R_0): $$\sum_{x=1}^{\text{max. age}} (l_x * m_x)$$

If R_0=1, population size did not change

TABLE 11.3
Survivorship Table (l_x) and Fertility Table (b_x) for Women in the United States, 1978

Age Group	Midpoint or Pivotal Age *x*	Proportion Surviving to Pivotal Age l_x	No. Female Offspring per Female Aged *x* Per 5-Year Time Unit (b_x)	Product of l_x and b_x (V_x)
0–9	5.0	0.9854	0.0	0.0
10–14	12.5	0.9836	0.0030	0.0029
15–19	17.5	0.9816	0.1310	0.1286
20–24	22.5	0.9785	0.2808	0.2748
25–29	27.5	0.9751	0.2800	0.2730
30–34	32.5	0.9713	0.1478	0.1436
35–39	37.5	0.9663	0.0473	0.0457
40–44	42.5	0.9583	0.0098	0.0094
45–49	47.5	0.9453	0.0005	0.0005
50 and above	—	—	0.0	0.0
			$R_0 = \sum_0^{\infty} l_x b_x =$	0.8785

Source: *Statistical Abstract of the United States, 1982* (1982–1983).

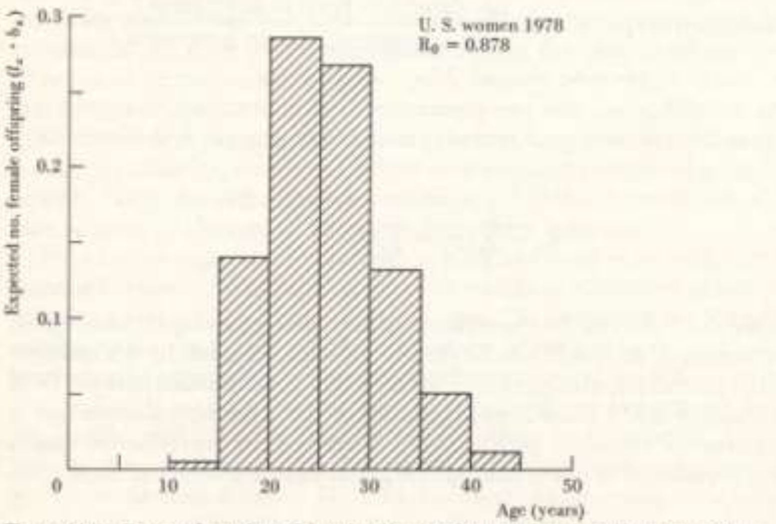


Figure 11.7 Expected number of female offspring for each female in the United States, 1978. Data from Table 11.3. The area under the curve is the net reproductive rate (R_0).

Reproductive value

Reproductive rate (V_x): $$\sum_{t=x}^{\text{max. age}} (l_t/l_x)*m_x$$

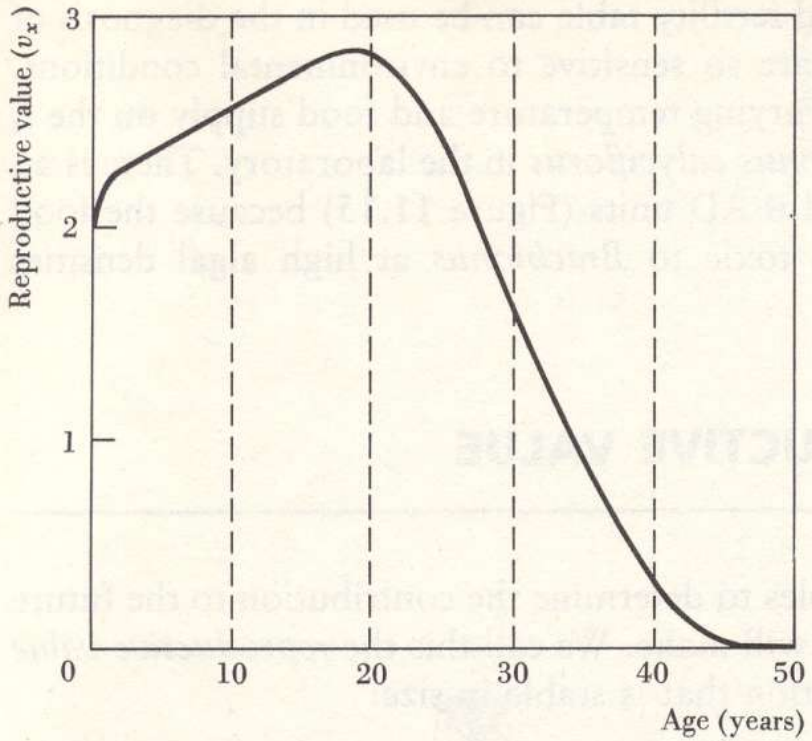
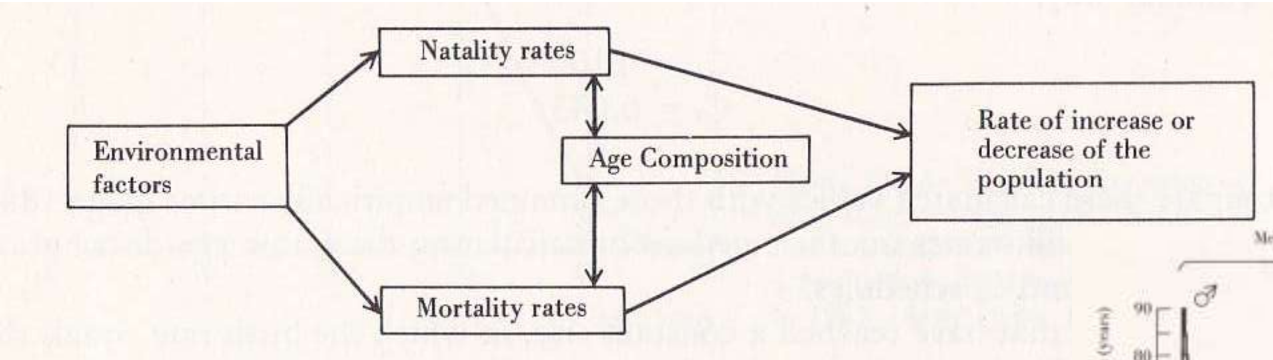


Figure 11.16 Reproductive value of Australian women, 1911. This was the first calculation of reproductive value in a population, done by Sir Ronald Fisher in 1929. (After Fisher 1958.)

Age distribution



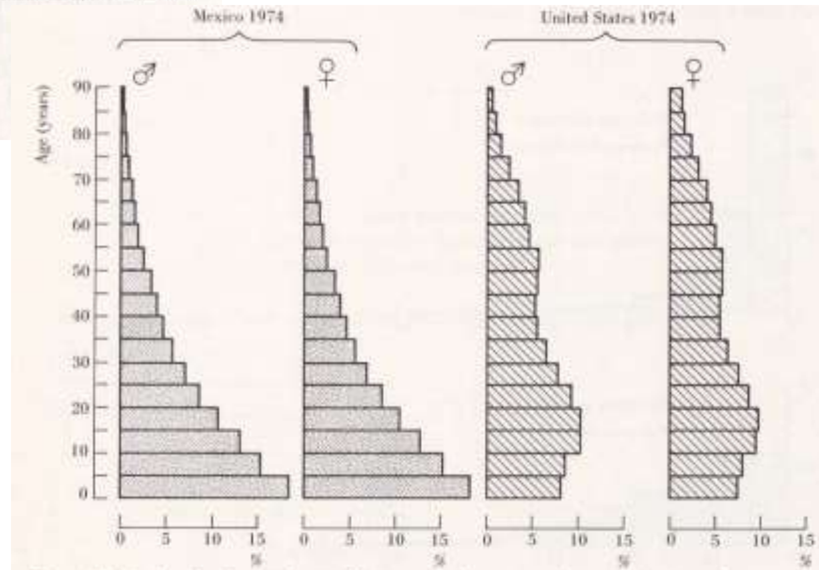
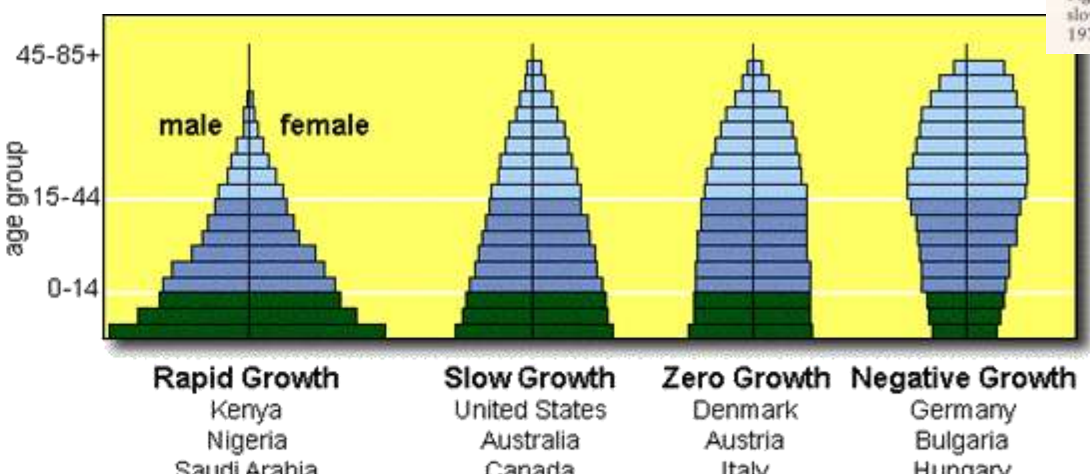


Figure 11.18 Age distributions for rapidly increasing human population in Mexico and slowly increasing population in the United States. (Data from Demographic Yearbook 1974.)



Modeling population size on the base of life table data

- Leslie model
  - If we know for each age group (a) the survival rate (p_a) and fertility (m_a)
  - Population size of each age groups (n_a), by which the entire population is estimatable for the next period (t)

Pl.

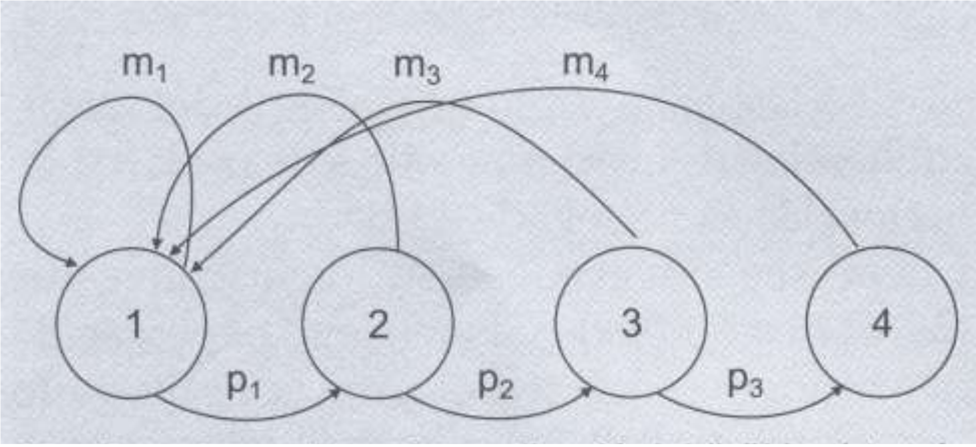
$n_1(t+1)=n_1(t)*m_1+n_2(t)*m_2+….$

$n_2(t+1)=n_1(t)*p_1$

$n_3(t+1)=n_2(t)*p_2$

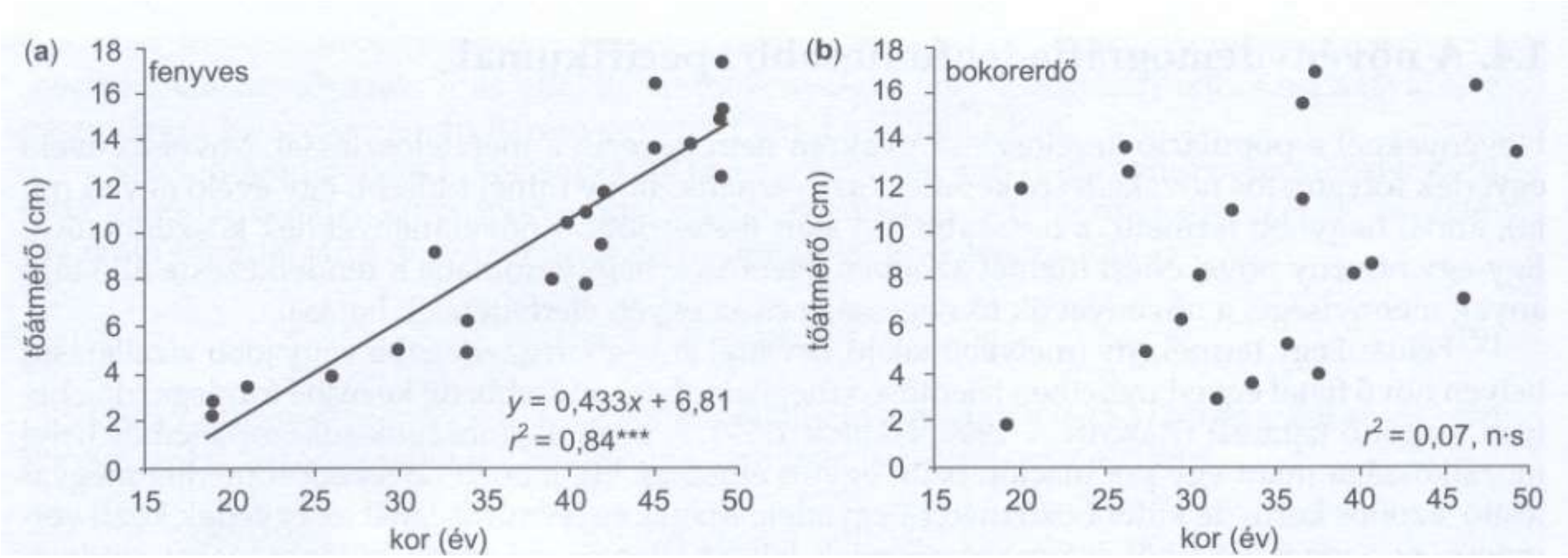
.

.



Speciality of plant demography

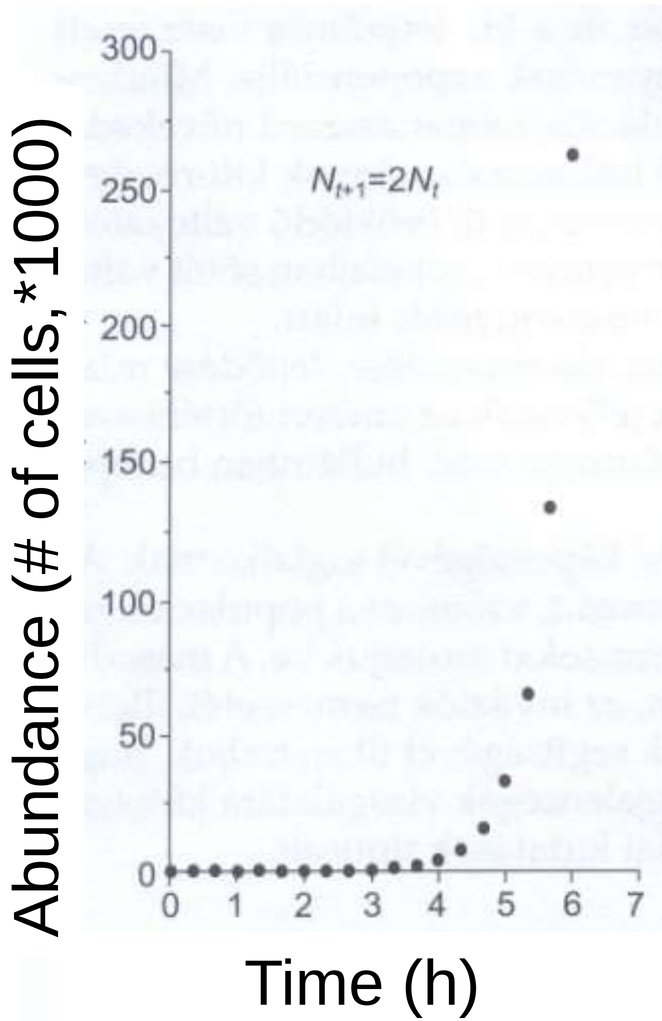
Age distribution could be different form size distribution – survival and fertility are size dependent for most plants



Manna tree (Fraxinus ornus) age (kor év) and size (diameter of stump, tőátmérő cm) at two different habitats:

- fenyves- soil with similar depth
- bokorerdő- soil with very varying depth

Population Growth



$R_0=2$

Exponential (Geometrical) growth

- If there is no death, one bactery which cell able to proliferate every 20th minutes could cover the entire surface of the Earth within a day!

$$N_{t+1}=R_0*N_t$$

where:

- N_t abundance in the i^th period
- N_{t+1} abundance in the t+1^th period
- R_0 net reproductive rate (λ, growth factor)

$R_0= N_{t+1}/N_t$

The speed of the growth is depend on the # of birth and death within a period

In the case of plants the growth measured by growth of the biomass

Exponential growth

Discrete generations:

Species with a single annual breeding season (e.g. colorado beetle)

$N_{t+1}=R_0*N_t$

Exponential growth when the net reproductive rate (R_0) constant

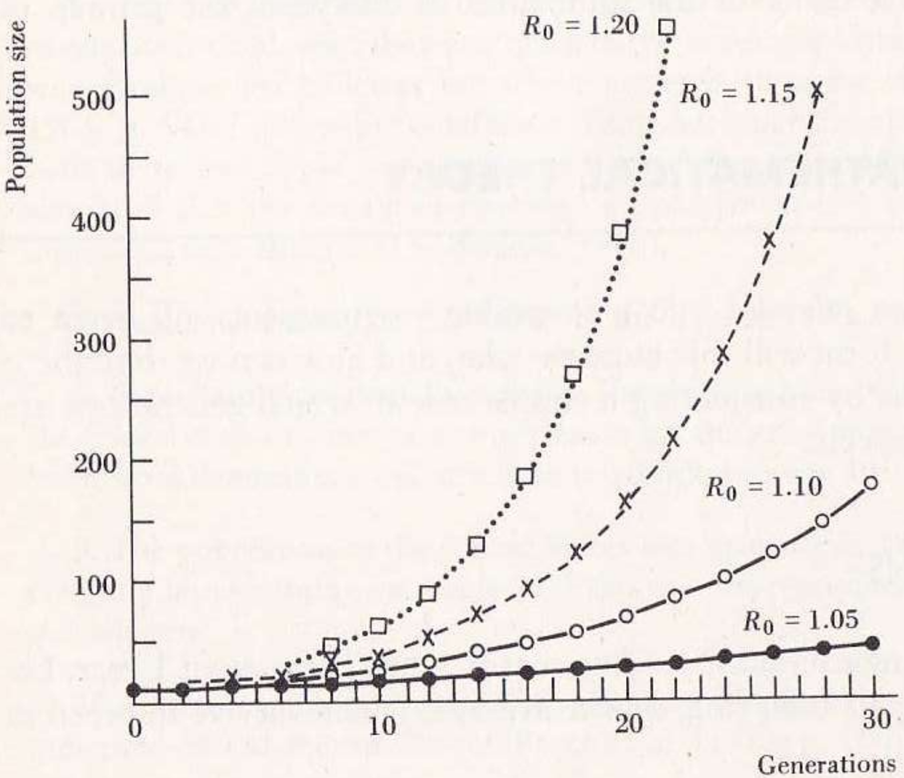


Figure 12.1 Geometric population growth, discrete generations, reproductive rate constant. $N_0 = 10$.

$R_0>1$: Population exponentially increasing

$R_0=1$: Population size is not changing

$R_0<1$: Population exponentially decreasing

$N_t=N_0* R_0^t$

$N_{0:}$ Population size in the starting period (0th)

Exponential growth

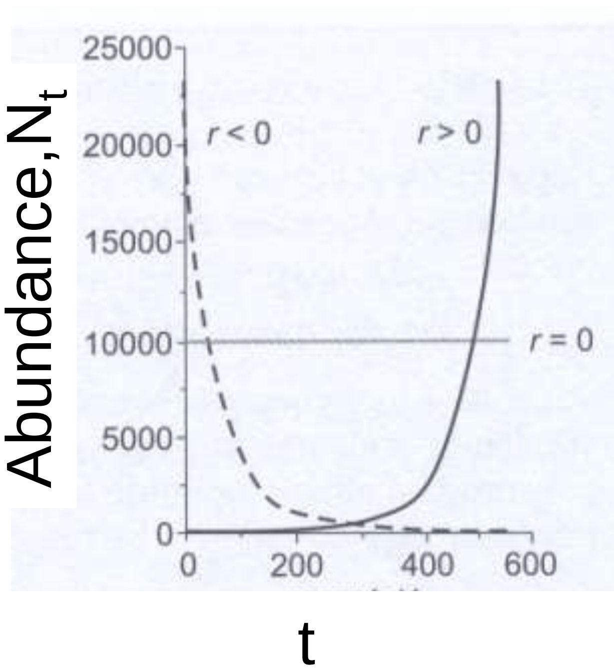
Overlapping generation:

Species with prolonged or continuous breeding season (e.g. human)

change of population size within dt time interval:

dN
---- = r *N
dt

$$\frac{dN}{dt} = r \cdot N$$



r: per-capita rate of population growth within dt time interval

r= b – d

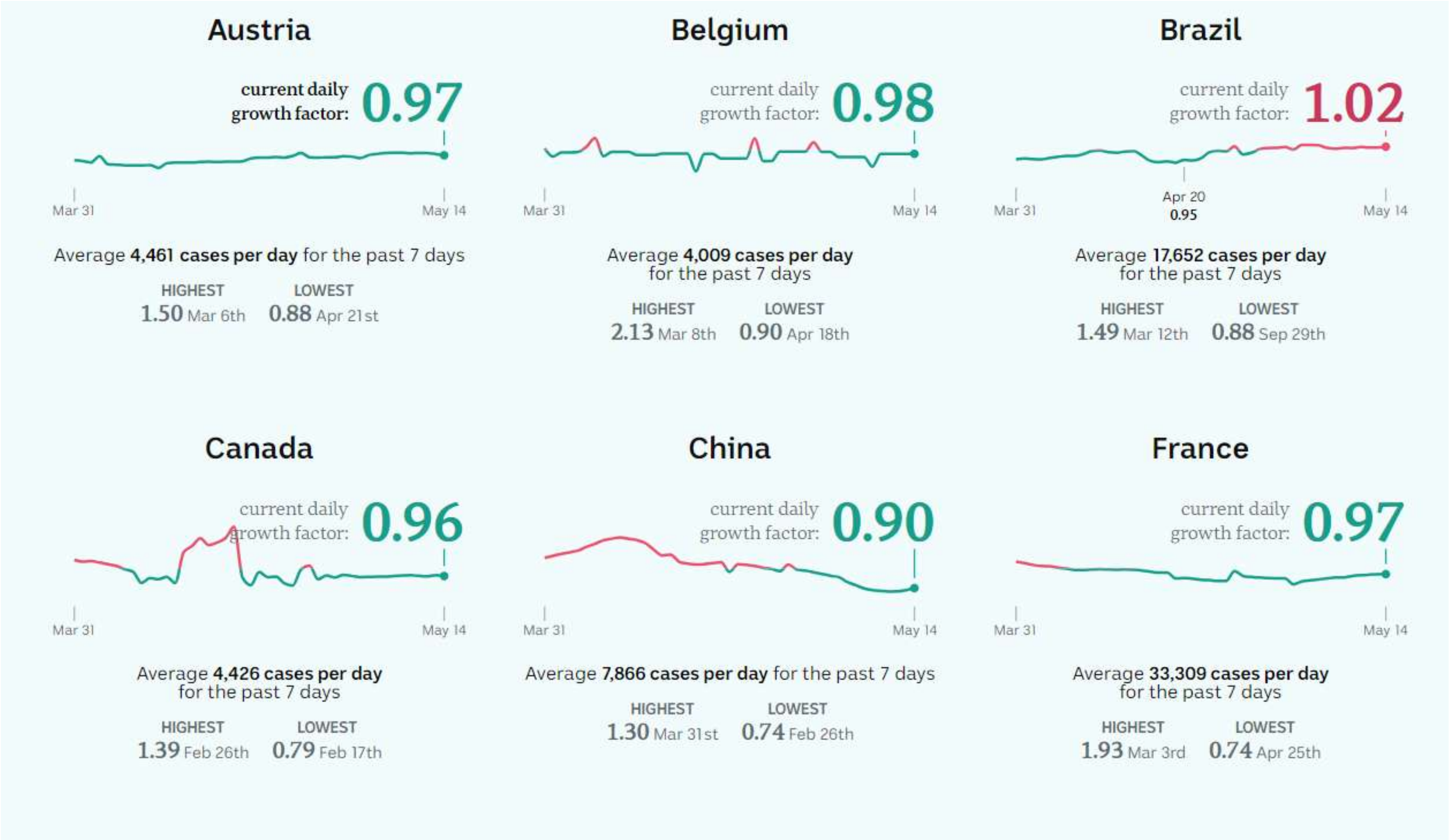
Where:

b: instantancous birth rate

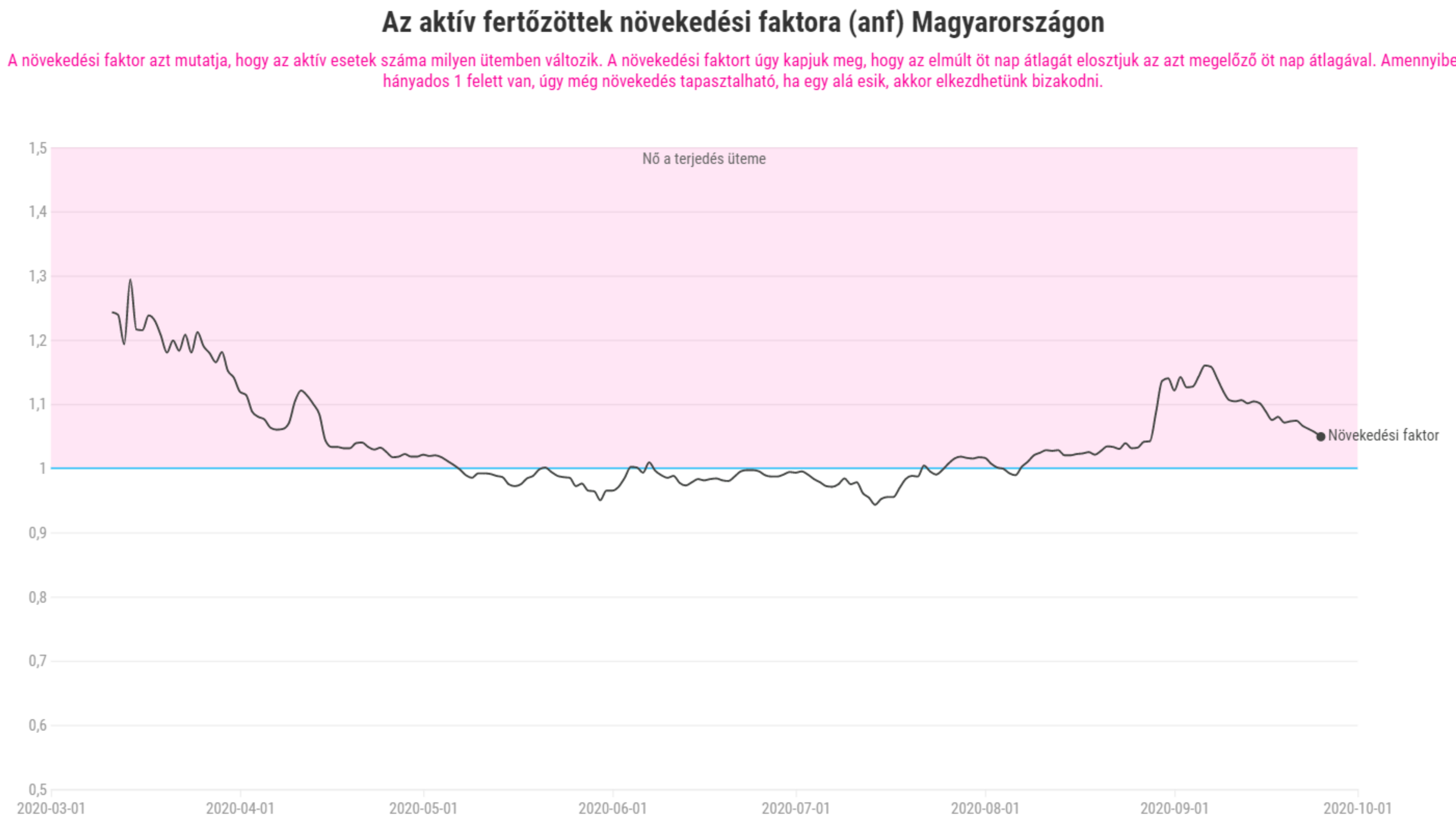
d: instantancous death rate

Exponential increase/decrease when r independent from the N

COVID-19



R_0: Covid-19 reproductive rate (growth factor) in some countries

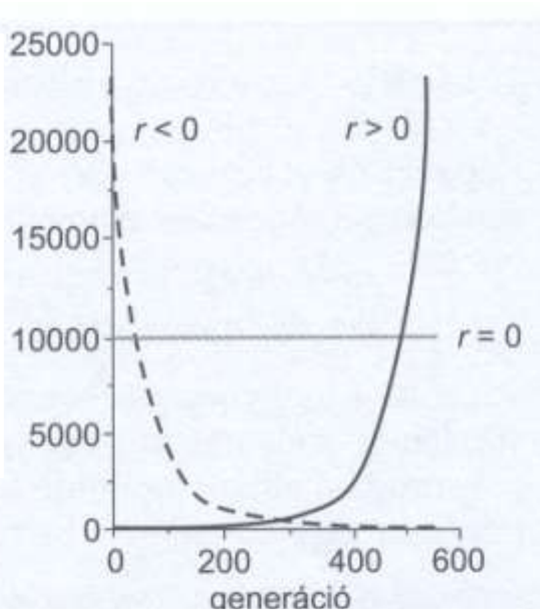


R_0: Covid-19 reproductive rate (growth factor) in Hungary

Exponential growth

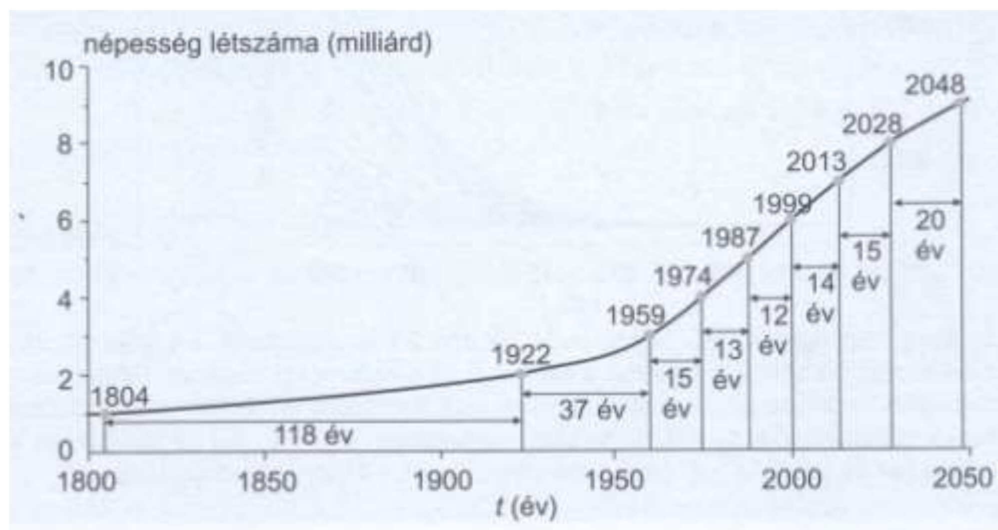
Human population

Abundance, N_t

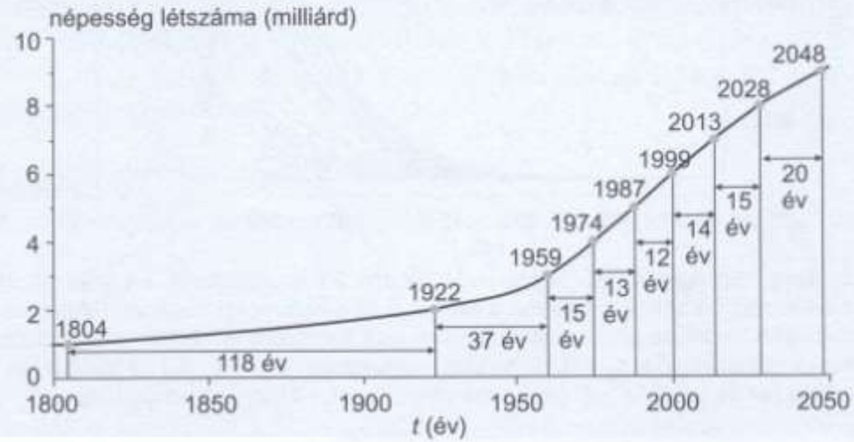


t

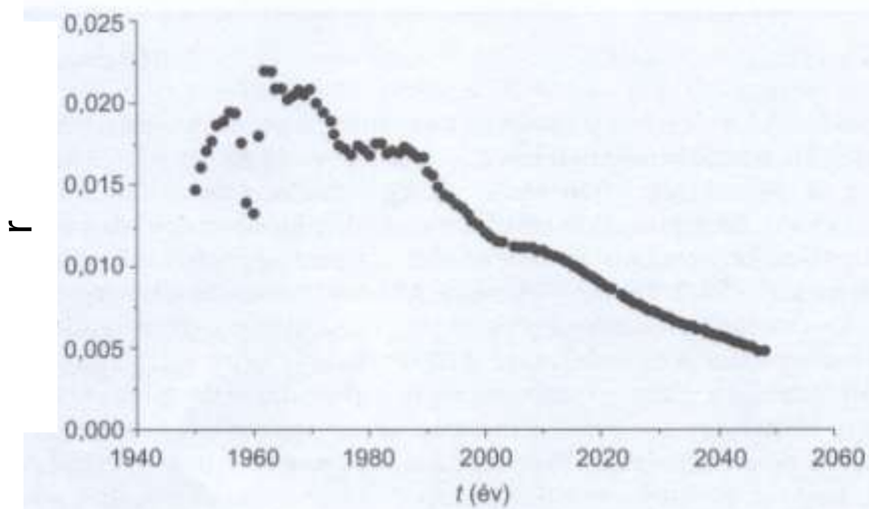
Population size (billion people)



Populációnövekedési modellek



4. ábra A világ népességének növekedése. A nyilak alatti számok az 1 milliárdos növekményhez szükséges időtartam hosszát adják meg. (Global Population Profile, 2002 nyomán).

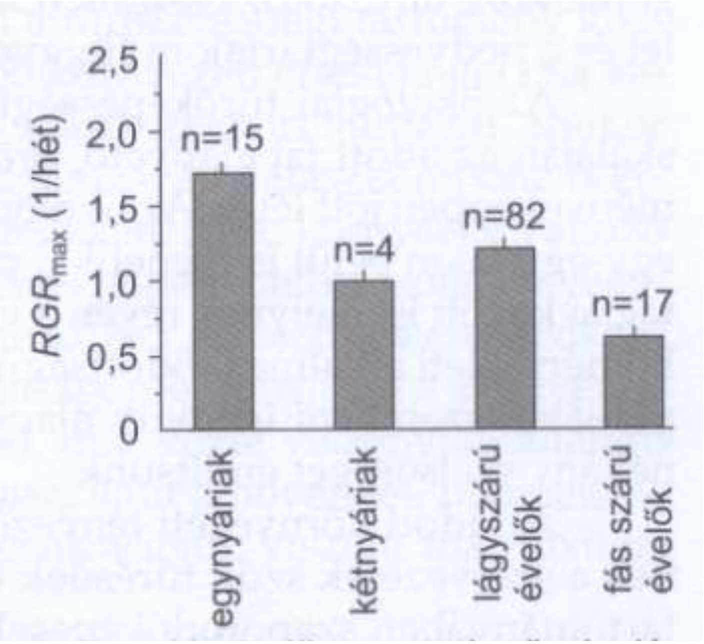


7. ábra A teljes emberi népesség növekedési üteme. A kiugróan alacsony értékeket 1960 körül egy kínai éhínség magyarázza (US CENSUS BUREAU adatai alapján).

In the case of the human population near stable r (population growth) was typical until ~1990, since then there is a decreasing tendency

r_0 (R_0): maximum reproductive rate (e.g. following catastrophe, epidemic, settling new area)

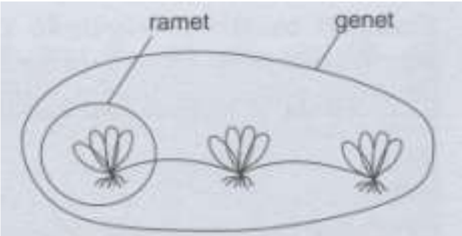
Population growth - plants



Maximal RGR of different Plants (herbaceous, biennial, perennial, woody plants)

Relative growth rate (RGR)

$$RGR = \frac{1}{B} * \frac{dB}{dt}$$



6. ábra Egyedfogalmak egy indás nö-vénynél.

where:

B: biomass of the individuals

dB: change of the biomass with dt time interval

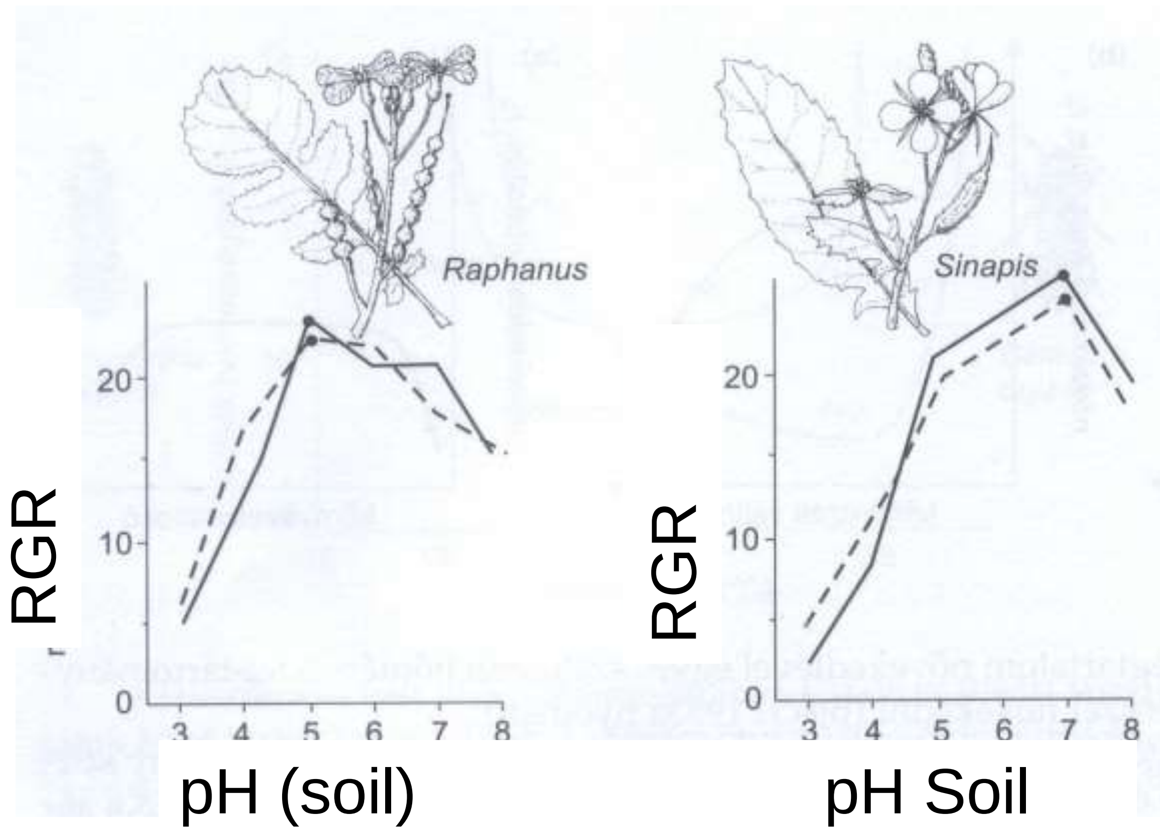
Algae (hydrological): RGR= 1.4/day

Weeds (terrestrial): RGR= 0.38/day

Population growth

The role of ecological limiting factors

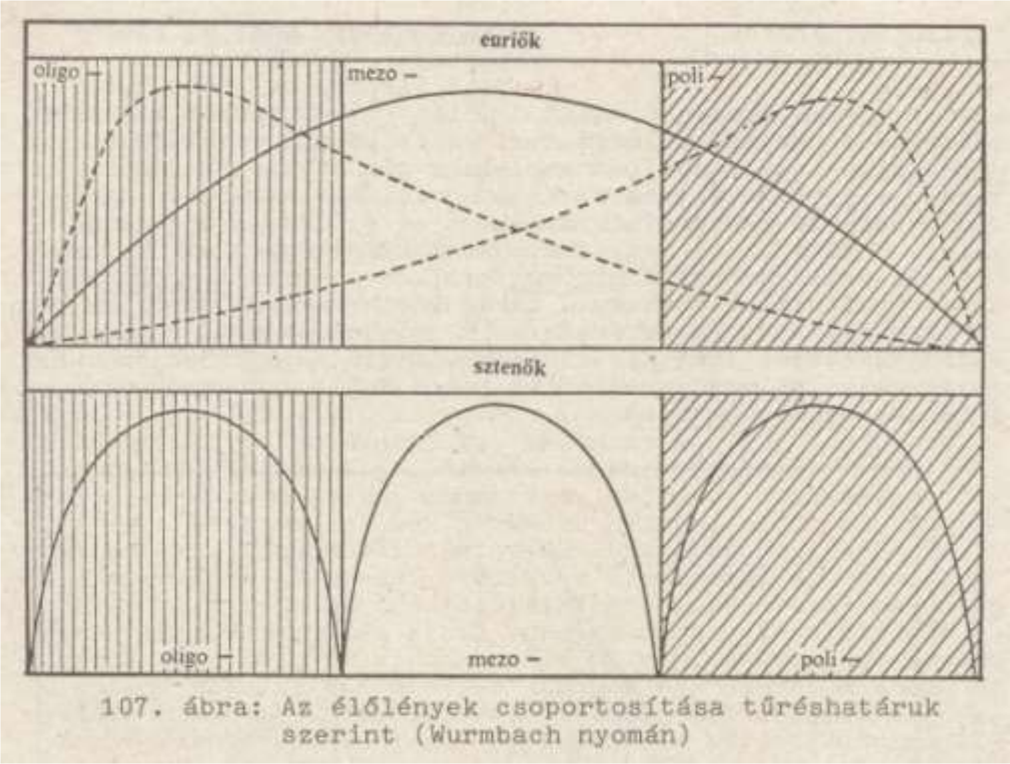
Ecological tolerance interval, where the $r_0 > 0$, $R_0 > 1$ ==> population able to growth



14. ábra A mészkerülő repcsény retek (*Raphanus raphanistrum*) és a vadrepce (*Sinapis arvensis*) válaszgörbéi egyfajú veteményekben **(monokulturában).** Egy-egy vonal egy-egy kísérlet eredménye (MULLER-DOMBOIS, ELLENBERG 1974).

Ecological tolerance

.

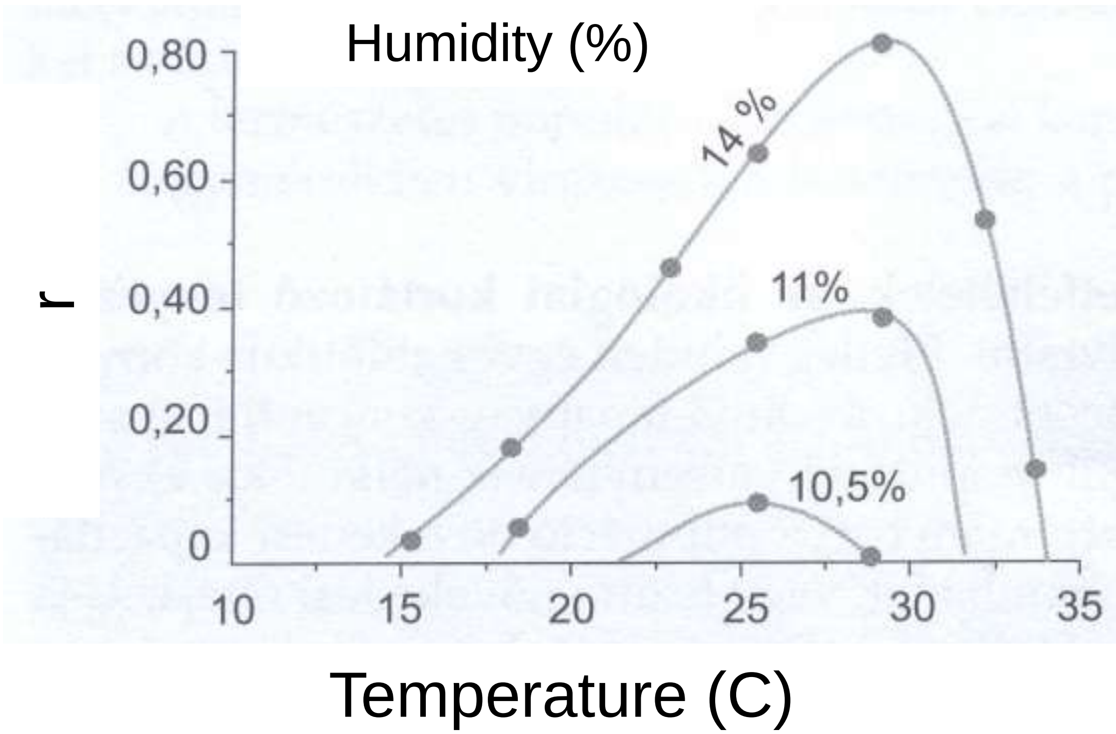


Euriök - generalist

sztenők - specialist

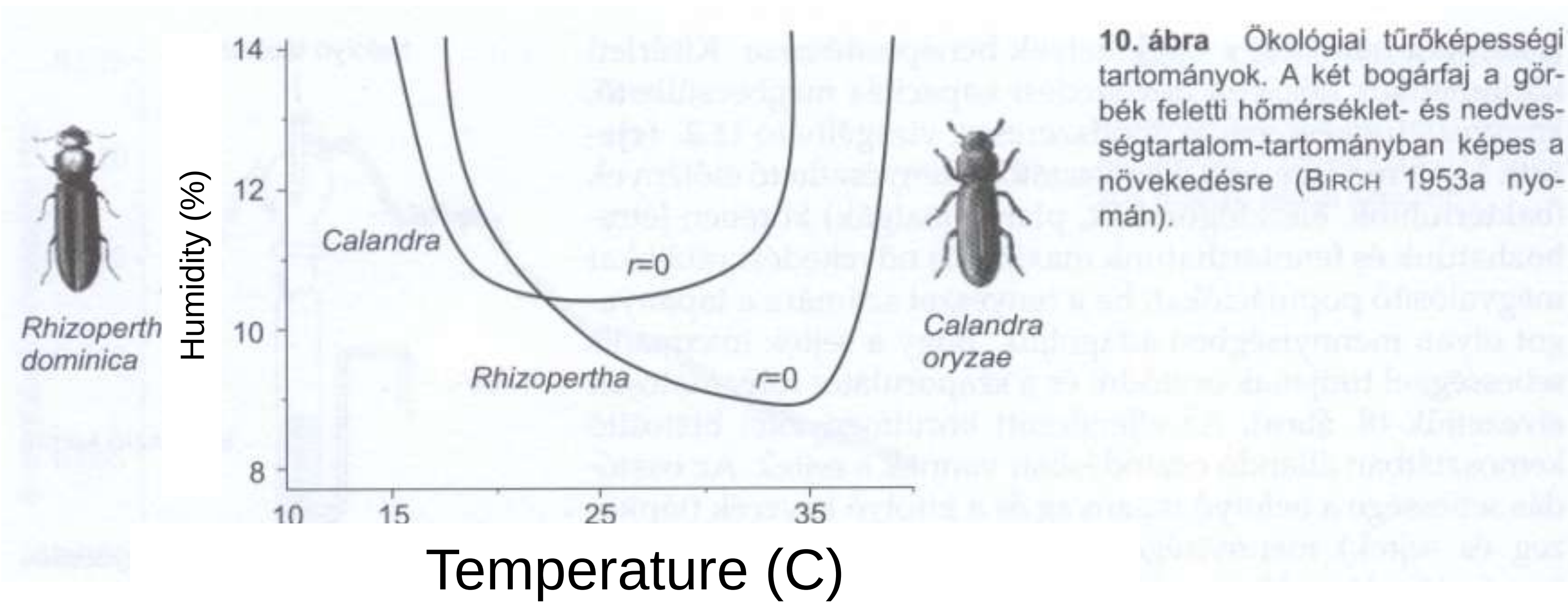
Population growth

Ecological tolerance interval, where the $r_0>0$, $R_0>1$ ==> population able to growth

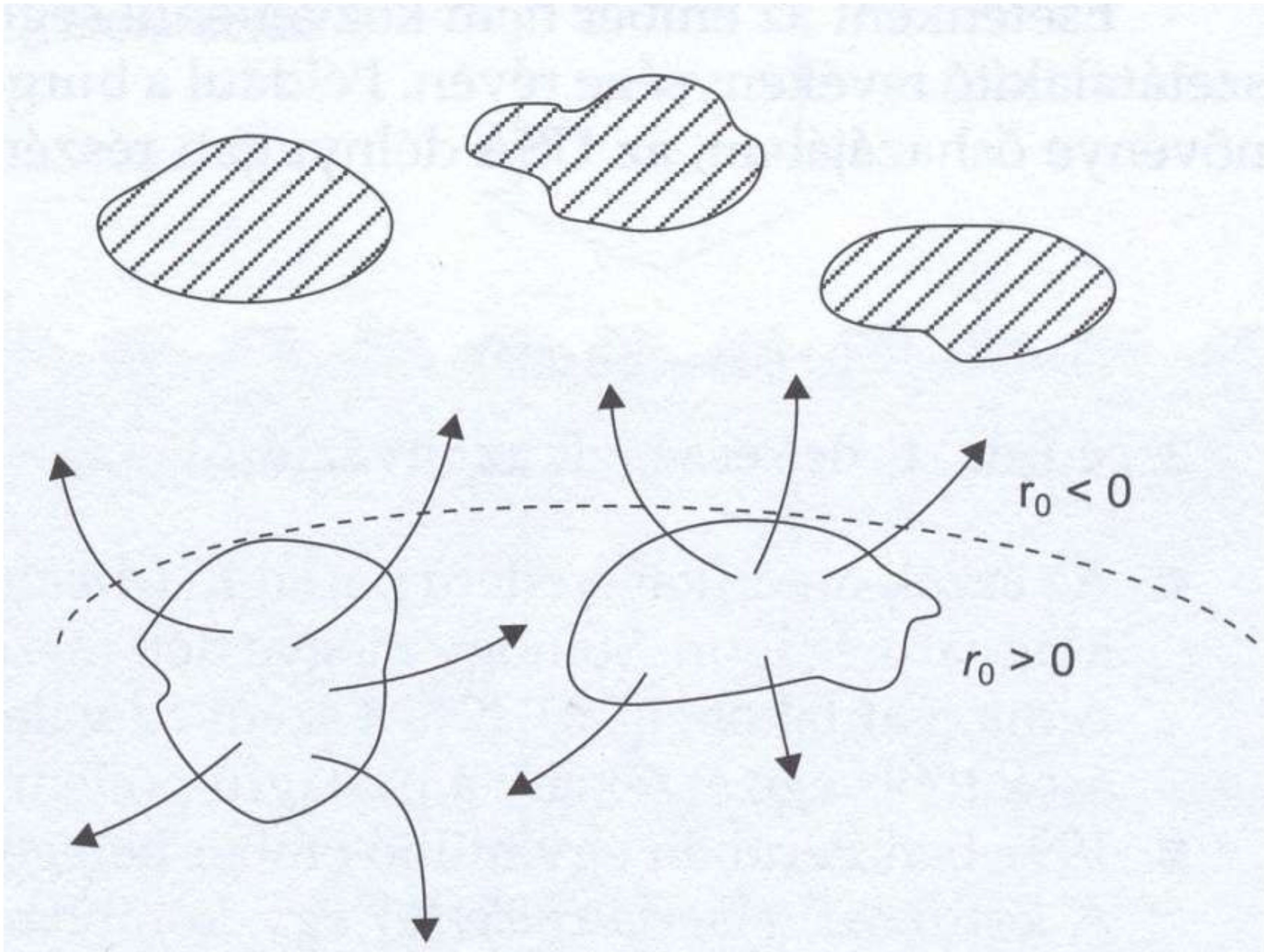


Population growth

Ecological tolerance interval, where the $r_0>0$, $R_0>1$ ==> population able to growth



Population growth and dispersal

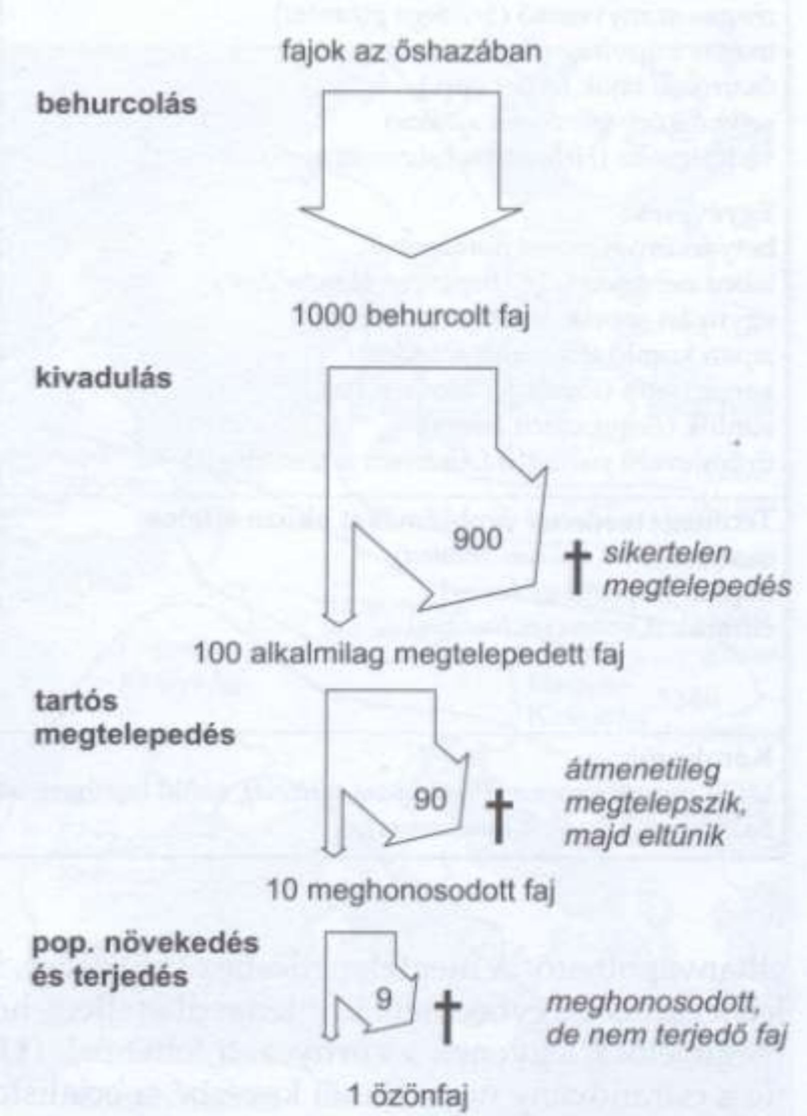


Population which r>0 is source, population which r < 0 is sink

Exponential growth

Typical for species with high dispersal

- Invasive species
- Speed of the dispersal depend on maximum growth rate (r_0)

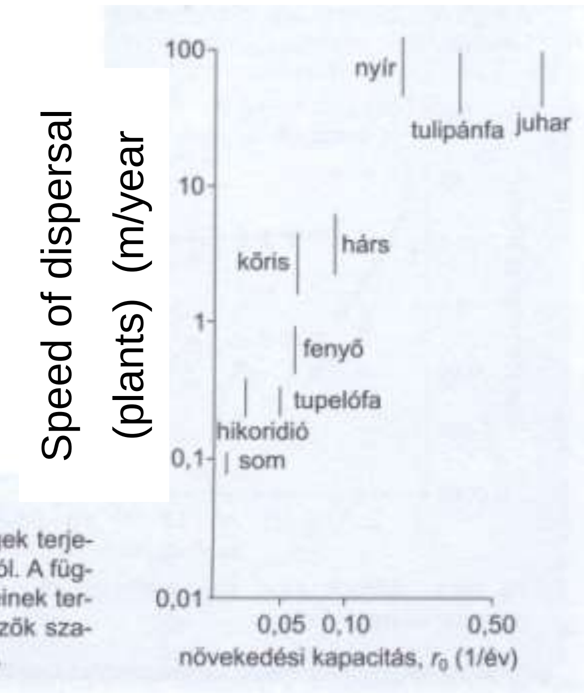


13. ábra Az özönfajjá válás 10-es szabálya (WILLIAMSON és FITTER 1996 nyomán).

„10% role"
An average 10% of an introduced alien species survive in the new area

↑ An average 10% of these species could live longer in the new area

↑ An average 10% of these species could reproduce extremly-> invasive species



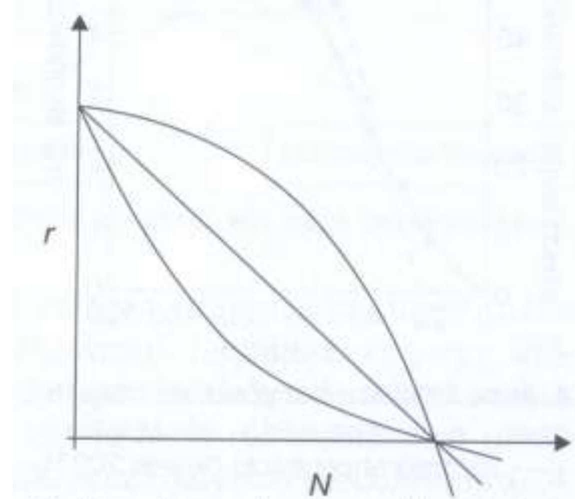
17. ábra Az Appalache-hegység déli részén honos fa nemzetségek terjedési sebességének függése a populációk növekedési kapacitásától. A függőleges vonalak a nemzetségbe tartozó fajok terjedési sebességeinek terjedelmét jelzik. Az adatok a szétszóródás és az életmenet jellemzők szabadföldi vizsgálatából származó becslések (CLARK és mtsai 2001).

Density dependent population growth

Population growth could regulated by environmental factors which influence depend on the population size

- E.g.
  - food
  - site
  - predators
  - parasites

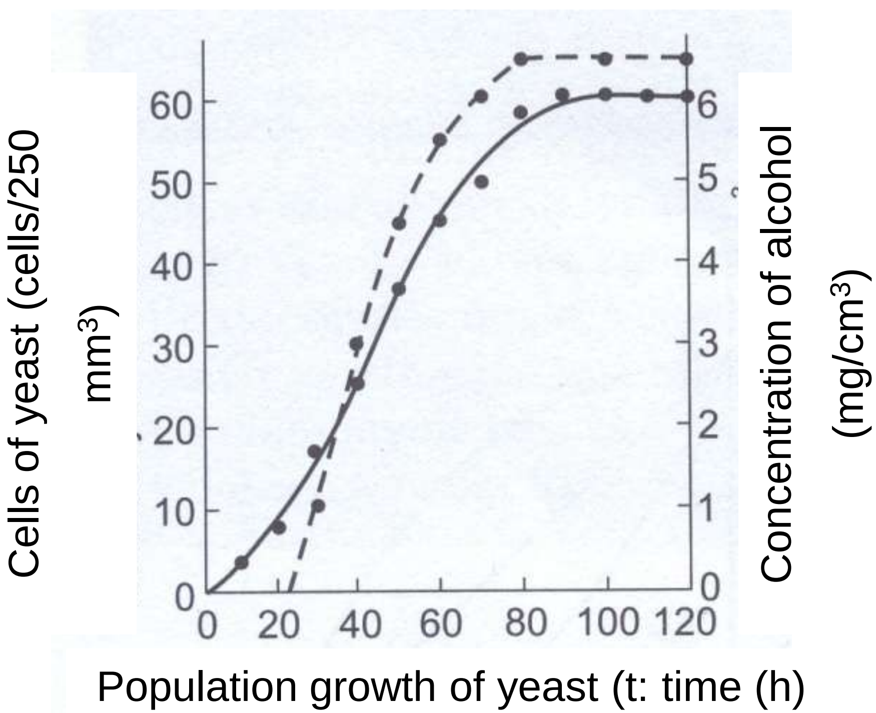
Regulation of the population growth is needed for long existence of the populations

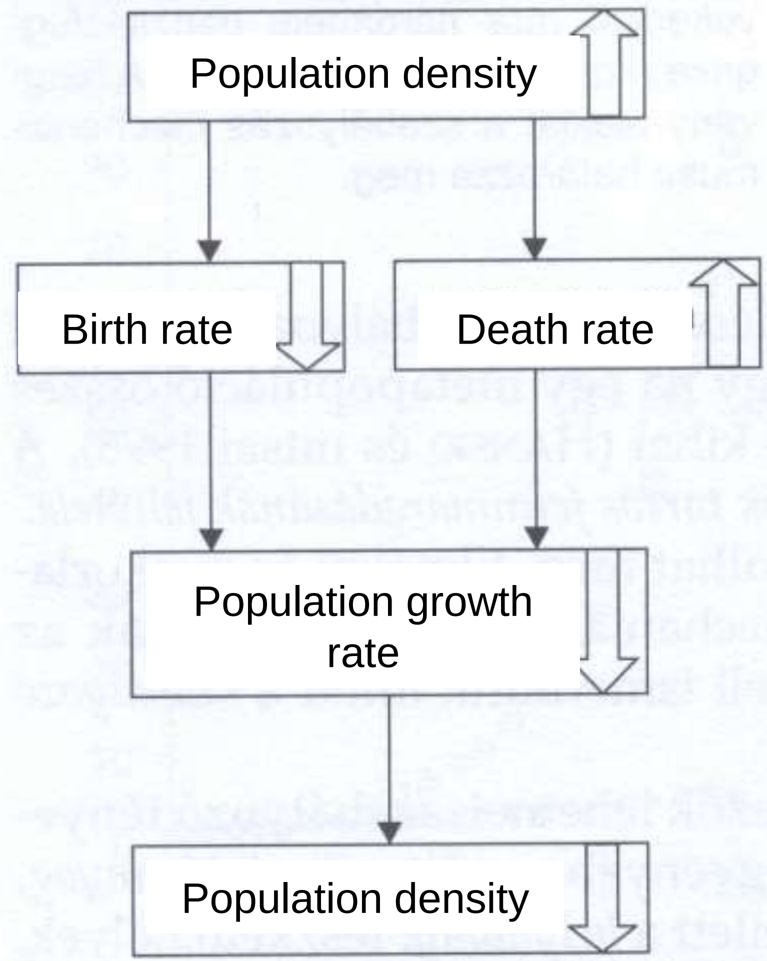


2. ábra A egyedenkénti, pillanatnyi növekedési ráta háromféle denzitásfüggése (konkáv, lineáris, konvex). A függvény alakját a szabályozás mechanizmusa határozza meg.

Density dependent population growth

- Density dependent growth



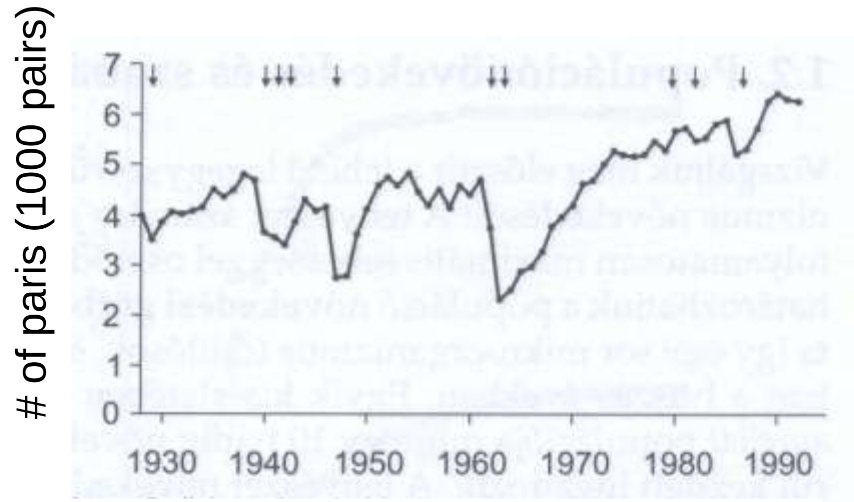


Population growth

Ecological limiting factors:

- Corrective factors (Only modify the population size)

- Regulatory factors (population density influence the growth rate)



In the case of grey heron the cold winters (arrows) increase the death and decrease the population size but we can regard as corrective factors

Logistic model

$$\frac{dN}{dt} = r_0 * N * \frac{K-N}{K}$$

where K: Carrying capacity

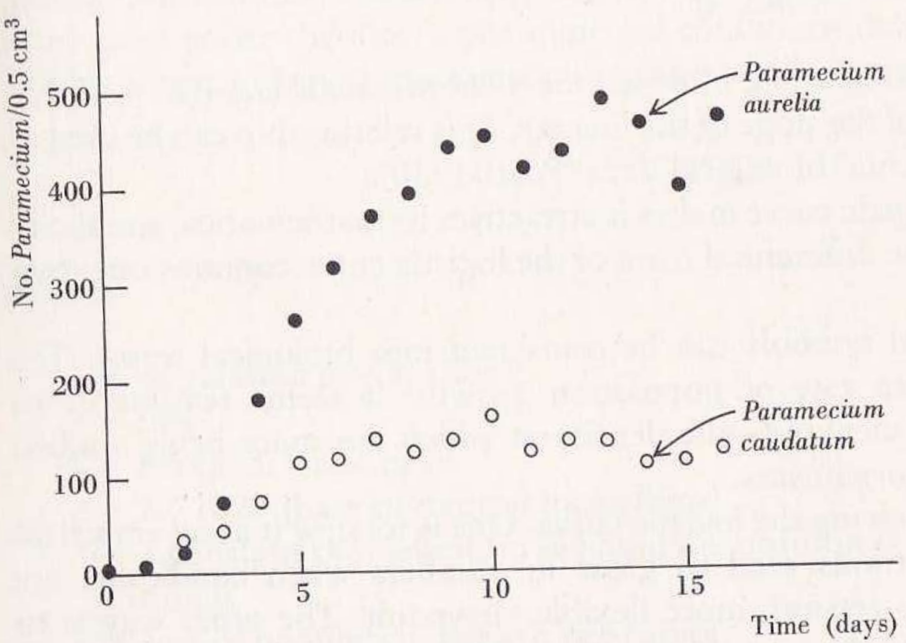
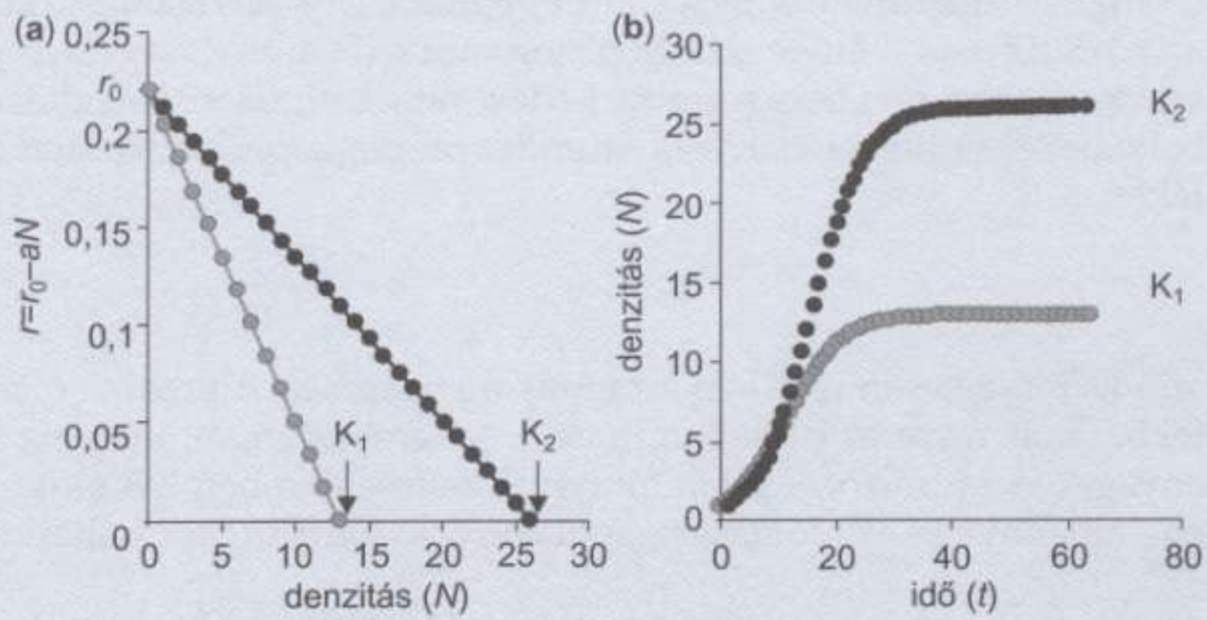


Figure 12.5 Population growth in the protozoans *Paramecium aurelia* and *P. caudatum* at 26°C in buffered Osterhout's medium, pH 8.0, "one-loop" concentration of bacterial food. (Data from Gause 1934.)

Logistic model

$$\frac{dN}{dt} = r_0 * N * \frac{K-N}{K} \qquad K = r_0 / a$$

Carrying capacity (K) is lower when density dependence of the growth rate is higher



12. ábra A növekedési ráta különböző mértékű denzitásfüggése (**a**), valamint az (**a**) ábrához tartozó növekedési görbék (**b**).

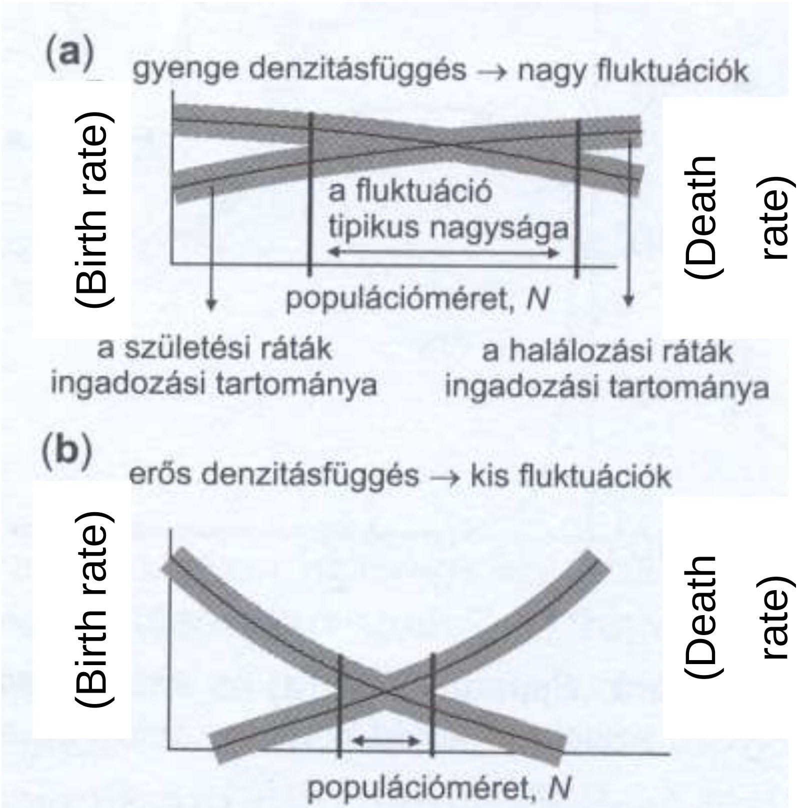
Logistic model

Fluctuation of the population size at K level is depend on the strenght of the density dependence

a- high fluctuation

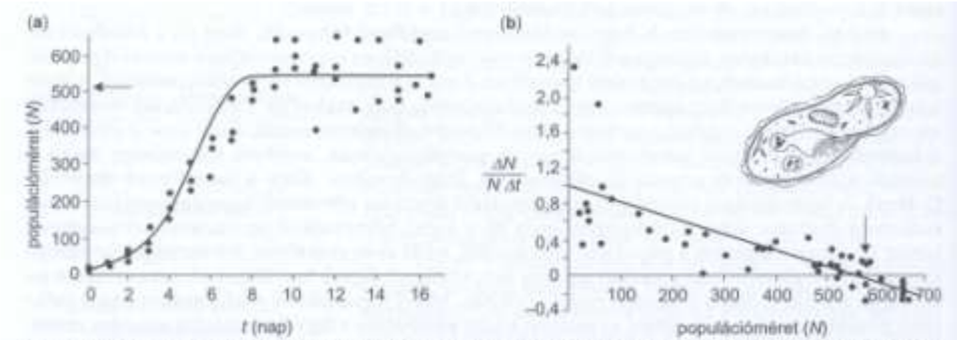
b- small fluctuation

$$\frac{dN}{dt} = r_0 * N * \frac{K-N}{K}$$



10. ábra Denzitásfüggő születési és halálozási ráták logisztikus növekedés esetén. (**a**) Gyenge denzitásfüggés, (**b**) erős denzitásfüggés (Case 2000 nyomán).

Logistic model



8. ábra A papucsállatka (*Paramecium aurelia*) populáció logisztikus növekedési görbéje. (**a**) A sejtszám időbeli változása. (**b**) A sejtenkénti növekedési ráta lineárisan csökken az egyedszámmal. Mindkét ábrán látható, hogy az egyensúlyi denzitás 552 körül van (Gause 1934 nyomán, Case 2000).

Implicit model: it is not contains the regulatory factors

$$\frac{dN}{dt} = r_0 * N * \frac{K-N}{K}$$

Monod model

Explicit model: contain the dynamics of regulatory factors

$$r(b) = r_0 * \frac{c}{c+k}$$

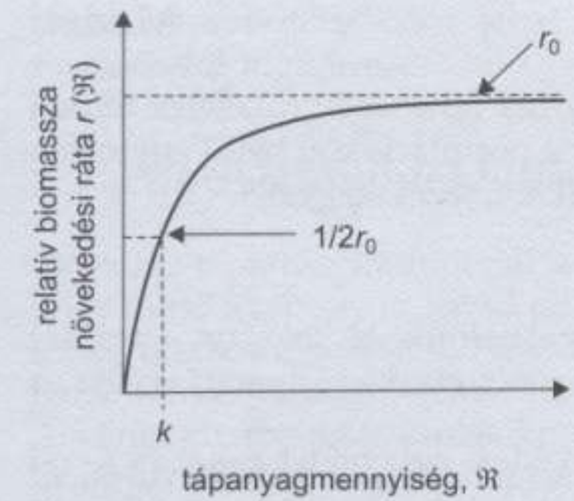
Ahol

r(b):relative growth of biomass

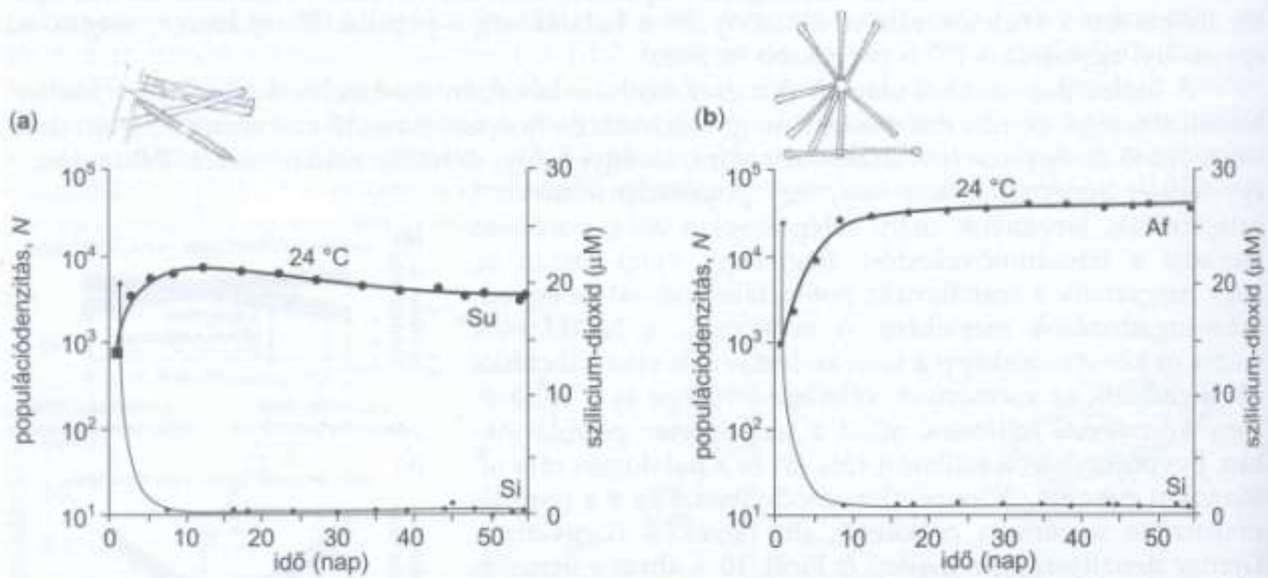
r_0: a maximum growth rate

c: concentration of limiting source ($\mathscr{R}$)

k: half-saturation constans,

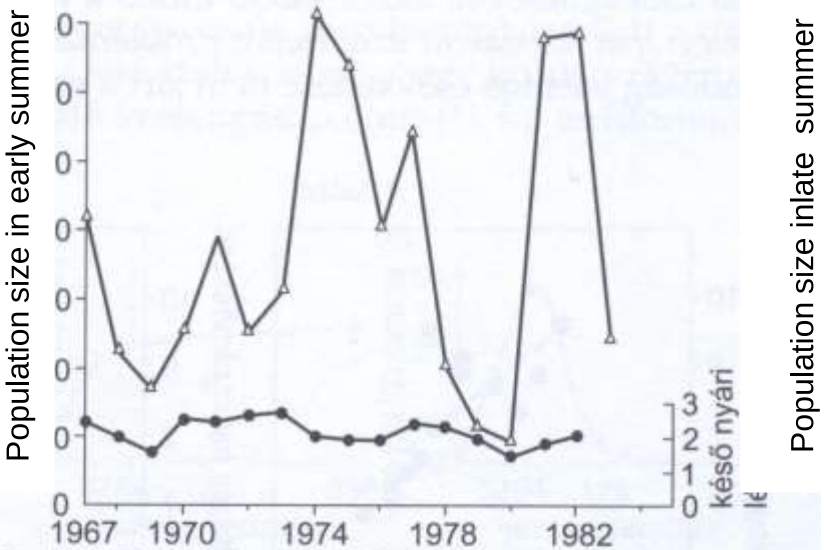


13. ábra A Monod-függvény.



11. ábra *Synedra ulna* (**a**) és *Asterionella formosa* (**b**) kovamoszatok tiszta tenyészeteinek növekedése és a szabályozó szilícium-dioxid-koncentráció változása az időben, 24 °C-on (Tilman 1981 nyomán).

Regulation of population growth



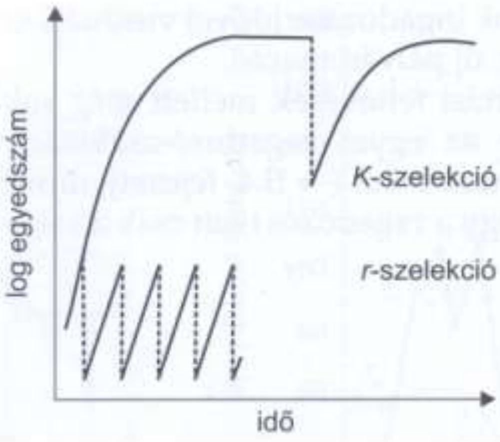
25. ábra Sebes pisztráng (*Salmo trutta*) populáció kora nyári (△) és késő nyári (●) létszáma (ELLIOTT 1984, BEGON és mtsai 1986 nyomán).

Regulatory factors

- Which season they act
- Which stadium/age groups are sensitive to the density change
- Which stadium/age groups are critical to the density change

In the case of salmon the late summer death rate is density dependent

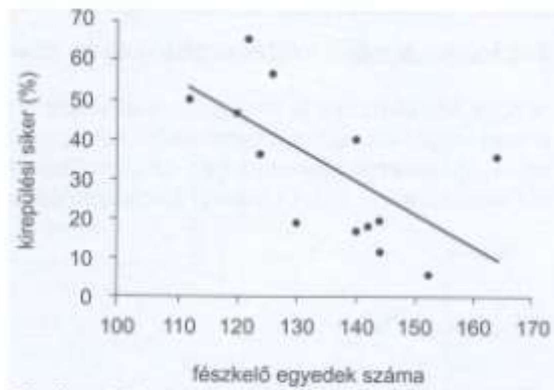
Regulation of population growth



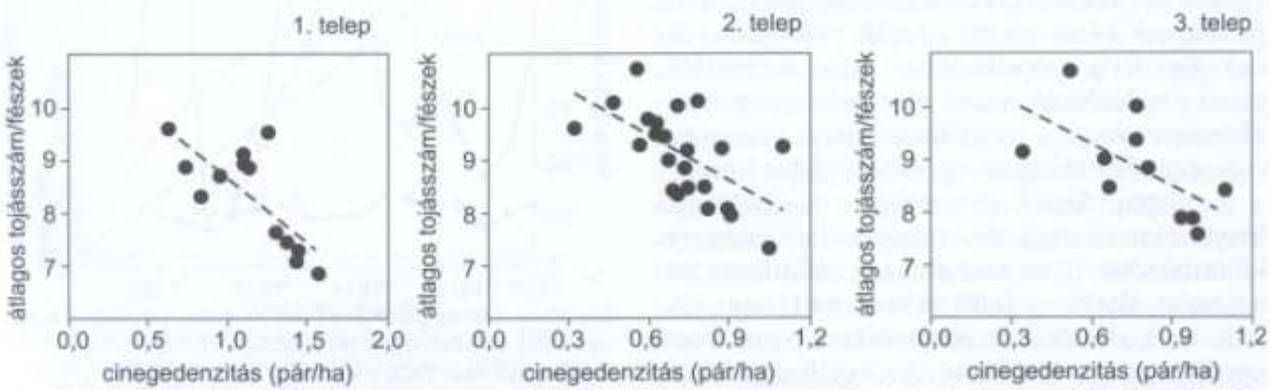
26. ábra Tenyésztési sémák. A szaggatott vonalak a tenyészet kis denzitásra csökkentését jelölik. Az *r*-szelekciós séma átlagosan alacsony denzitáson, a *K-szelekciós* séma átlagosan magas denzitáson tartja a tenyészetet. (Az *y* tengely a denzitás logaritmusát mutatja!)

Regulation:

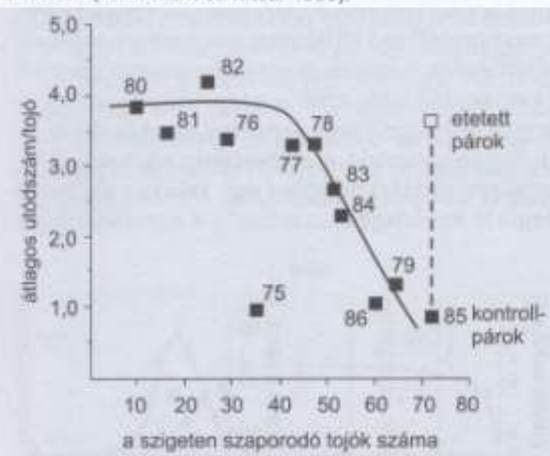
- Outside the breeding season (r-selection)
- During the breeding season (K- selection)



28. ábra A fészkelés sikeressége (tojások hányad részéből származik kirepülő fióka egy-egy fészekben) különböző méretű bütykös ásólud (*Tadorna tadorna*) populációkban (PATTERSON és mtsai 1983).



27. ábra Széncinege (*Parus major*) párok átlagos tojásszámának függése a fészkelő párok denzitásától (pár/hektár), 3 különböző odutelepen. Egy-egy pont egy-egy év adata (BOTH 2000 nyomán).



31. ábra Egy táplálékhozzáadási kísérlet egy kanadai énekes verébsármány (*Melospiza melodia*) populációban 1985-ben. A számok a pontok mellett az adatfelvétel évét jelölik (ARCESE és SMITH 1988, BEGON és mtsai 1986 nyomán).

Population growth regulation and demography

Critical stadiums/age groups: their density influence the birth/death in the population

Sensitive stadiums/age groups: these groups sensitive to the density

e.g.. Flue in the population of Papua-New Guinena

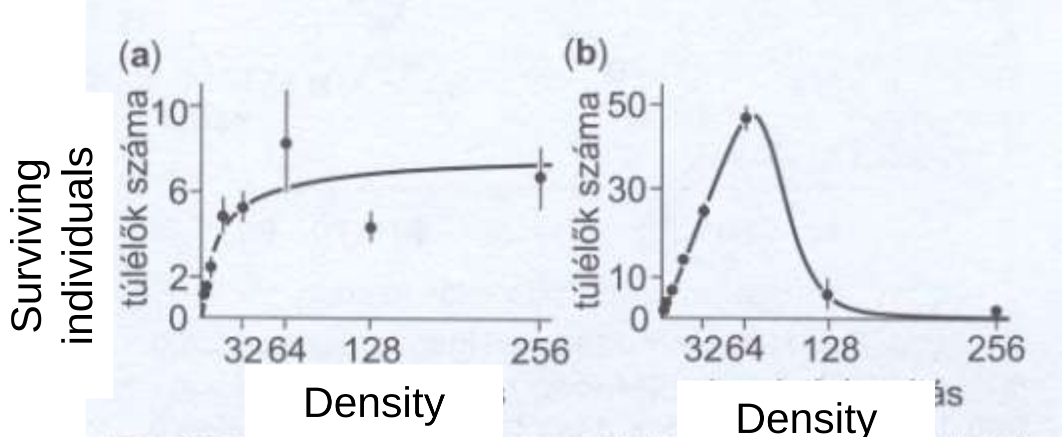
Sensitive: new born and eldery people, higher death rate because of the flue

Critical: teenager and young adults, the most responsible groups of dispersal of the flue

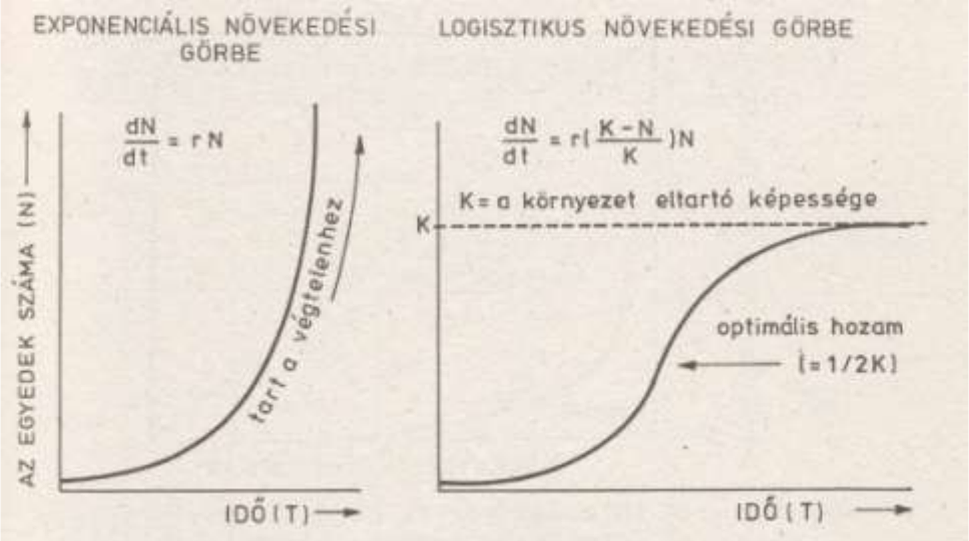
When competition among individual vary with population density, growth will depend on density:

- Contest competition (a)

- Scramble competition (b)



29. ábra Pontosan kompenzált (**a**) és túlkompenzált (**b**) denzitásfüggés bogaraknál. A pontok az átlagot, a bajuszok a szórást jelölik. (**a**) *Stegobium paneceum*, (**b**) *Lasioderma serricorne* (BELLOWS 1981).



149. ábra: A populációnövekedés két alapvető formája: exponenciális növekedés (bal oldali görbe) és logisztikus növekedés (jobb oldali görbe) (Wilson-Bossert nyomán)

High r value

- Living in extreme habitats
- Dominantly limited by abiotic factors, living transient habitats

Importance of fast finding of habitats

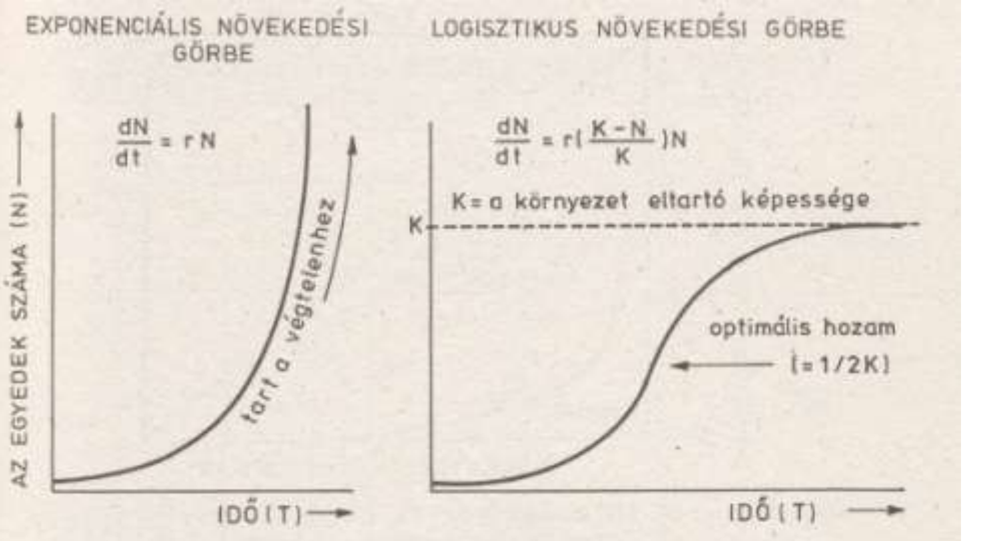
Importance of fast invasion of habitats

Surviving large changes (abiotic)

R-K strategists, R-K continuom

Characteristics of r- and K-selected organisms

r-organisms	K-organisms
Exponential growth	Logistic growth
Type III surivorship curve	Type I surivorship curve
short-lived	long-lived
small	large
weak	strong or well-protected
waste a lot of energy	energy efficient
less intelligent	more intelligent
have large litters	have small litters
reproduce at an early age	reproduce at a late age
fast maturation	slow maturation
little care for offspring	much care for offspring
strong sex drive	weak sex drive
small size at birth	large size at birth
High dispersal speed	Low dispersal speed



149. ábra: A populációnövekedés két alapvető formája: exponenciális növekedés (bal oldali görbe) és logisztikus növekedés (jobb oldali görbe) (Wilson-Bossert nyomán)

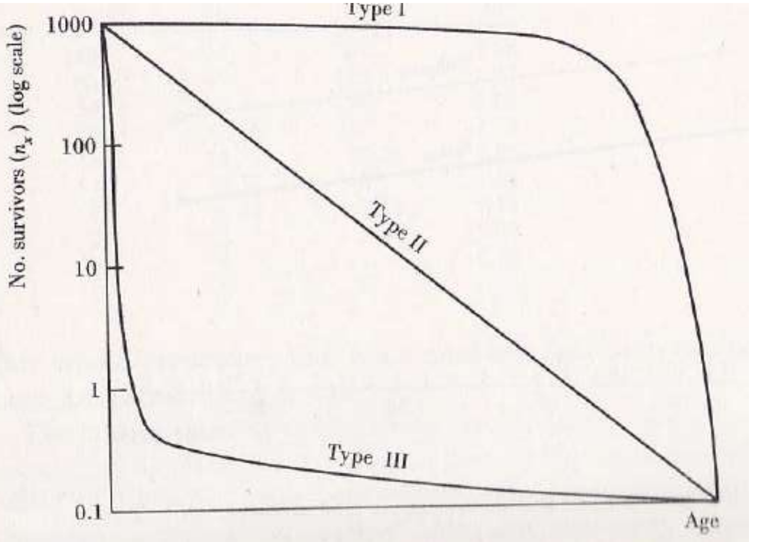
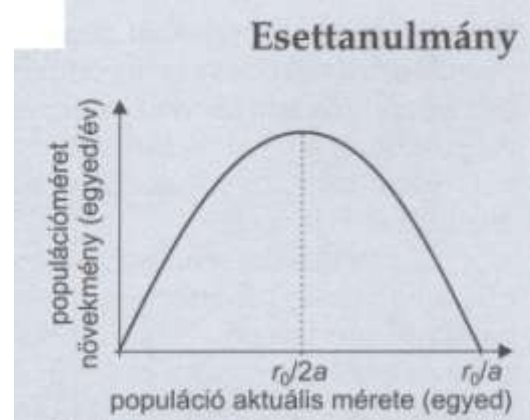


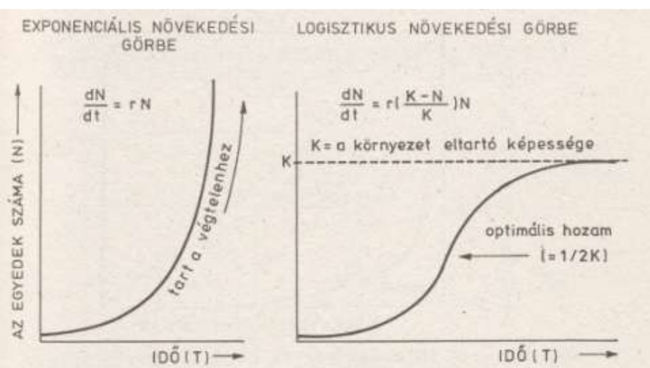
Figure 11.2 Hypothetical survivorship curves. (After Pearl 1928.)

Optimal „harvesting/fishing”

- For sustainable harvesting/fishing the population size need to keep at the K/2 level when the population able to produce the highest population growth
- For it need to know correctly the N, r_0 and K values – Unfortunately, there are several bad examples (God fishing) by human habit

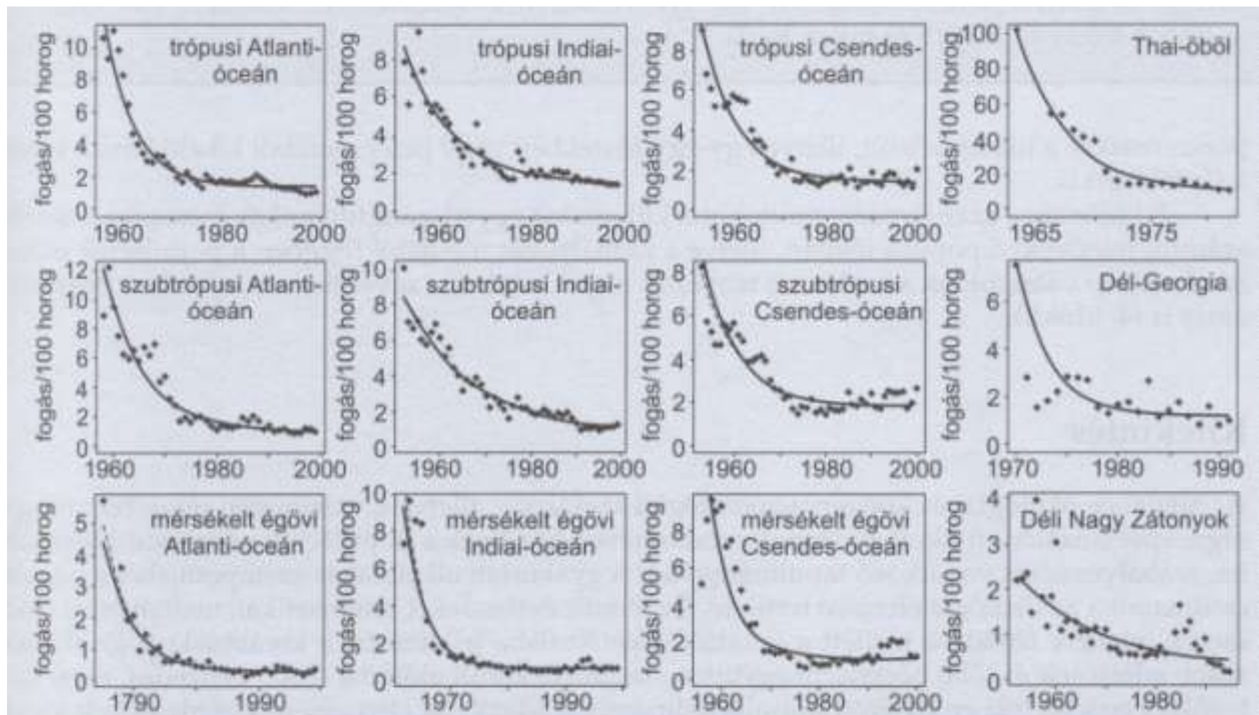


32. ábra A populáció méretének növekedése (lehalászható növekmény) a populáció aktuális méretének függvényében.



149. ábra: A populációnövekedés két alapvető formája: exponenciális növekedés (bal oldali görbe) és logisztikus növekedés (jobb oldali görbe) (Wilson–Bossert nyomán)

Optimal growth:
- ½ K
- $r_0/2a$



33. ábra Az ábrákon az Észak-atlanti tőkehal (*Gadus morhua*) populációkban egységesen bekövetkezett gyors fogáscsökkenés követhető nyomon az 50-es évektől napjainkig, különböző óceáni régiókban (OLSEN és mtsai *megjelenés alatt*).

Evolution and Ecology

Darwin and Wallace (1958) Natural Selection – operates through the following steps:

1. Variation occurs in every group of plants and animals, Individuals are not identical in any population
2. Every population of organisms produce an excess of offspring
3. Competition will occur among these offspring for the resources they need to live
4. The most fit offspring will survive. Among all the offspring competing for limited resources, only those individuals best able to obtain and use these resources will survive
5. If the characteristics of the most fit organisms are inherited, these favoured traits will be passed on the next generation

The environments that organisms inhabit shape the evolution that occurs.

Traits favoured by natural selection are the products of one or more individual genes – alleles of a locus change in frequency over time

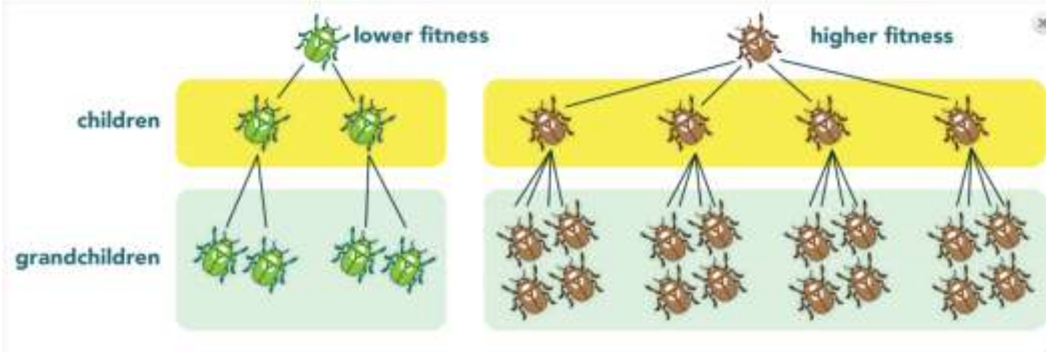
Evolution through natural selection results in **adaptation** and under appropriate conditions produce new species (**speciation**)

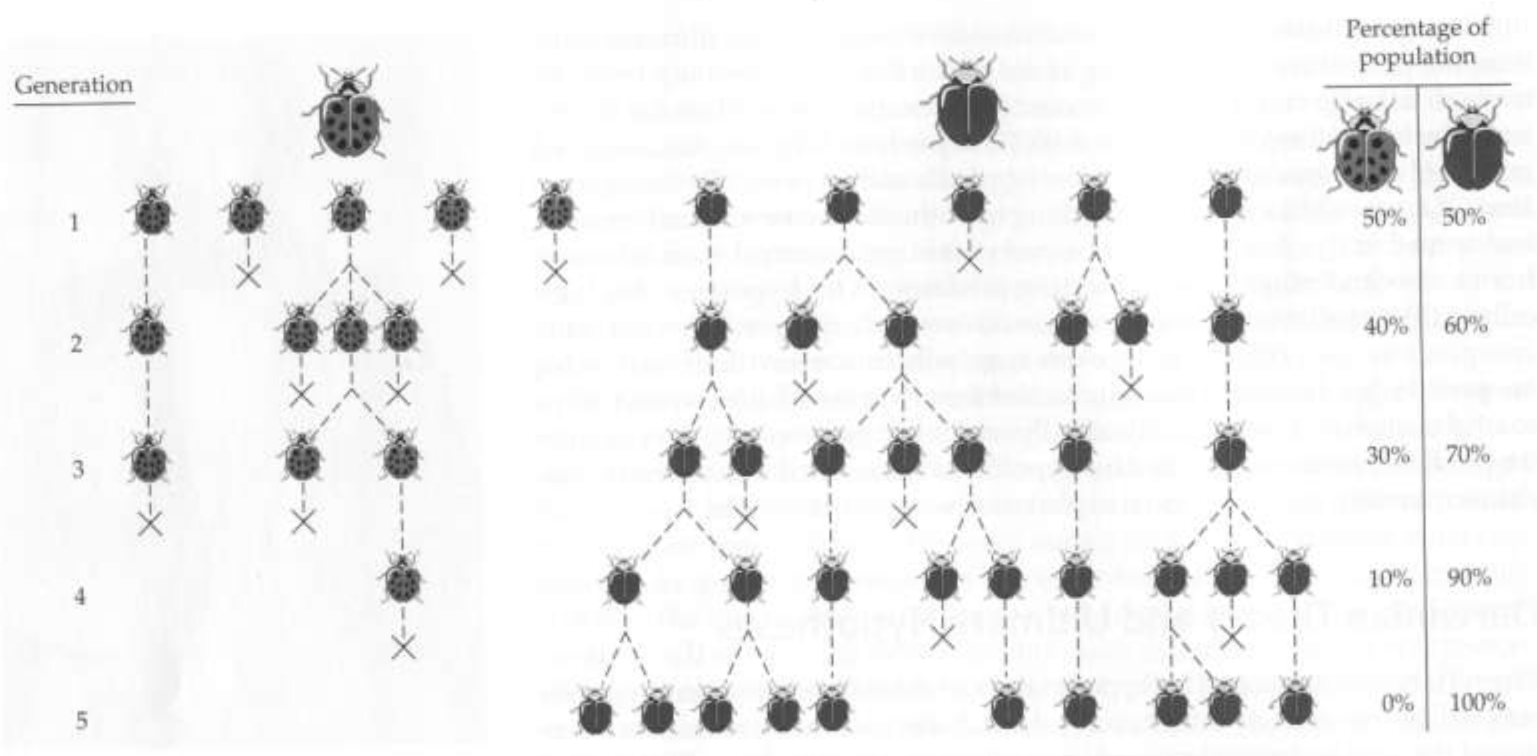
Evolution and Ecology

Darwinian fitness: Survival of the form (phenotypic or genotypic) that will leave the most copies of itself in successive generations

Two basic components:

- survival
- Reproductive success





Evolution and Ecology

Adaptation

Natural selection acts on phenotypes

Changes in gene frequencies occur only when there is a correlation between genotype and phenotype

Three types of selection operate on phenotypic characters

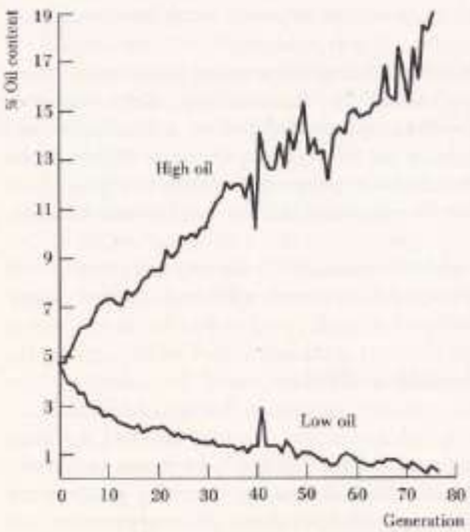


Figure 2.2 Directional selection in corn (maize), *Zea mays*, for high and low oil content over 76 generations. (After Dudley 1977.)

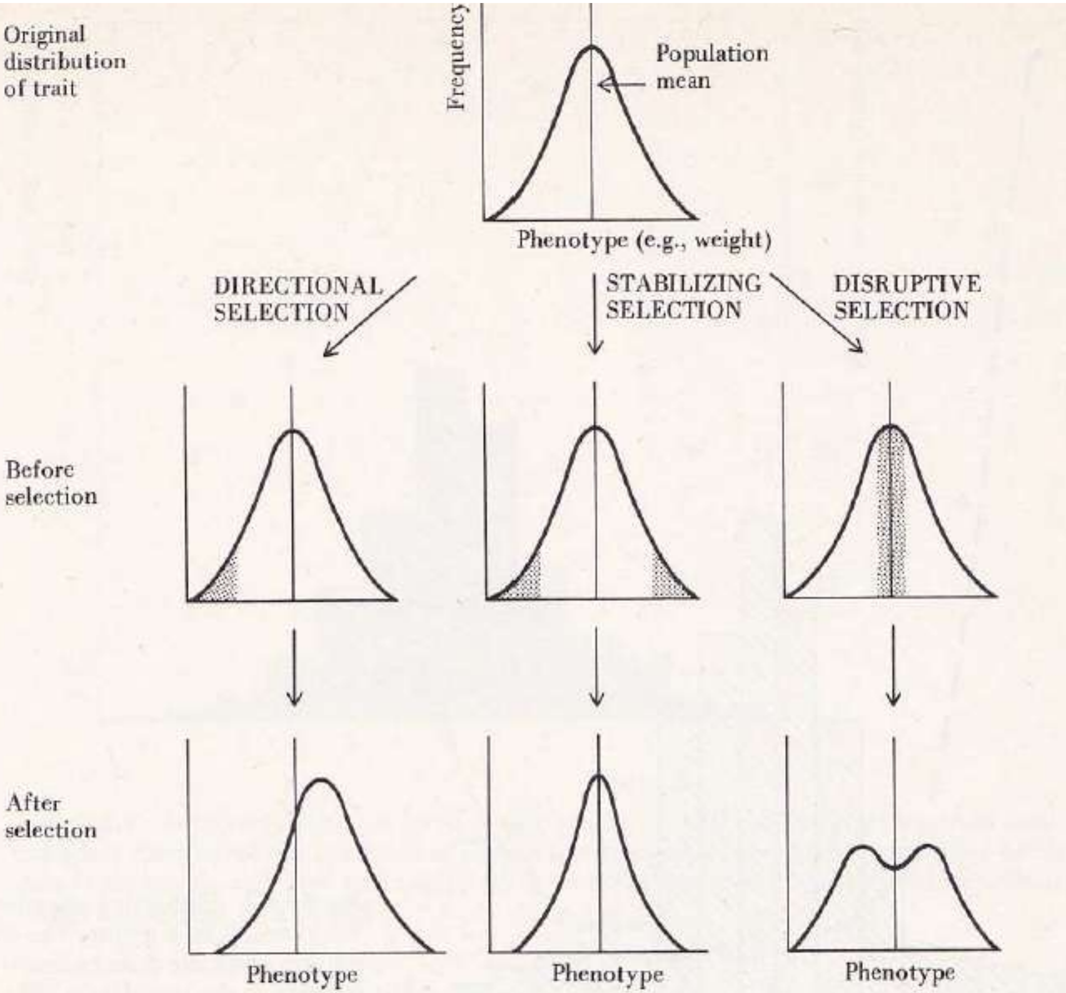


Figure 2.1 Three types of selection on phenotypic characters. Individuals in the shaded areas are selected against.

Evolution and Ecology

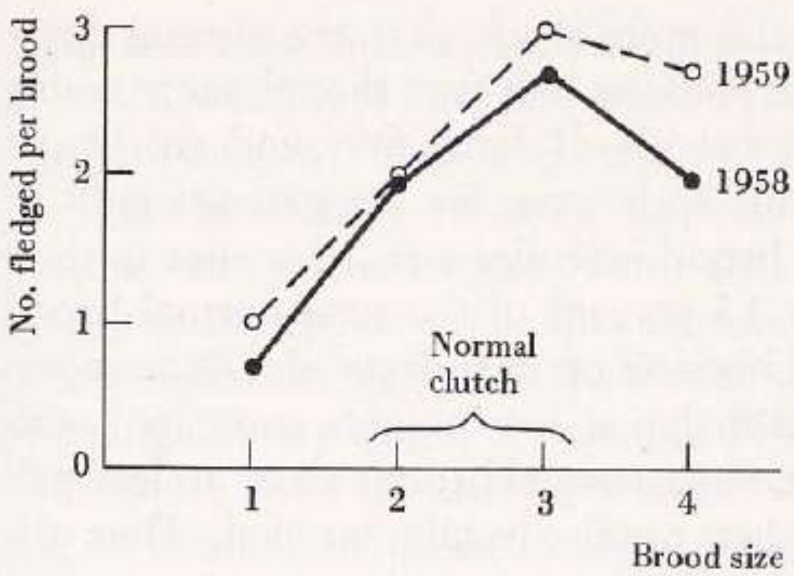


Figure 2.5 Production of young swifts (*Apus apus*) in relation to clutch size in England. The normal clutch is two to three; broods were increased to four artificially. Larger broods do not produce more young, and natural selection is stabilizing. (After Perrins 1964.)

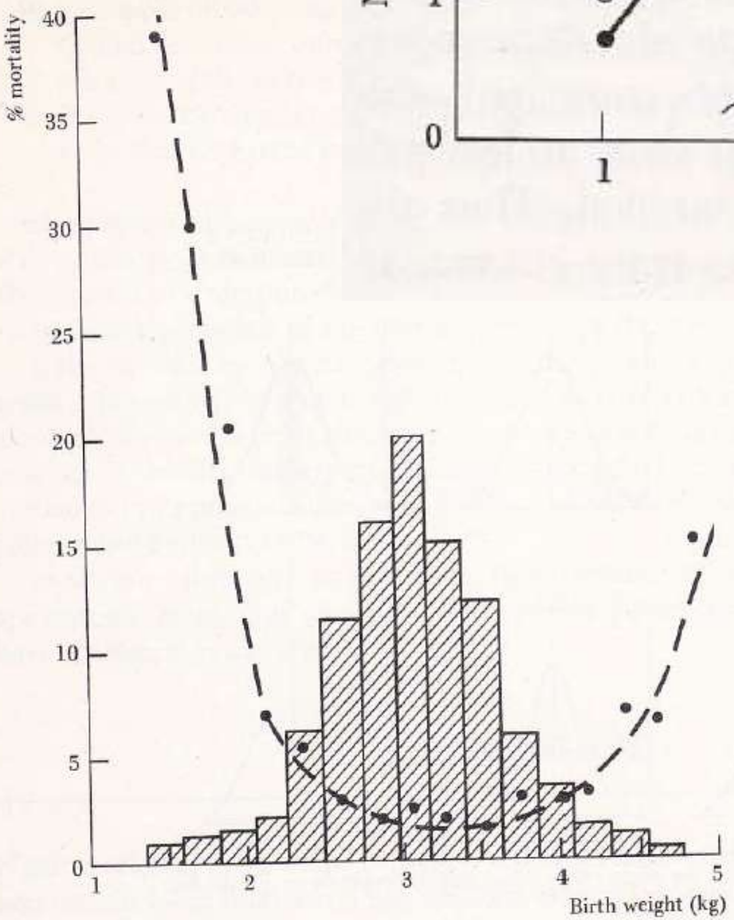
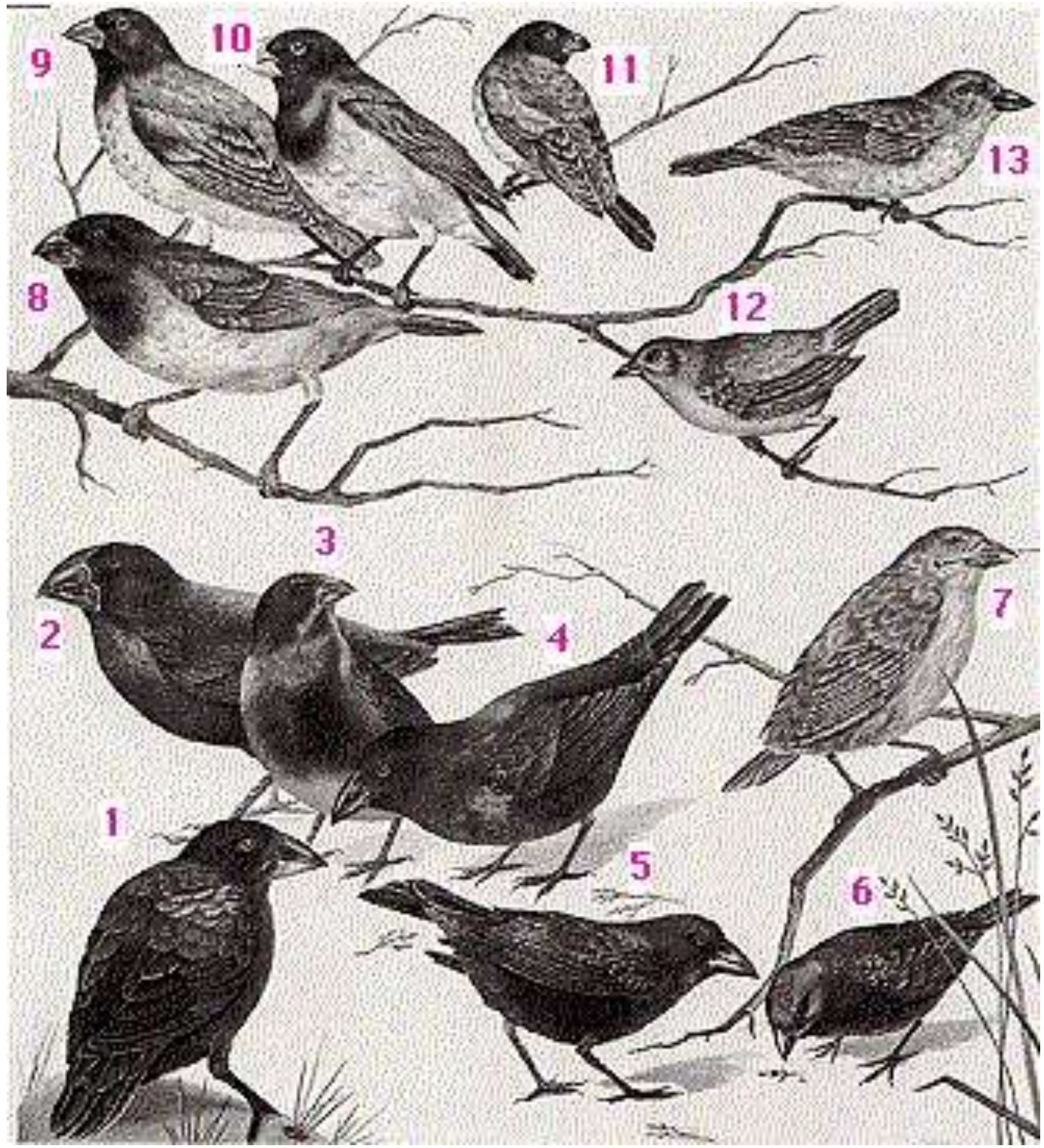


Figure 2.3 Stabilizing selection for birth weight in humans. The shaded histogram gives the distribution of birth weights in the population. The curve represents percent mortality at birth. (Data from Karn and Penrose 1951.)

Darwin finch, Galapagos islands
Adaptive radiation – disruptive selection

1. Large cactus finch (Geospiza conirostris)
2. Large ground finch (Geospiza magnirostris)
3. Medium ground finch (**Geospiza fortis**)
4. Cactus finch (Geospiza scandens)
5. Sharp-beaked ground finch (Geospiza difficilis)
6. Small ground finch (Geospiza fuliginosa)
7. Woodpecker finch (Cactospiza pallida)
8. Vegetarian tree finch (Platyspiza crassirostris)
9. Medium tree finch (**Camarhynchus pauper**)
10. Large tree finch (**Camarhynchus psittacula**)
11. Small tree finch (Camarhynchus parvulus)
12. Warbler finch (Certhidia olivacea)
13. Mangrove finch (Cactospiza heliobates)



film

Speciation

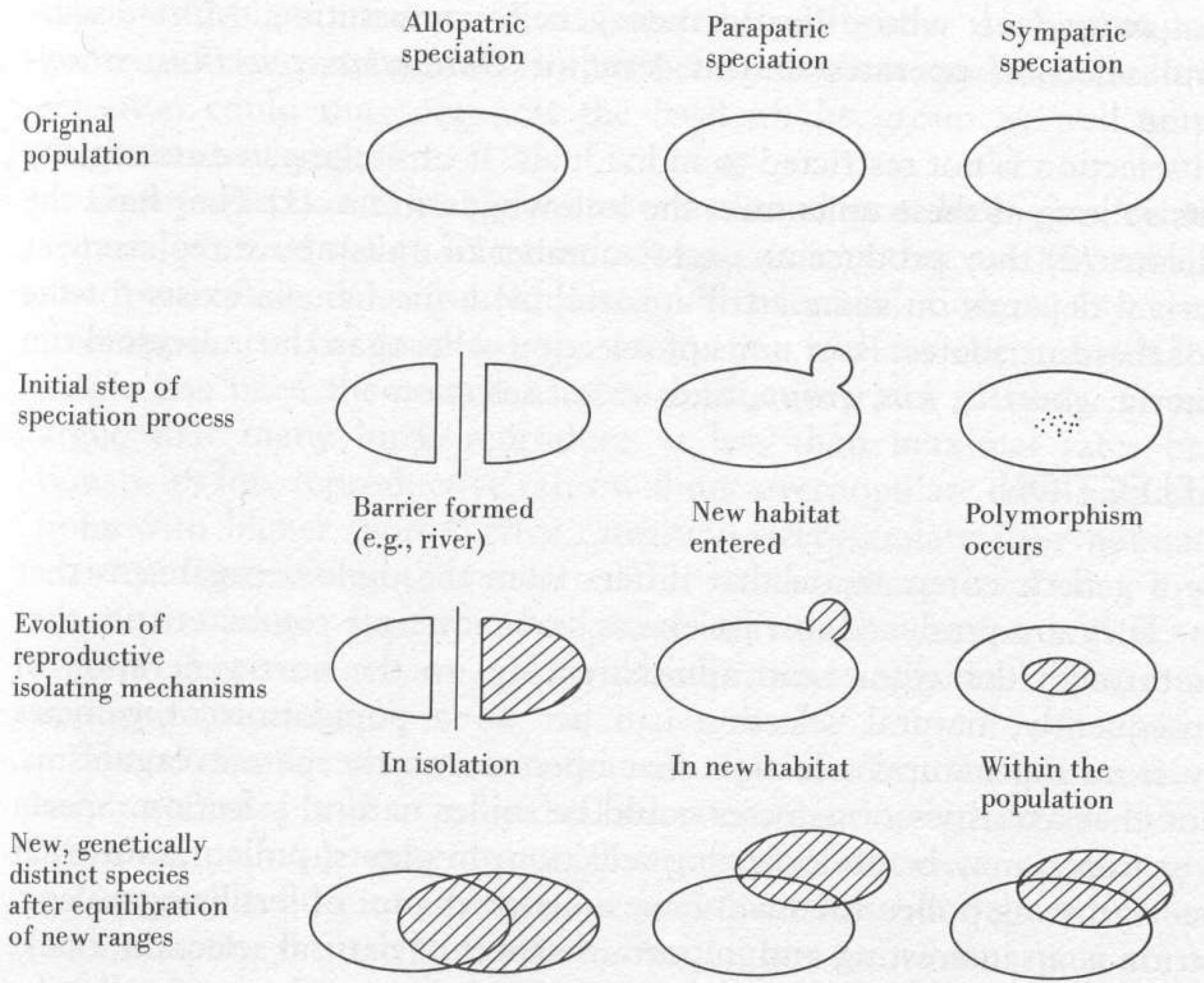


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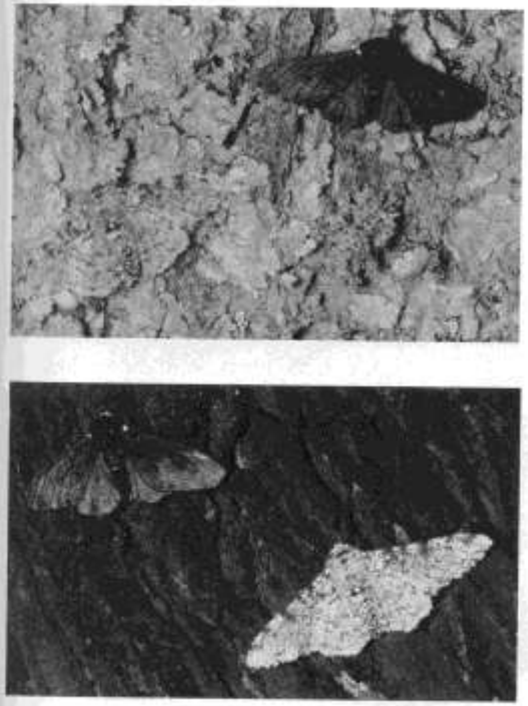
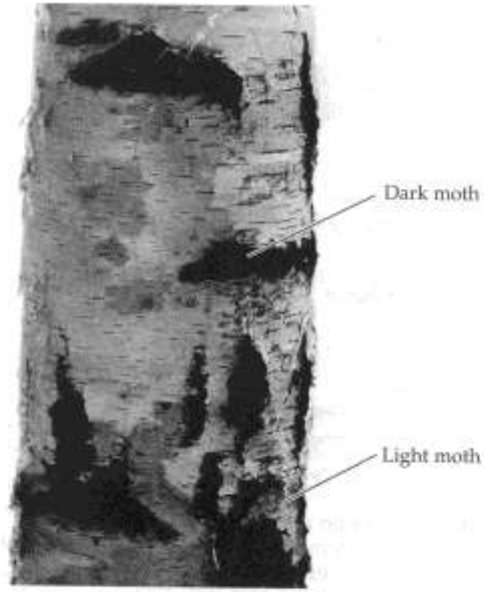
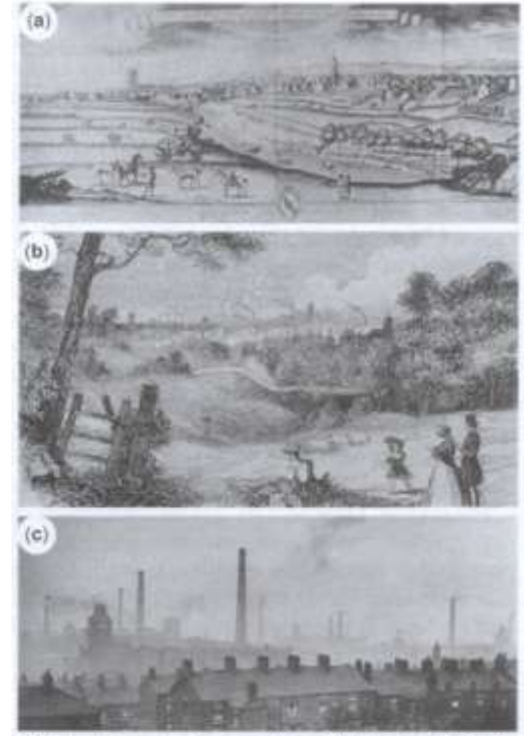
Figure 2.8 Three general hypotheses of speciation. Allopatric speciation is probably the most common type.





10 The salt and pepper moth *Biston betularia*. One typical (light coloration) individual and one melanic (black) individual are shown in each photograph. Photographs (left) by Michael Tweedie; (right) photograph by Bruce Grant.



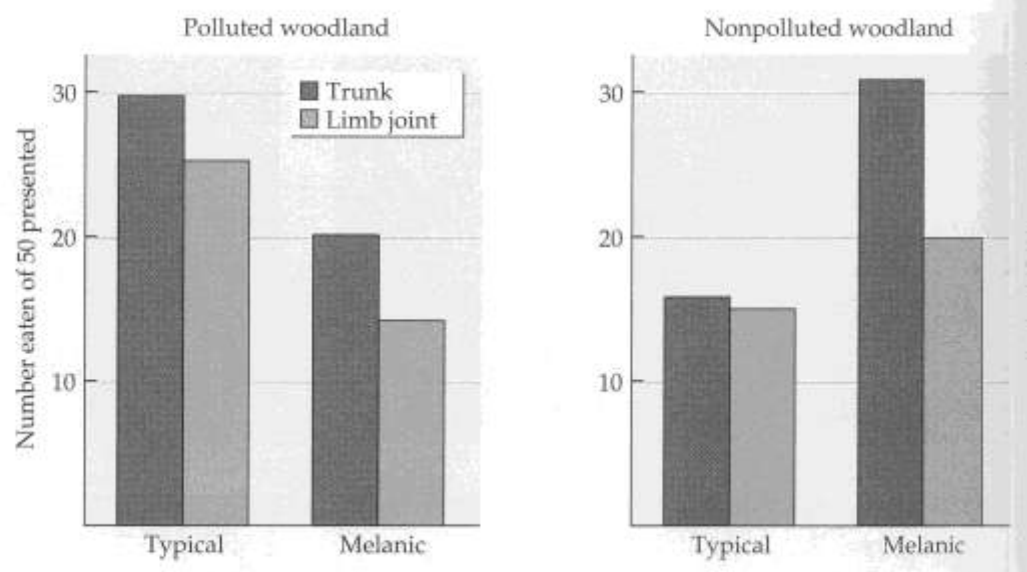
13. ábra Manchester környékének látképe (**a**) 1730, (**b**) 1860 és (**c**) 1954-ben. Az **a** és **b** képet ugyanazon a helyen állva készítették, míg a **c** ugyanannak a területnek a képe máshonnan fényképezve (Rupor 2006 nyomán).

Natural selection of peppered moth species during XIX-XX century in UK.

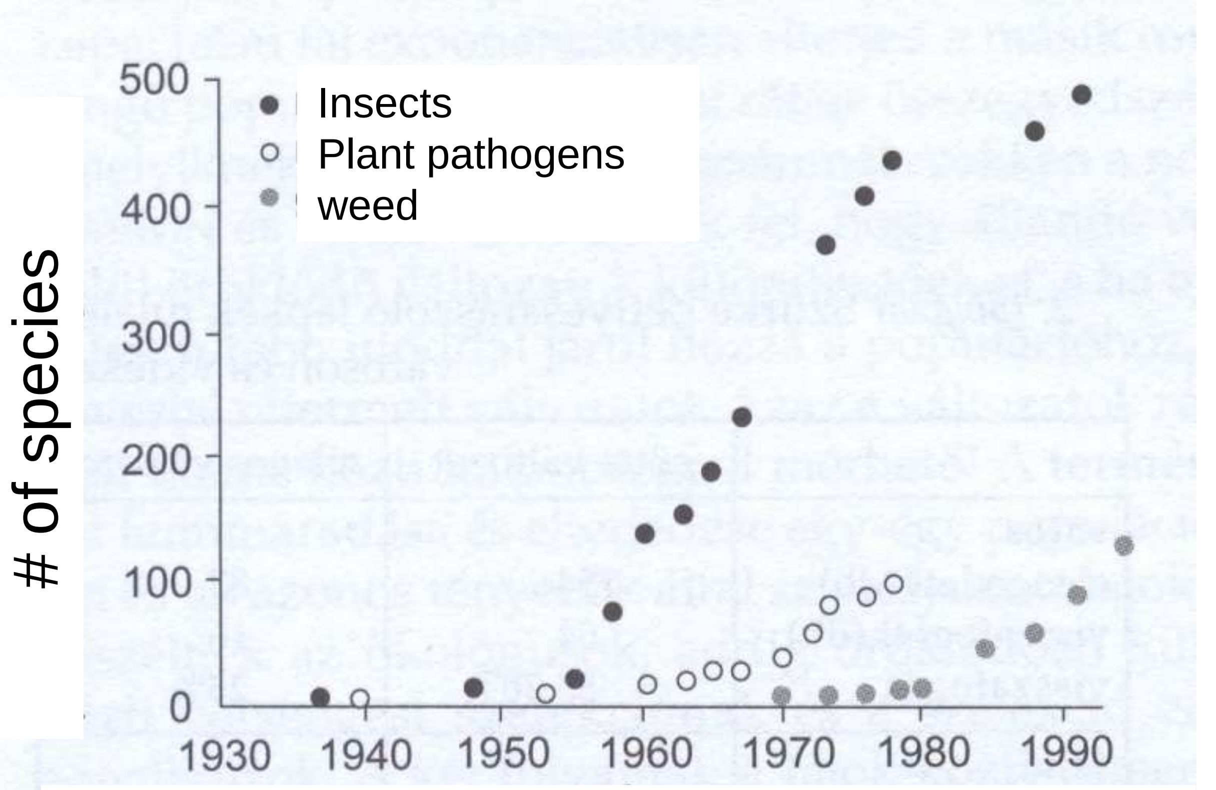
Ratio of dark types increased in polluted habitats against white types – industrial melanism

Evolutionary processes can be fast

In polluted woodland are more dark types comparing to not polluted woodland



Evolutionary processes can be fast



Number of pesticid resistence species during 1938-1992

Unit of selection

Species ?

Group ?

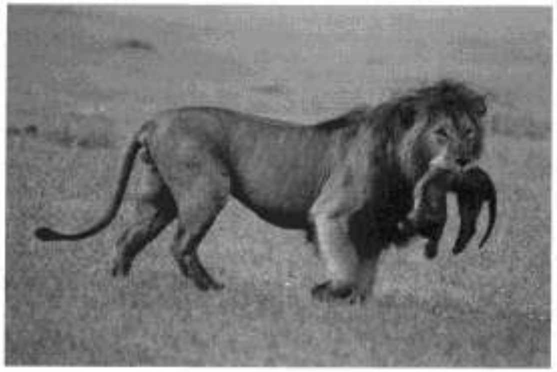
Individual?

Gene ?!

(„Selfish gene” DAWKINS 1976)

https://ia601602.us.archive.org/6/items/pdfy-RHEZa8riPwBuUyrV/The%20Selfish%20Gene.pdf

- Individual – gene machine of genes
- Individual not, but gene forming individual could be immortal
- Recent genes had higher fittness than not existing one
    - Higher fitness even against fitness of others (e.g. lions)
- Selfish Genes vs. Altruistic behaviour
    - Level of altruism is higher among individuals with high genetic similarity,



Lion behaviour

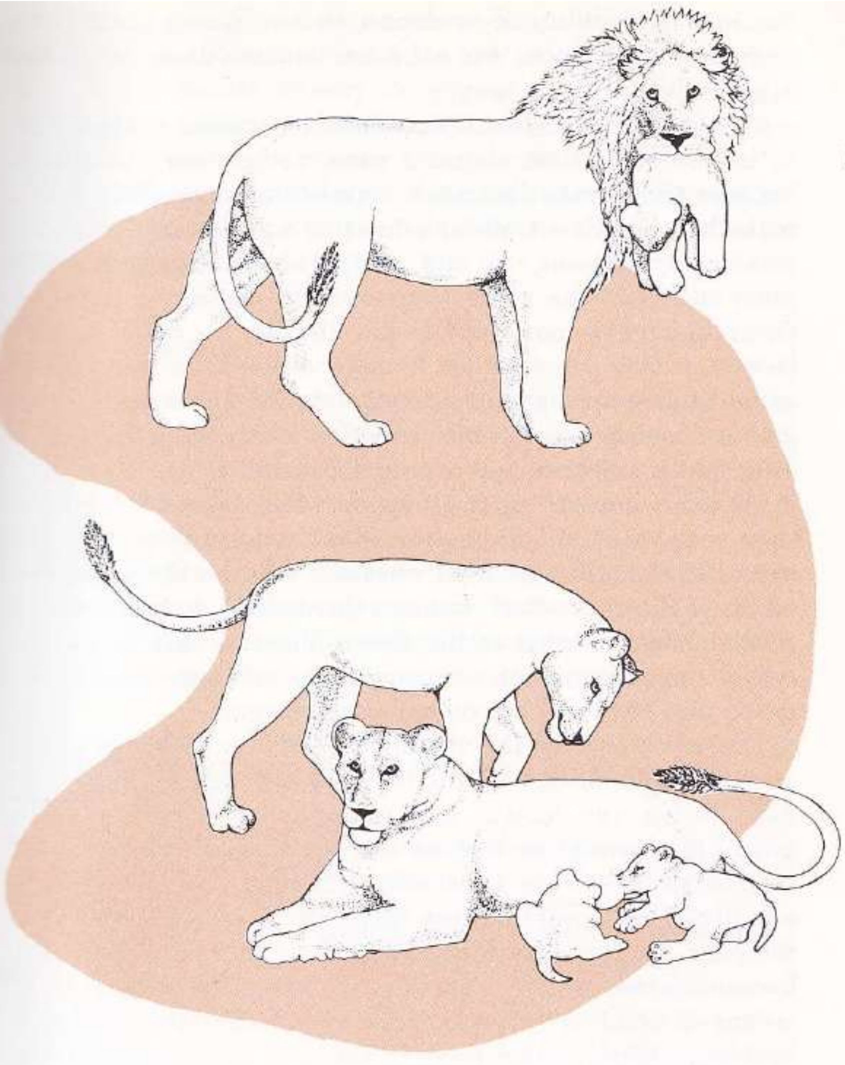
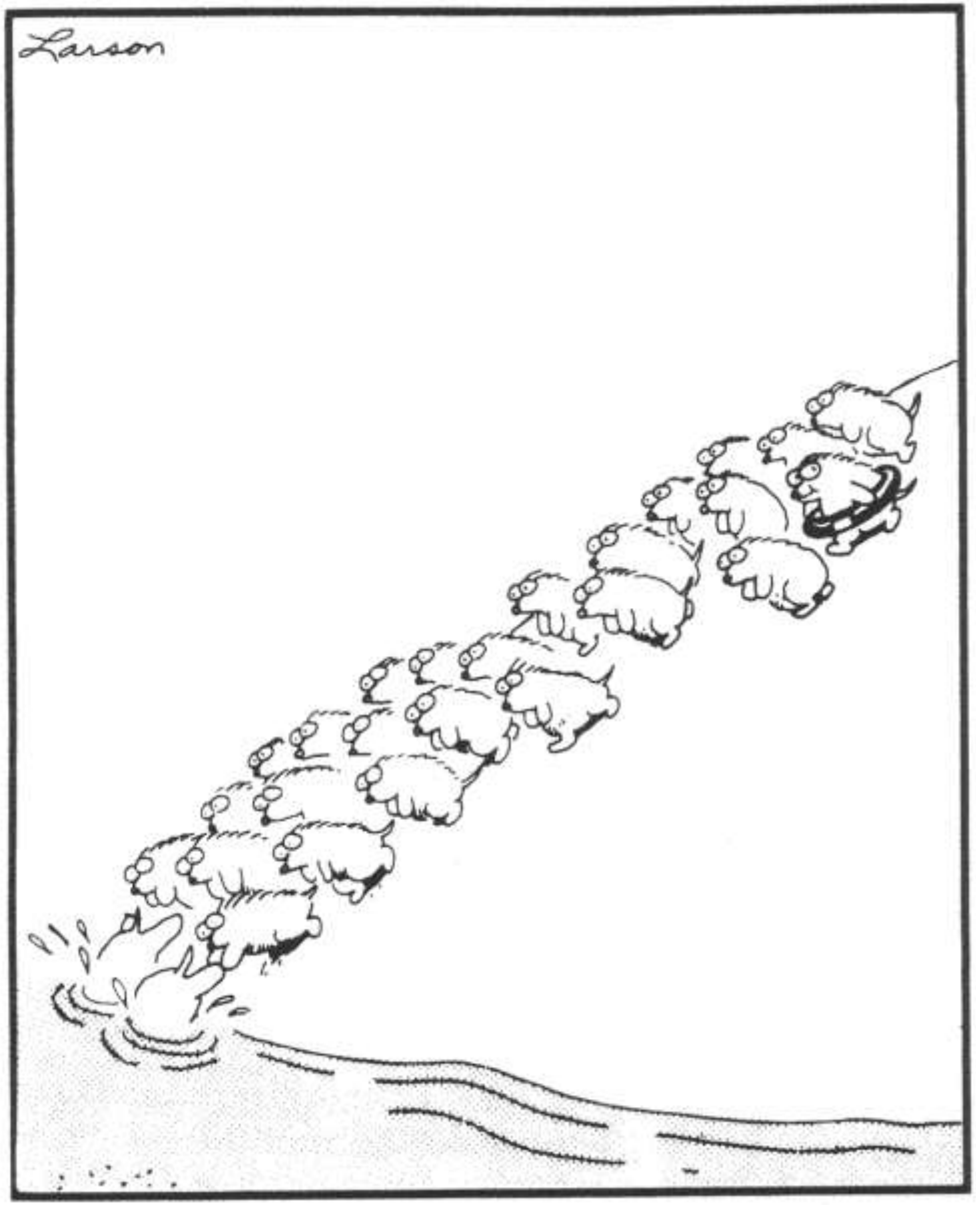


Fig. 1.1. Top: when a new male takes over a lion pride, he kills the young cubs fathered by the previous males. Bottom: a female suckles her sister's cub alongside her own.

Observation	Causal explanations	Functional explanations
1. Females are synchronous in oestrus	Chemical cues? Take-overs by males	Better cub survival Young males survive better and have greater reproductive success when they leave pride if in a group
2. High rate of copulation	Female infertility Time of ovulation concealed	Each copulation of less value to a male Increased paternity uncertainty may protect cubs from males Elicits competition between male coalitions, so females get best protectors taking over pride
3. Young die when new males take over pride	Abortion (?chemical) Take-over males kill or evict young	Females come into oestrus quicker Male removes older cubs which would compete with his young

Group – individual interest ?

.



Evolutionarily Stable Strategy (ESS)

Individual <-> Group

Optimal <-> Stable behaviour

<u>Hawk and Dove model</u>

Table 7.1. The game between Hawk and Dove. After Maynard Smith (1976b)

(a) Pay-offs:

Winner	+ 50	Injury	−100
Loser	0	Display	−10

(b) Pay-off Matrix: average pay-offs in a fight to the attacker.

Attacker	Opponent	
	Hawk	Dove
Hawk	(a) $\frac{1}{2}(50) + \frac{1}{2}(-100) = -25$	(b) +50
Dove	(c) 0	(d) $\frac{1}{2}(50-10) + \frac{1}{2}(-10) = +15$

Notes:

(a) When a Hawk meets a Hawk we assume that on half of the occasions it wins and on half the occasions it suffers injury.

(b) Hawks always beat Doves.

(c) Doves always immediately retreat against Hawks.

(d) When a Dove meets a Dove we assume that there is always a display and it wins on half of the occasions.

-stable ratio of strategies when an average hawk and an average doves has similar benefit

h – ratio of hawks

1-h – ratio of doves

Cost-benefit:

hawk $H = -25h + 50(1-h)$

doves $G = 0h + 15(1-h)$

ESS : $H = G$

$h_{hawk} = 7/12$

$h_{doves} = 5/12$

(ESS) if:

1. 7/12 of individuals behave as hawk, 5/12 of individuals behave as doves

or

2. Each individuals behave 7/12 as hawk and 5/12 behave as doves (mixed strategy)

- Net benefit at ESS : **6,25!**

  - hawk: (-25 x 7/12) + 50 (5/12) = 6,25

  - doves: (0 x 7/12) + 15 (5/12) = 6,25

- Net benefit **- only doves: 15! – optimal, but not stable!!!**

  - ESS: 6,25 – not optimal, but stable!!!

- The best strategy depend on behaviours of others.
- There is no “absolut best strategy” only ESS, which depend on existing strategies in the population and cost/benefit of it.

The cost/benefit of behaviour strategies could depend on various factor in the nature and could change in space and time.

Example in the nature:

Serious fights (high ratio of "hawk" strategy) – benefit >>> cost

Fights for breeding

- Reed deer

- Narval

- Sea lion

Only ritual behaviours (high ratio of "dove" strategy) – benefit <<< cost

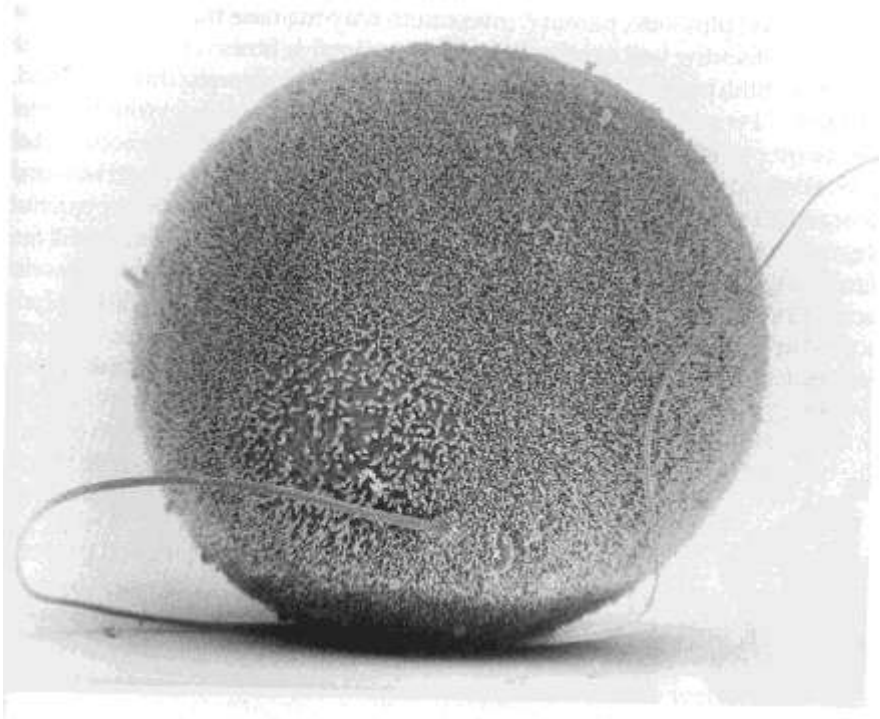
- Ratle snake

Evolution

Conflicts:

- Between sexes (One sex (female) give more to the offspring – potentially it could have less maximum offspring than the other sex (male)

- Between parents and offsprings (Care of offsprings reduce the chance to produce more offsprings)

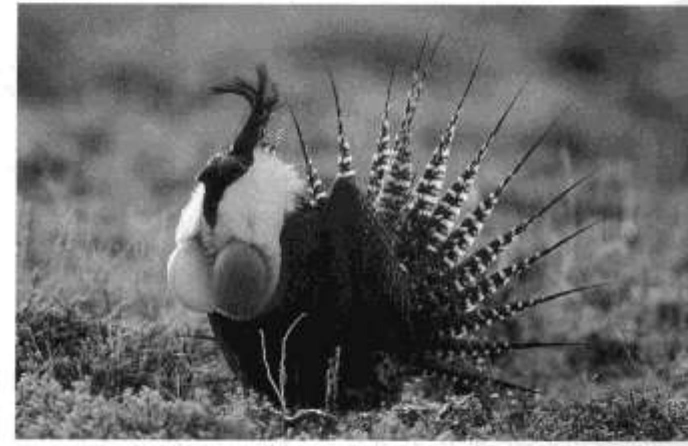


For sex which could have potentially less offsprings (females) – very important to find the partners (males) with the best quality. -> They choose

Sexual selection:

Selection for traits which increase mating/pairing of sex (males) which could have potentially more offsprings

Sexual selection between and within sexes



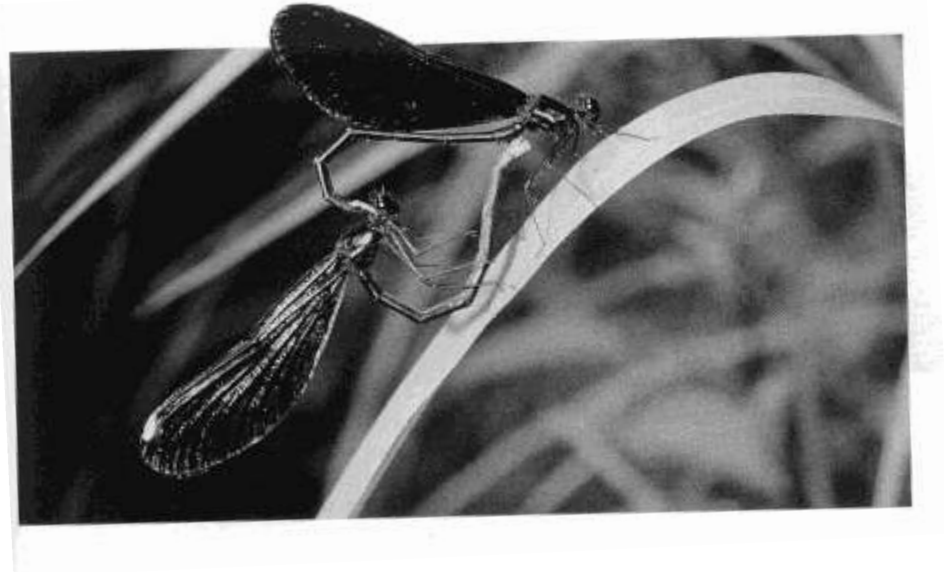
12 Sexually selected "ornaments" of males. Darwin believed that sexual selection via female choice was responsible for the evolution of elaborate plumage and remarkable displays in male birds such as the quetzal (left) and the sage grouse (top right). Darwin argued that the strange horns and snouts of certain beetles (bottom right) also arose via female choice, although males actually use these structures primarily as weapons when fighting for mates. Photographs by Bruce Lyon; Marc Dantzker; and the author.

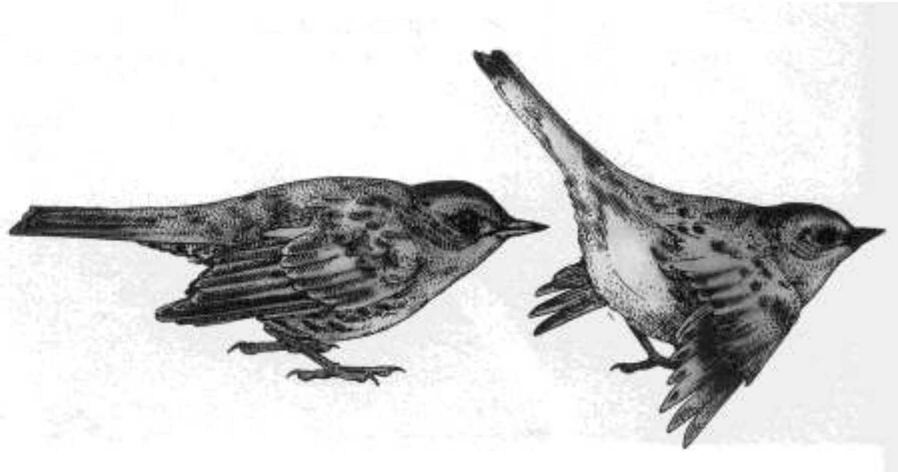
Sexual selection

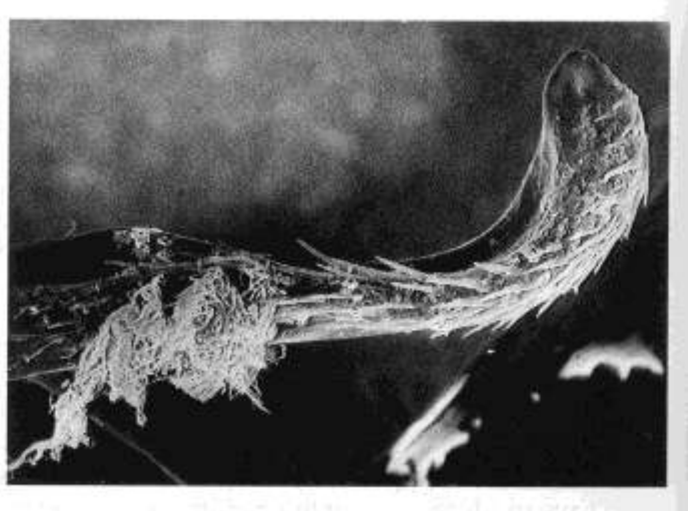
Intrasexual competition - within sex

Sperm competition

Intrasexual competition – competition after mating among males (whose sperm
· will fertilise the eggs)



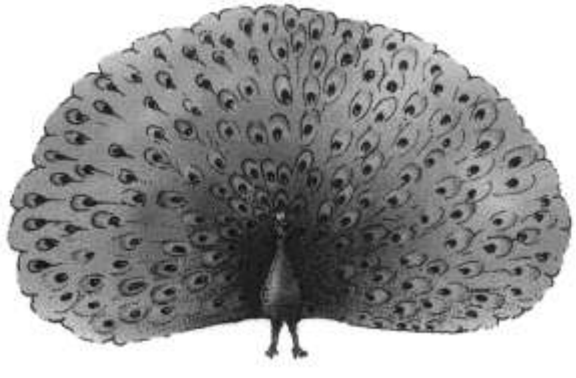


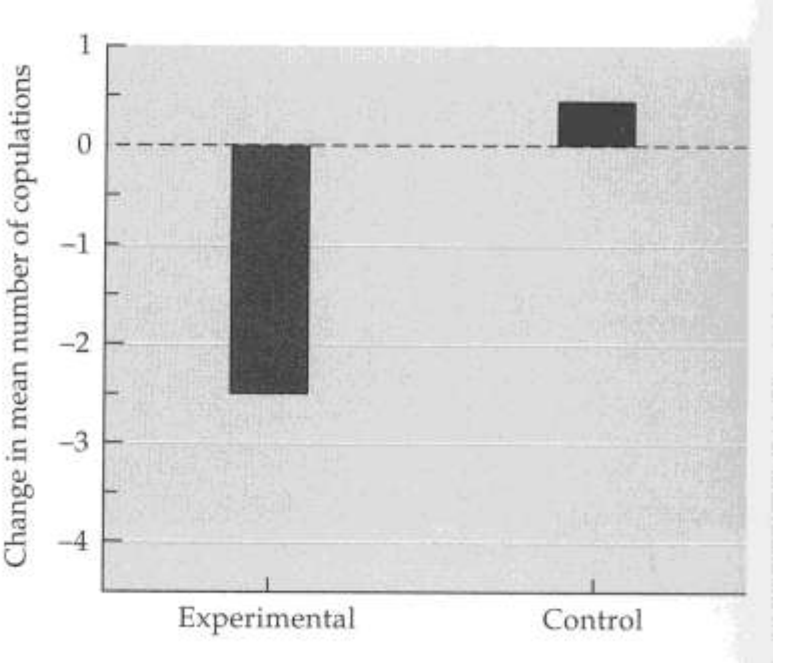


Sexual selection

Intrasexual competition, between sexes- Mate choice of females

38 Removal of eyespots from a peacock's tail reduces his attractiveness to females. After 20 eyespots had been cut from their tails, males averaged two fewer mates in the following breeding season compared with their performance in the previous year. After Petrie and Halliday [906].





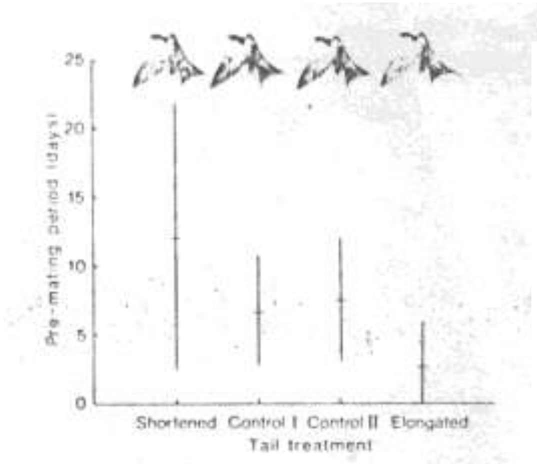
Intrasexual competition

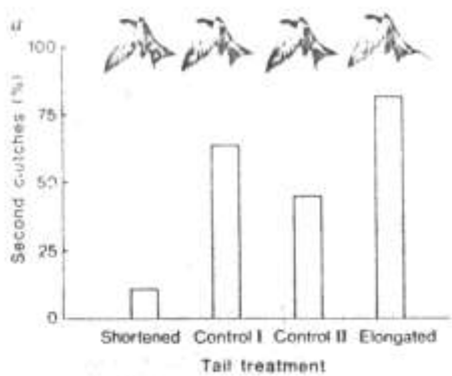
Barn swallow

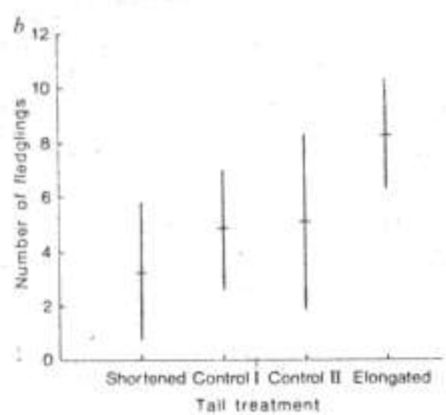
- Females prefer males with longer tail feathers
- Females prefer males with symetric tail feathers

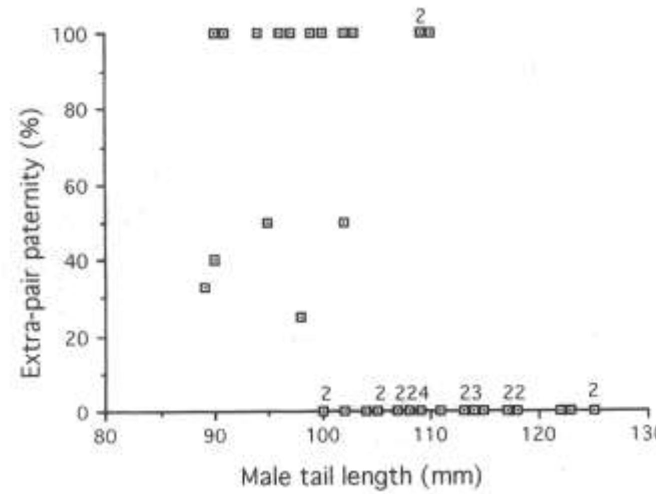
Mate choise by female

Handicap principle







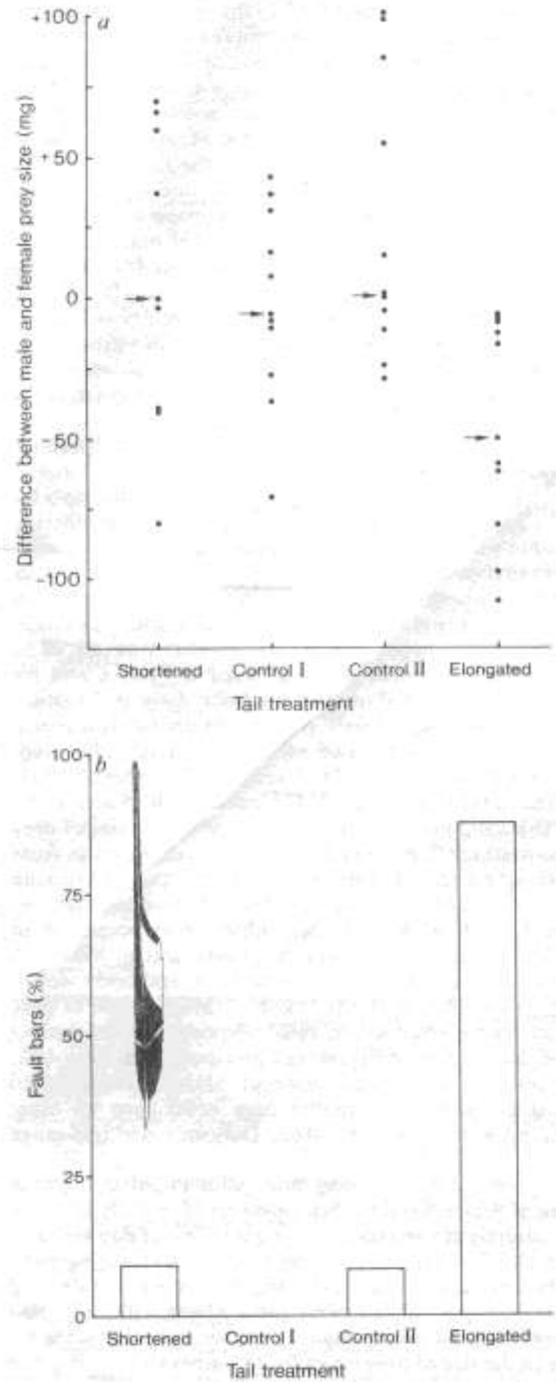


Why the tail is not long for every males?

Males with experimentally elongated tail feathers was able to rear the offspring but new feathers moult in Africa were shorter with more fault bars than control – less survival probability

Only males with good condition could have long tail

Symmetry of tail feathers are important as well



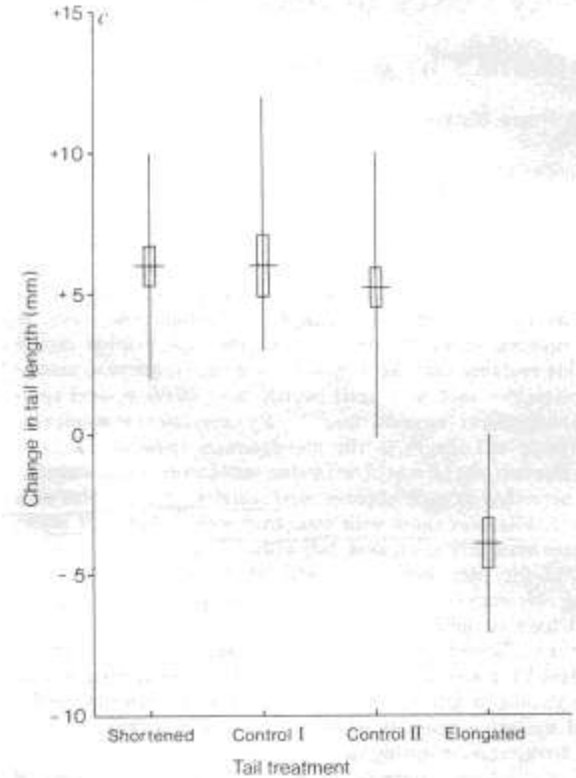


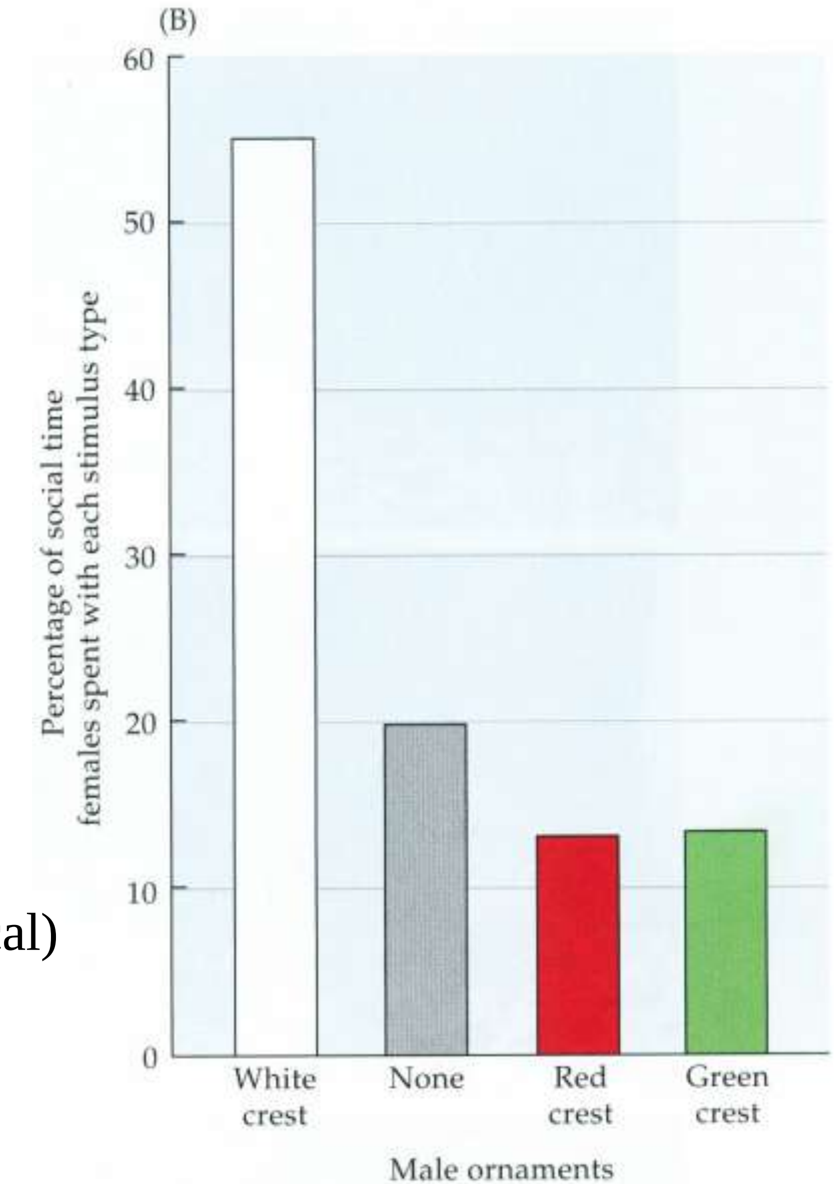
FIG. 1 *a*, Difference in median prey size (mg) taken by males and their mates to offspring aged 8–12 d in their first brood in relation to tail-size manipulation. Arrows indicate medians for each group. The difference in prey size differed among groups ($F=5.25$, $P<0.01$). The group with elongated tails differed from all other groups ($P<0.02$, Duncan's multiple-range test), whereas other groups did not differ ($P>0.10$). *b*, Proportion of male swallows having fault bars in their tail and wing feathers in relation to tail-size manipulation during the preceding breeding season. The thin white bar (arrow) on the drawing of the feather represents a fault bar. Sample sizes are 11, 9, 12 and 8 for the four groups. Frequency of males having fault bars differed among groups ($P=3.94\times10^{-6}$, Fisher exact probability test). All pairwise comparisons between males with elongated tails and other groups of males were statistically significant ($P<0.01$, Fisher exact probability test), whereas other pairwise comparisons were non-significant ($P>0.10$). *c*, Change in tail length of male swallows from one year to another as a result of moult in relation to tail-size manipulation during the preceding breeding season. Values are means (horizontal lines), ±s.d. (vertical bars), and ranges (vertical lines). Sample sizes are 11, 9, 12 and 8 for the four groups. Change in tail length differed among groups ($F=22.29$, $P<0.001$, one-way analysis of variance). The group with elongated tails differed from all other groups ($P<0.01$, Duncan's multiple-range test), whereas all other comparisons were non-significant ($P>0.10$). Tail length did not differ among groups before treatment ($P>0.10$, analysis of variance), but did so after moult ($F=4.41$, $P<0.01$).

Sensory exploitation – new traits which could improve mating/paring of males

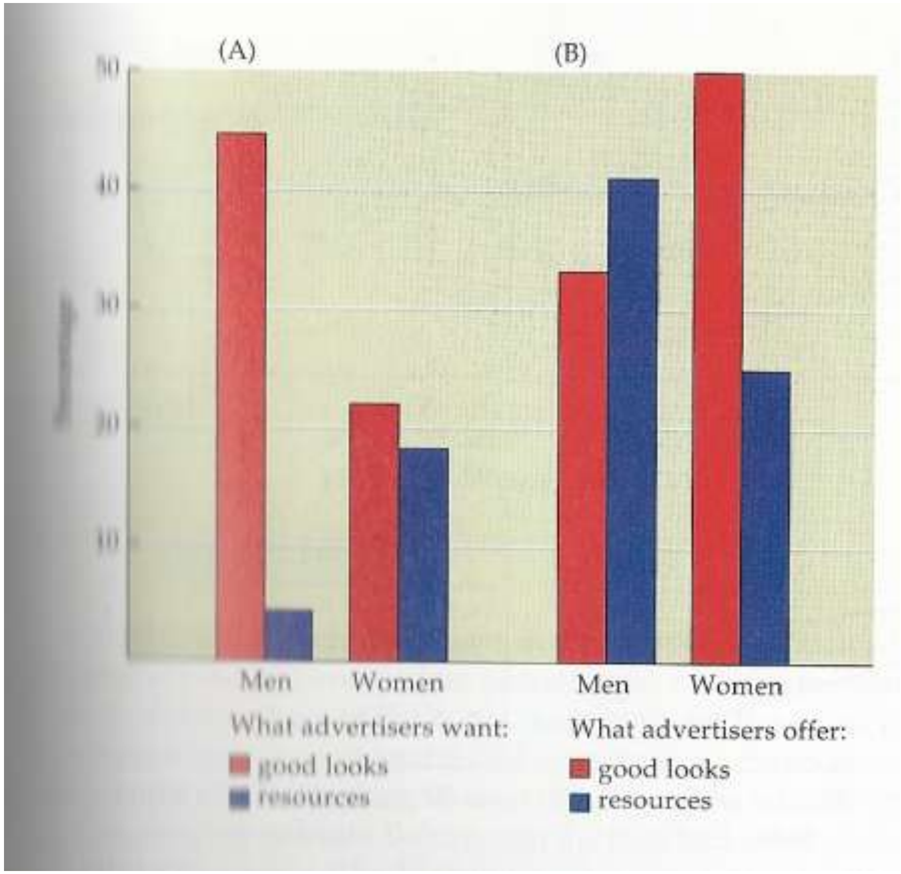
- Zebra finch experiment

Glueing white feather on the head of finch increased the interest of females toward these males during pairing.

New kind of males trait (behaviour/morphological) can be successful if it is attractive for females.

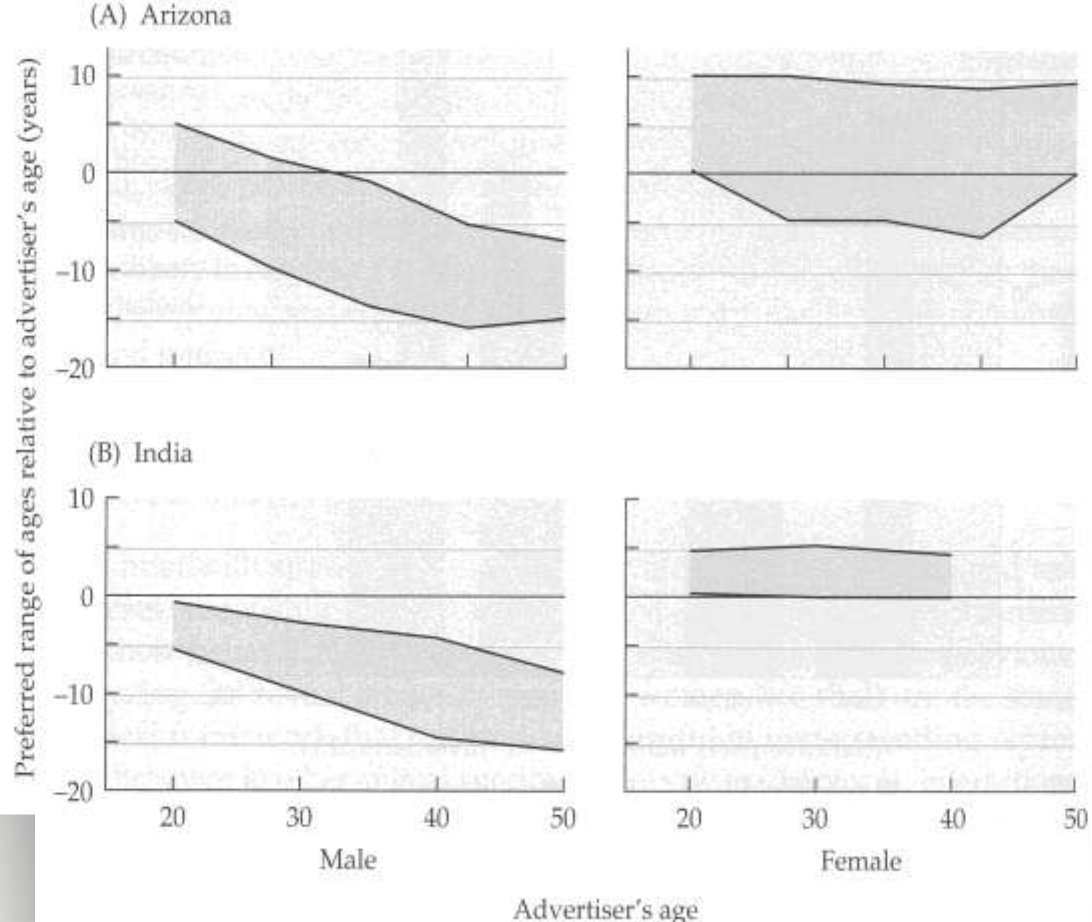


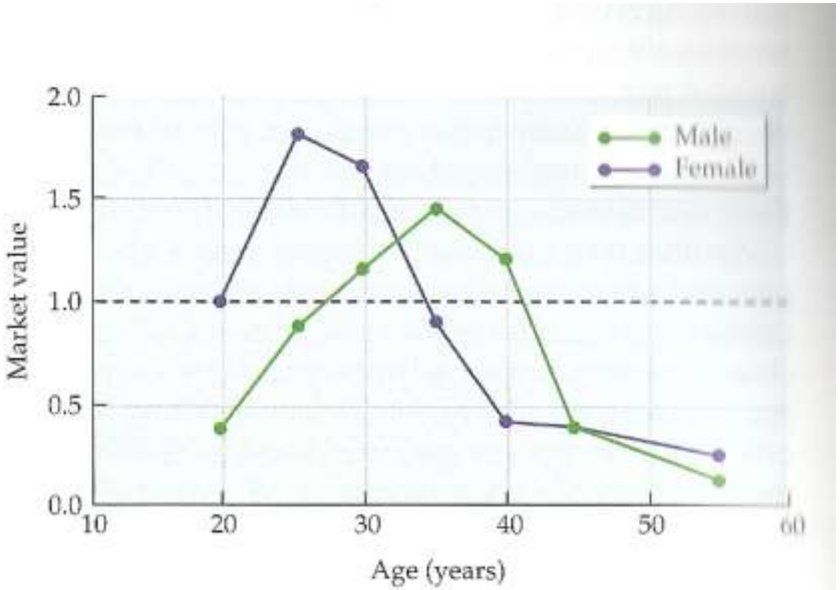
Human is totally different ???



What want and offer men and women in the ordinary dating advertising

6 Different cultures show similar mate preferences. Men advertise for younger women and women advertise for older men in both (A) the *Arizona Solo* and (B) the *Times* of New Delhi, India. The advertisers indicated their own age and the maximum and minimum ages they would accept in potential partners. After Kenrick and Keefe [613].

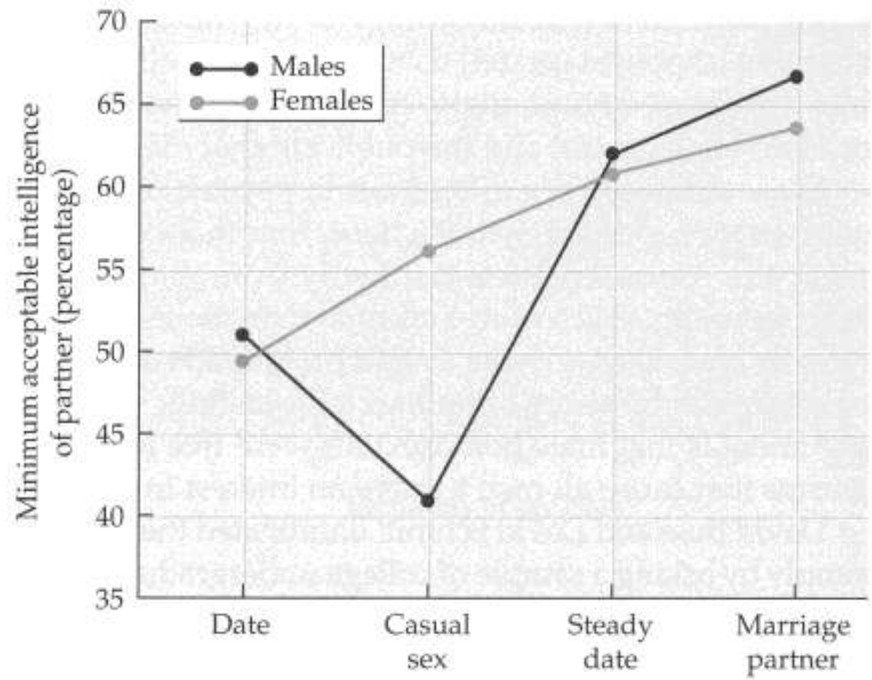


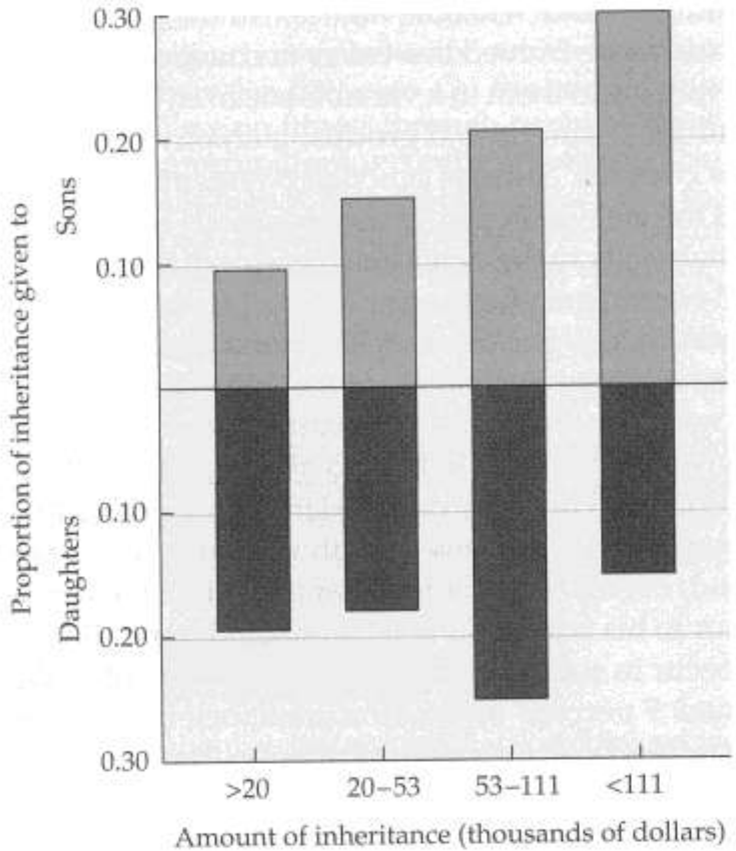


- Males prefer the most fertile age group both in Arizona and in India

- In the case of females preference different from males, not the age alone

13 Sex differences in mate selectivity. College men differ from college women in the minimum intelligence that they say they would require in a casual sexual partner. However, men and women have similar standards with respect to the minimum intelligence they say they would require in a marriage partner. After Kenrick et al. [614].





24 Inheritance decisions. Wealthy Canadian parents bias their legacies toward their sons, who are more likely than daughters to convert exceptional wealth into exceptional reproductive success. After Smith et al. [1073].

Inheritance decision: division of the heritance between daughters and sons depend on the amount of inheritence

Among animals, females produce more male offspring and/or provide more sources to male offpsring when male partner is high quality

Parental care

„any investment by the parent in an individual offspring that increases that offspring's chance of surviving (and hence reproductive success) at the cost of the parent's ability to invest in other offspring” (Trivers)

Monogamy – social monogamy -> both sex contribute in the parental care

Polygyny -> males mates with several females, females only with one male, usually the females provide parental care

Poliandry -> females mates with several males, males only with one females, usually the males provide parental care

Promiscuity -> both males and females mate with several individuals, either sex may care ofsprings

Human-> Social monogamy

Interspecific interactions, Niche theory, Competition model

Interaction among species

- Competition	**- / -**
- Predation	+/-
- Commensalism,	+/0
- Amensalism, allelopathy	0/-
- Mutualism	+/+
- Neutralism	0/0

Organisation of Communities. Niche theory. Niche elmélet alapjai. Models of competition

- Living conditions and Resources influence the distribution and abundance
  - Living conditions , independent from the condition of the living organism: eg. temperature, humidity, soil composition, pH ofthe water, salinity, polution
  - Resources: all things which quantity could modify by the living organism

Resources:

.

Solar radiation

Inorganic materials:

- CO_2
- minerals
- Oxigen
- N
- H_20

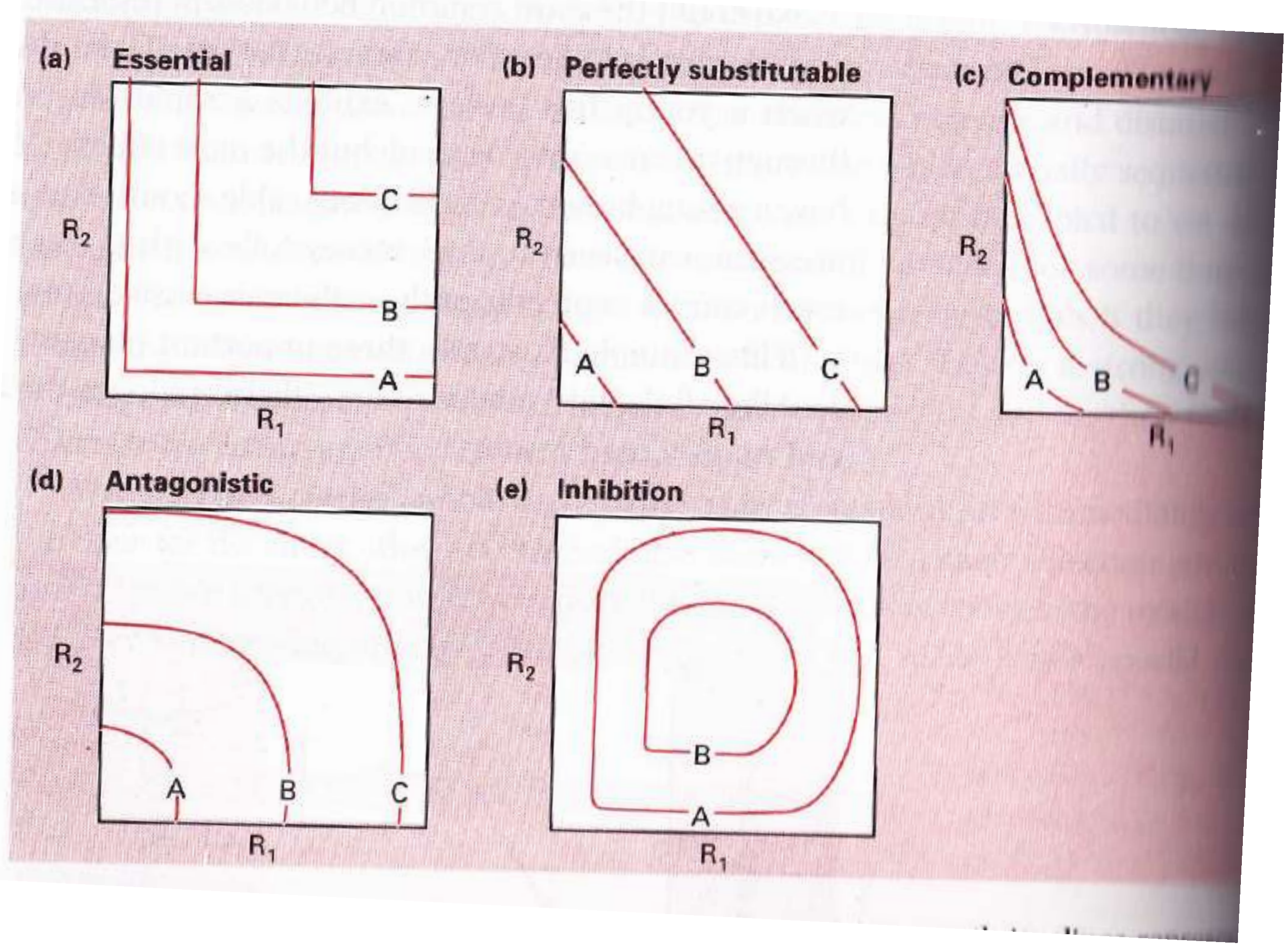
Other organism

Burrows

Seeds

…..etc,

Classification of resources

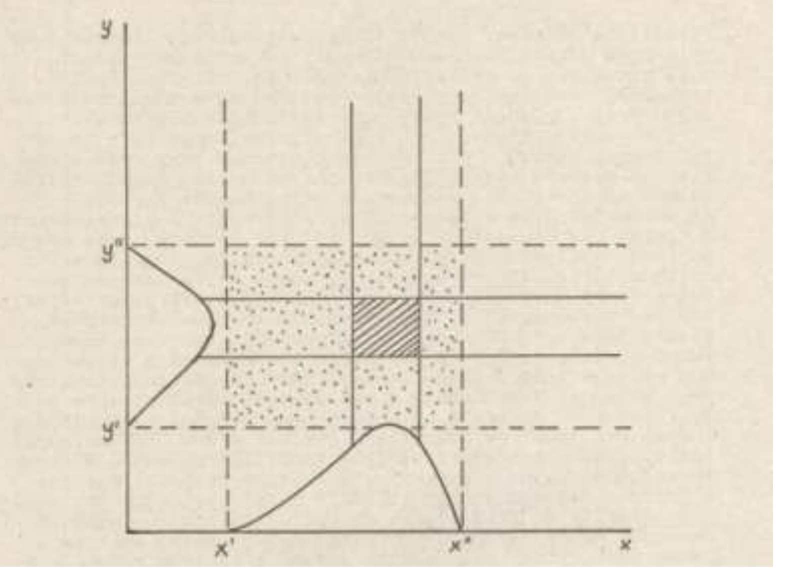


Niche

Population/species needs large number (N) resources for living

Niche: niche is an „N-dimensional hypervolume", where the dimensions are environmental conditions and resources, that define the requirements of an individual or a species to practice its way of life, more particularly, for its population to persist (Hutchinson)

- Fundamental niche, part of the N-dimensional hypervolume where the given population/species could occur

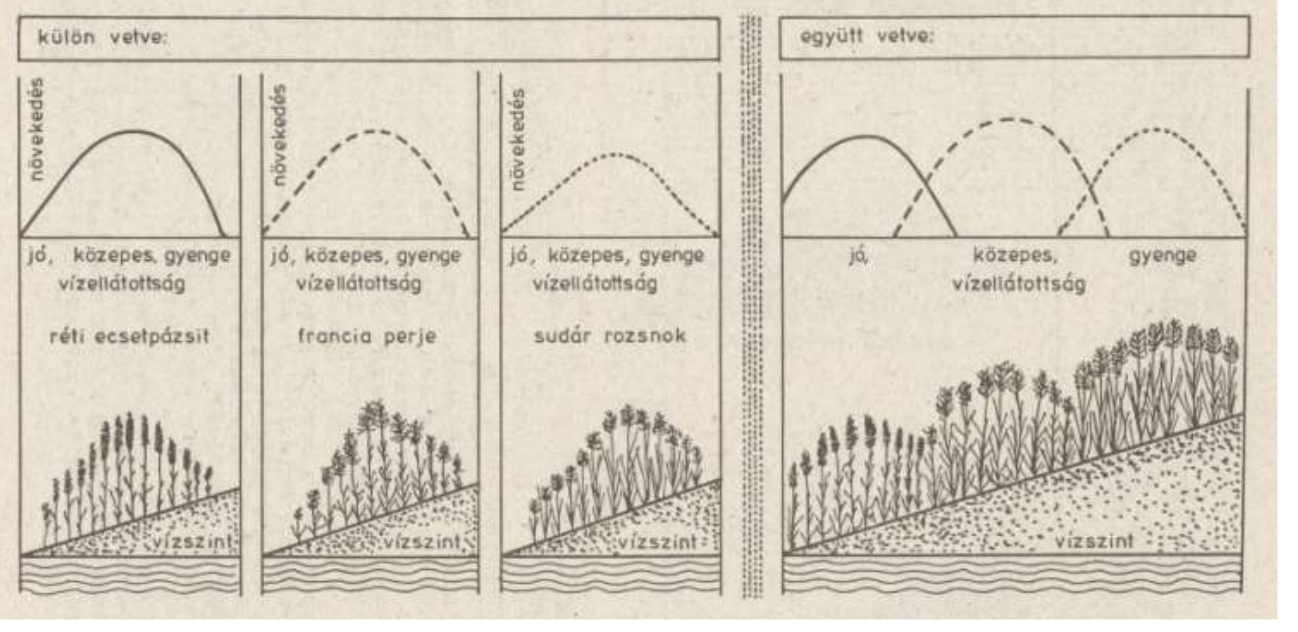


- Realised Niche, part of the N-dimensional hypervolume where the given population/species occurs

Niche

Niche: niche is an „N-dimensional hypervolume", where the dimensions are environmental conditions and resources, that define the requirements of an individual or a species to practice its way of life, more particularly, for its population to persist (Hutchinson)

- Fundamental niche, part of the N-dimensional hypervolume where the given population/species could occur



Growth of three grass species in relation to water availability when it was seeding separatelly (left part) and mixed way (right part).

- Realised Niche, part of the N-dimensional hypervolume where the given population/species occurs

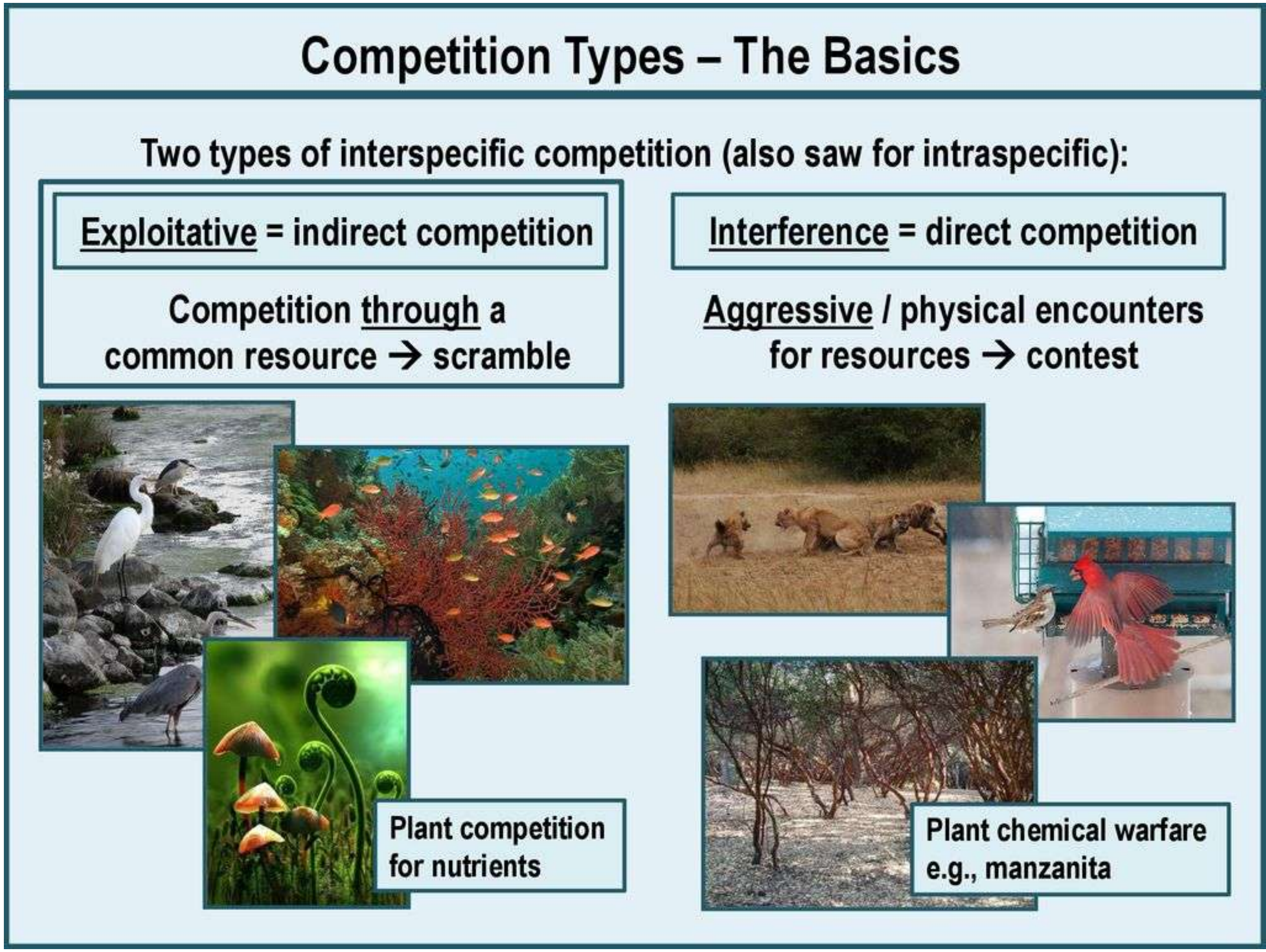
Competition

- Intraspecific, density dependent growth

- Interspecific

Interference -> Contest

Exploitative ->Scramble



Competition between species when their niche overlapping

The level of the niche overlap indicate the level of the competition

In the case of large niche overlap:

1- niche segregation or 2- the last competitive species will gone

When the niche overlap occur for resources which has no or minimal regulatory function of the species -> there is minimal competition

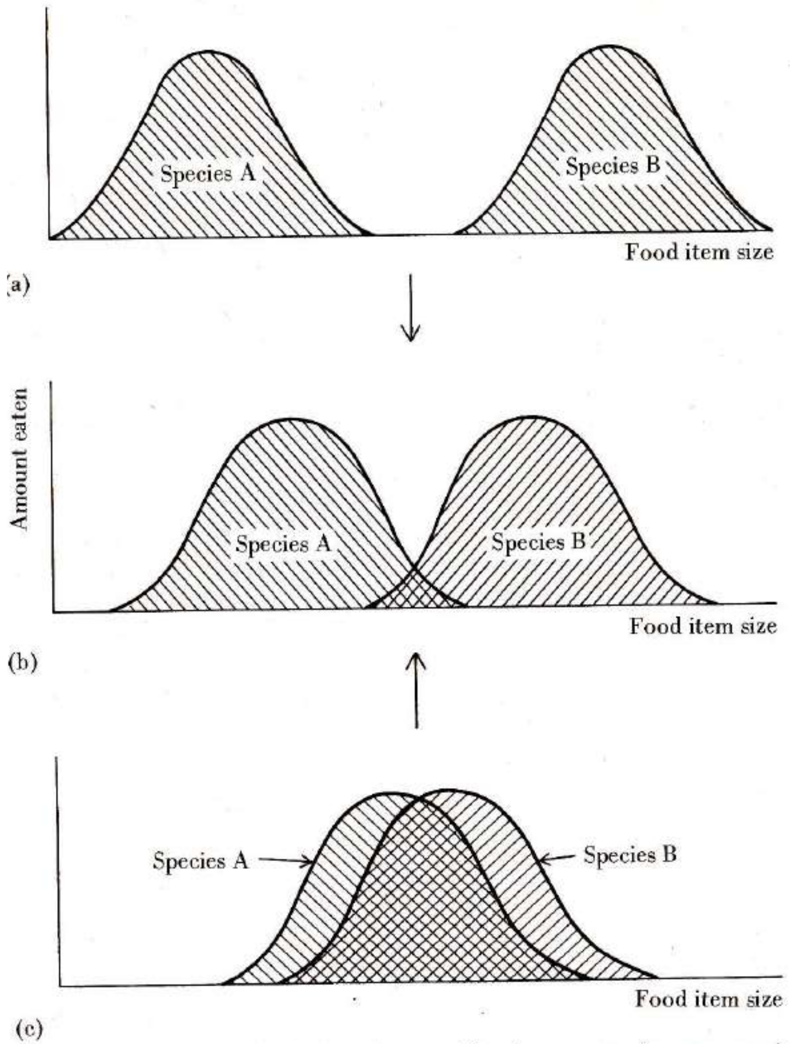


Figure 13.20 Hypothetical resource-utilization curves for two species. Food size is the resource for which competition may occur in this hypothetical situation. Arrows indicate direction of evolutionary pressures toward case (b).

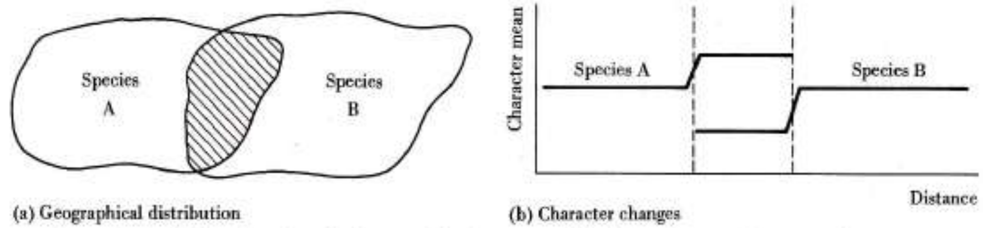


Figure 13.21 Schematic view of character displacement arising from interspecific competition in the zone of overlap of two species. This scheme is inferred as an explanation of the observations in Figure 13.22.

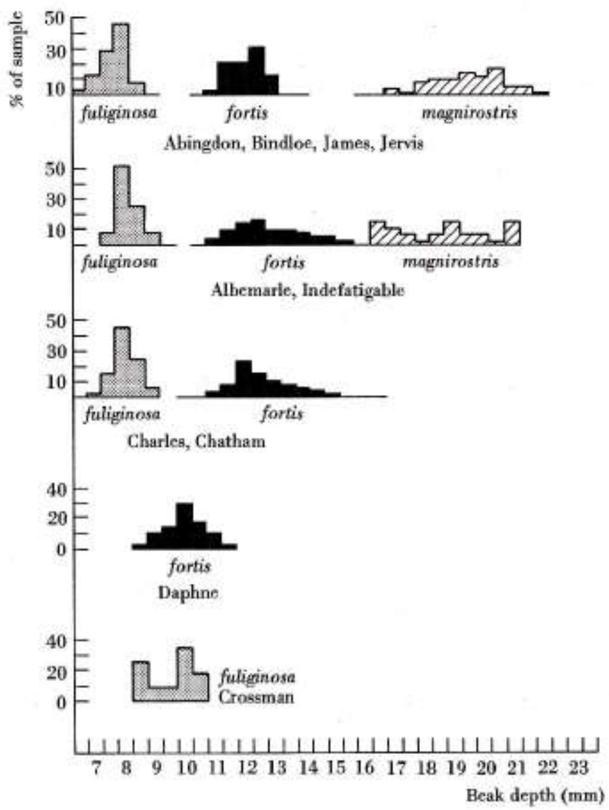
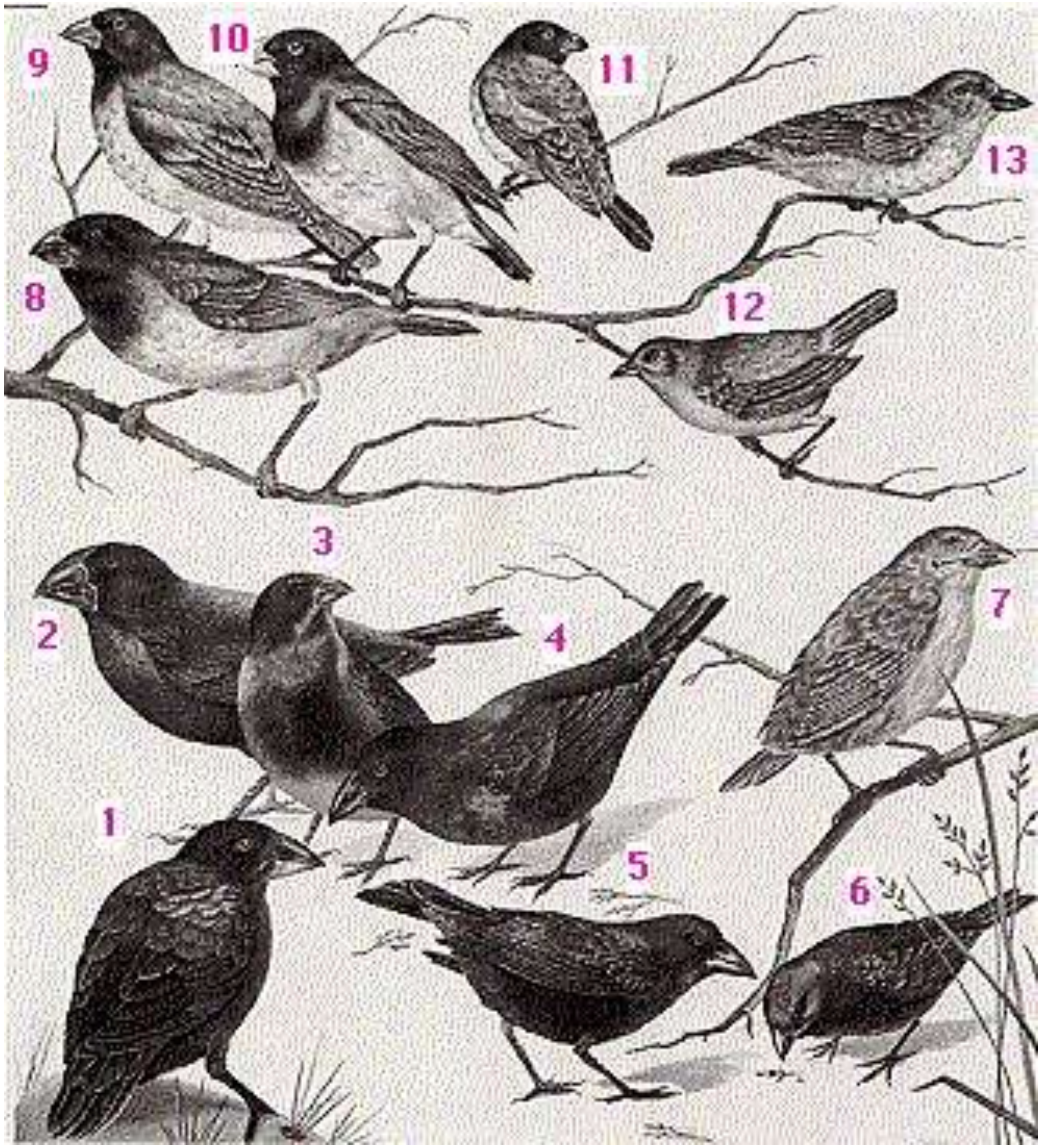


Figure 13.22 Character displacement in beak size in Darwin's finches from the Galápagos Islands. Beak depths are given for *Geospiza fortis* and *G. fuliginosa* on islands where these two species occur together (upper three sets of islands) and alone (lower two islands). *Geospiza magnirostris* is another large finch that occurs on some islands. (After Lack 1947.)

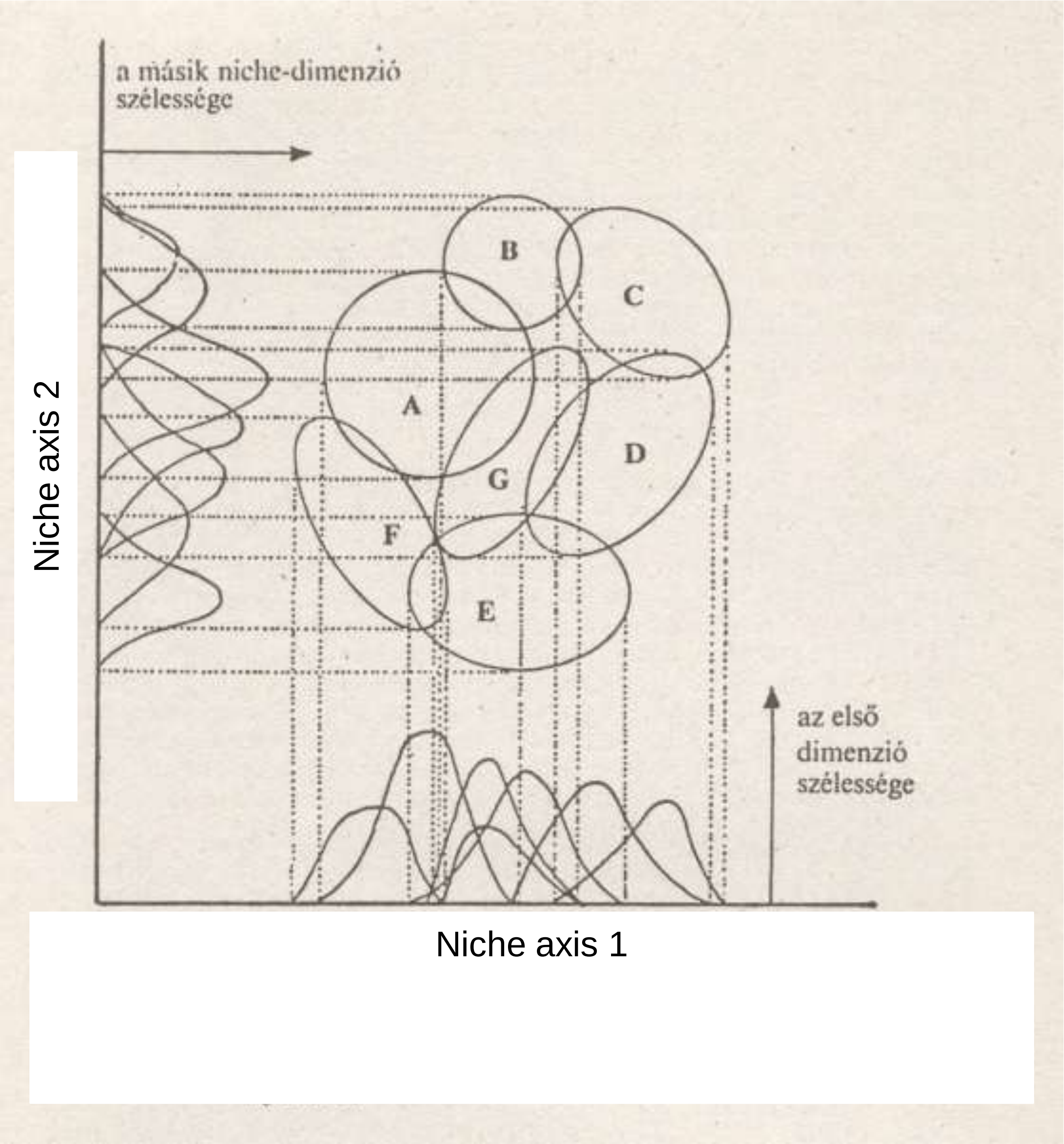
Darwin finch, Galapagos islands
Adaptive radiation – disruptive selection

1. Large cactus finch (Geospiza conirostris)
2. Large ground finch (Geospiza magnirostris)
3. Medium ground finch (**Geospiza fortis**)
4. Cactus finch (Geospiza scandens)
5. Sharp-beaked ground finch (Geospiza difficilis)
6. Small ground finch (Geospiza fuliginosa)
7. Woodpecker finch (Cactospiza pallida)
8. Vegetarian tree finch (Platyspiza crassirostris)
9. Medium tree finch (**Camarhynchus pauper**)
10. Large tree finch (**Camarhynchus psittacula**)
11. Small tree finch (Camarhynchus parvulus)
12. Warbler finch (Certhidia olivacea)
13. Mangrove finch (Cactospiza heliobates)



film

Permanent coexisting of species

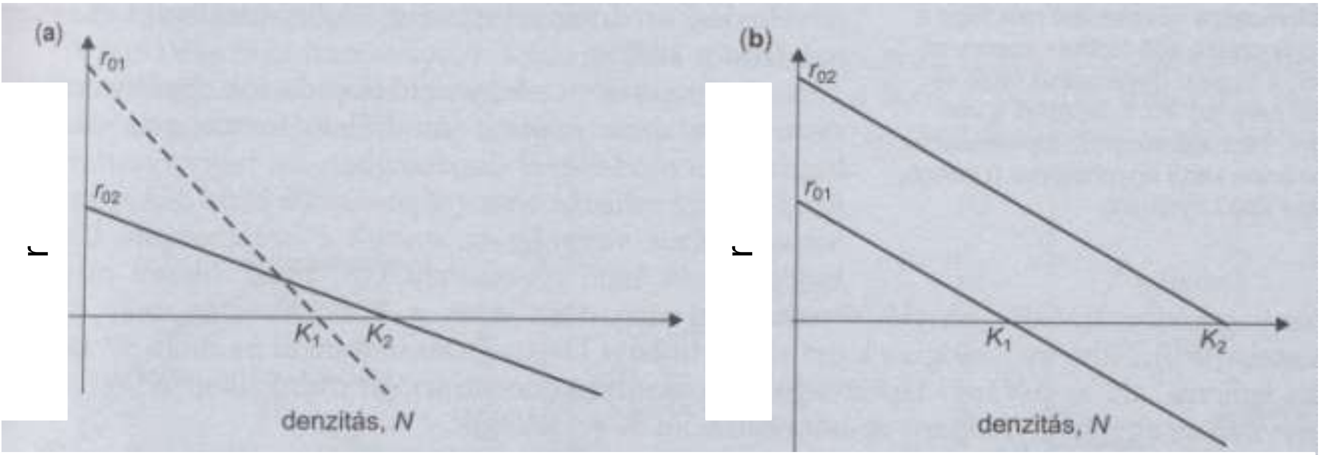


Competition when only one factor regulate the population growth

If two species compete and the same factor regulate both of them:

Species with the higher carrying capacity (K) will win and remains in the area

When only one factor regulate the growth of populations, only one population will exist



Density

The outcome of the competition depend on the environment

In the case of grain beetles the moisture and temperature modify the outcome of the competition

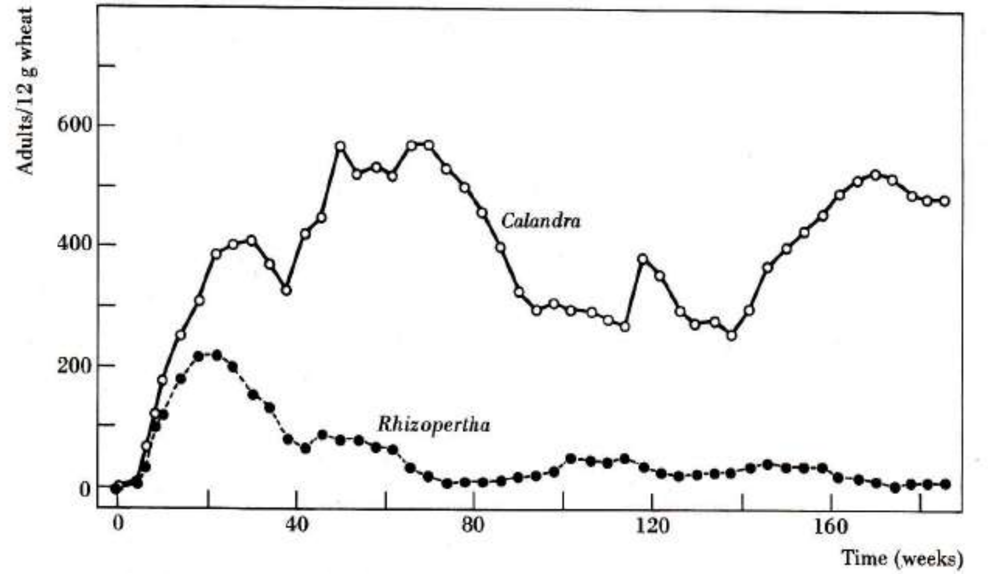


Figure 13.9 Population trends of adult grain beetles (*Calandra oryzae* and *Rhizopertha dominica*) living together in wheat of 14 percent moisture content at 29.1°C. (After Birch 1953b.)

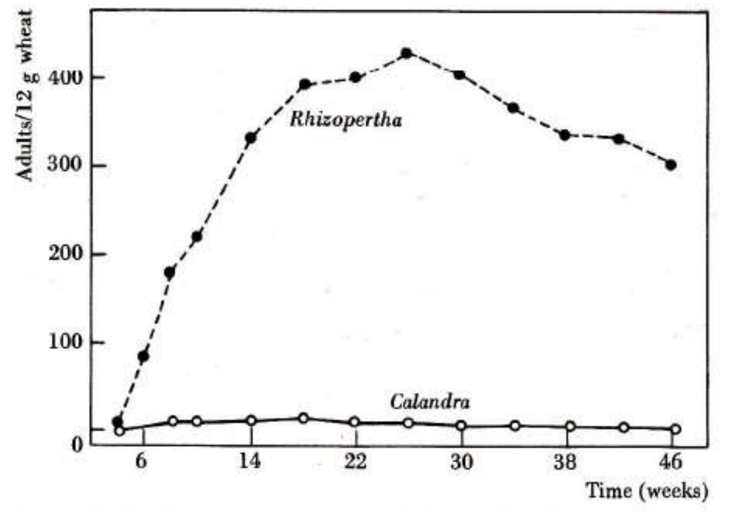
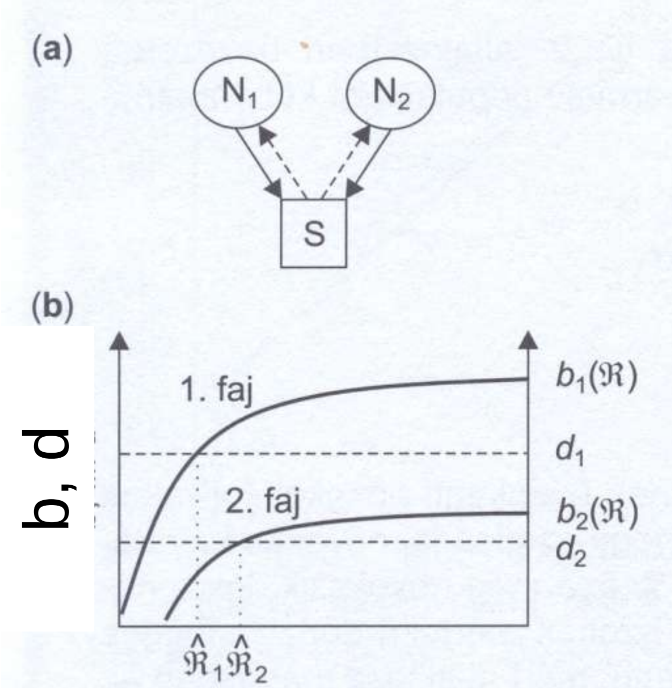


Figure 13.10 Population trends of adult grain beetles (*Calandra oryzae* and *Rhizopertha dominica*) living together in wheat of 14 percent moisture content at 32.3°C. (After Birch 1953b.)

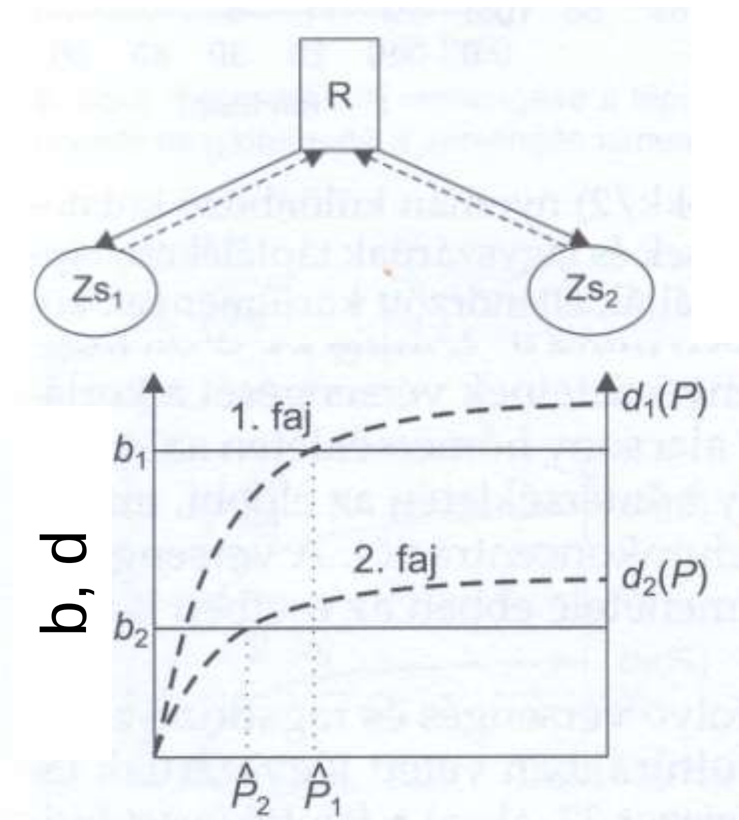
The outcome of the competition depend on the efficiency of the usage of the resources



Concentration of resource

When only one resource regulate the growth of populations, only the population will exist which reach the equilibrium population size at the lowest concentration of the given resource

The outcome of the competition depend on the efficiency of avoiding predators/parasites



Density of predator/parasite

When the same predator/parasite regulate the growth of populations, only the population will exist which reach the equilibrium population size at the highest density of the given predator/parasite

Lotka-Volterra competition model when there are several mutual regulatory factors of two species

Growth of the two species depend on density of both own and both on density of the other species, when there are at least two regulatory factors

1. Growth of 1st species

$$\frac{dN_1}{dt} = r_1 N_1 \frac{(K_1 - N_1 - \alpha_{12} N_2)}{K_1}$$

2. Growth of 2nd species

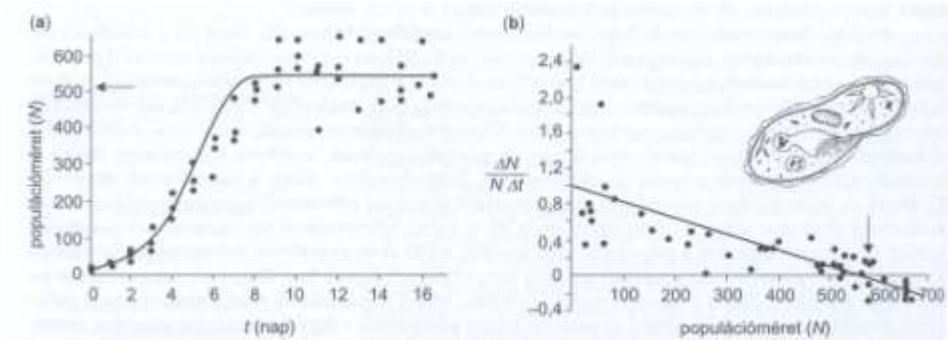
$$\frac{dN_2}{dt} = r_2 N_2 \frac{(K_2 - N_2 - \alpha_{21} N_1)}{K_2}$$

$\alpha_{12,}$ α_{21}: conversion factor for expressing species x in units of species y

N_2 individuals of 2nd species == $\alpha_{12*}N_2$ individuals of 1st species

N_1 individuals of 1st species == $\alpha_{21*}N_1$ individuals of 2nd species

Logistic model

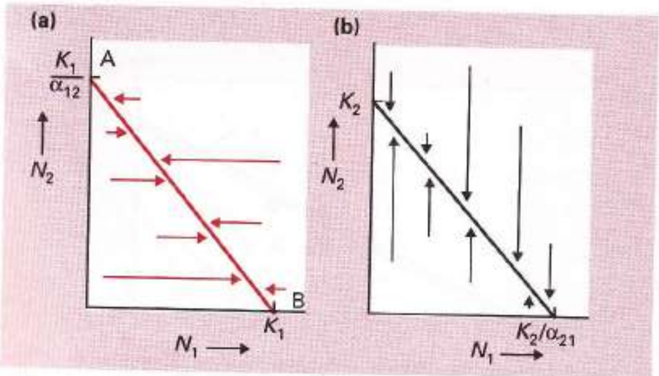


8. ábra A papucsállatka (*Paramecium aurelia*) populáció logisztikus növekedési görbéje. (**a**) A sejtszám időbeli változása. (**b**) A sejtenkénti növekedési ráta lineárisan csökken az egyedszámmal. Mindkét ábrán látható, hogy az egyensúlyi denzitás 552 körül van (GAUSE 1934 nyomán, CASE 2000).

K: Carrying capacity

$$\frac{dN}{dt} = r_0 \cdot N \cdot \frac{K-N}{K}$$

Modelling coexistence of two species



- 7.8 a: 1st species win
- 7.8 b: 2nd species win
- 7.8 c: instable coexistence of 1st and 2nd species, 1st or 2nd species will win
- 7.8 d: 1st and 2nd species stable coexistence

$N_1 \rightarrow \alpha_{12} N_2$
$N_2 \rightarrow \alpha_{21} N_1$

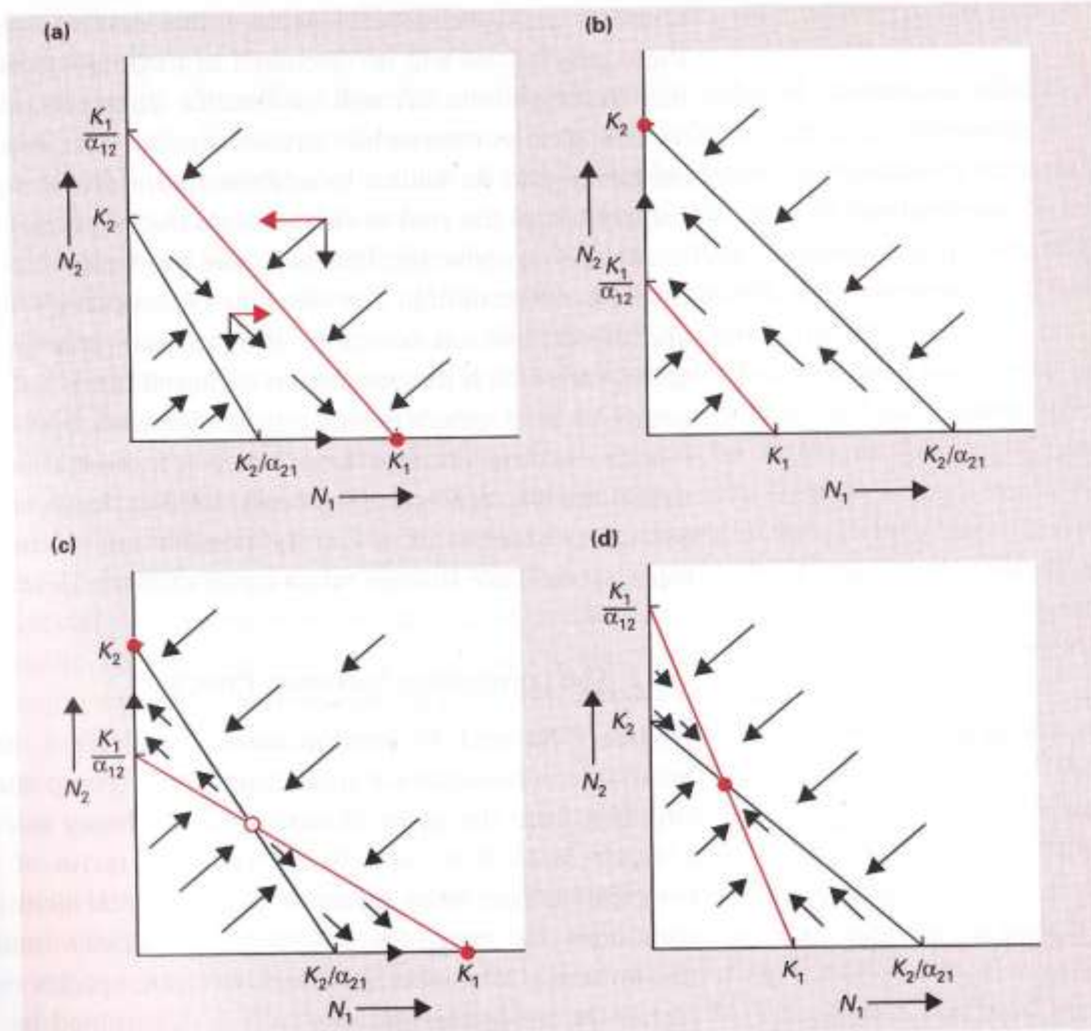


Figure 7.8 The outcomes of competition generated by the Lotka–Volterra competition equations for the four possible arrangements of the N_1 and N_2 zero isoclines. Vectors, generally, refer to joint populations, and are derived as indicated in (a). The solid circles show stable equilibrium points. The open circle in (c) is an unstable equilibrium point. For further discussion, see text.

Opportunity of permanent coexistince

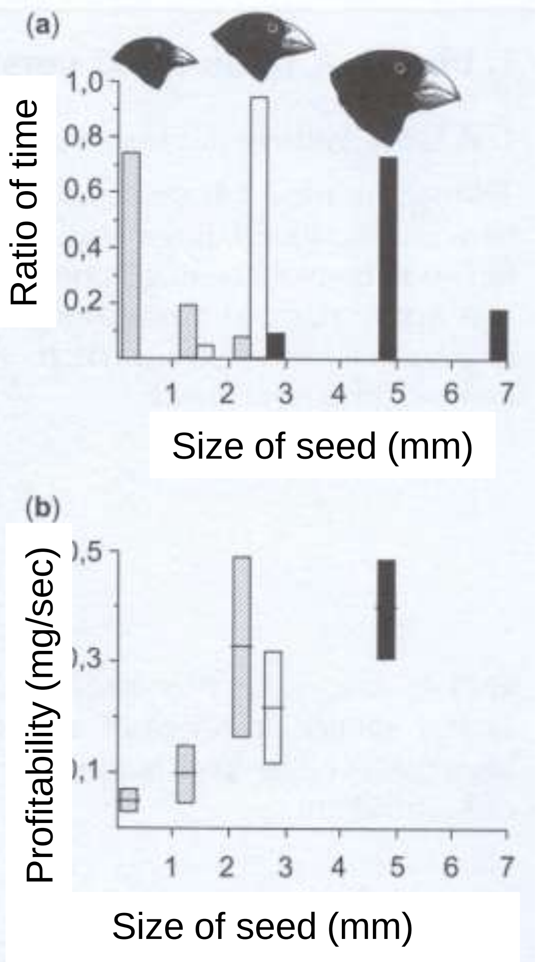
It is larger when difference between the type of resources is larger

When intraspecific competition is stronger then interspecific competition

$\alpha_{12} < 1$, $\alpha_{21} < 1$

Gause law, competitive exclusion principle:

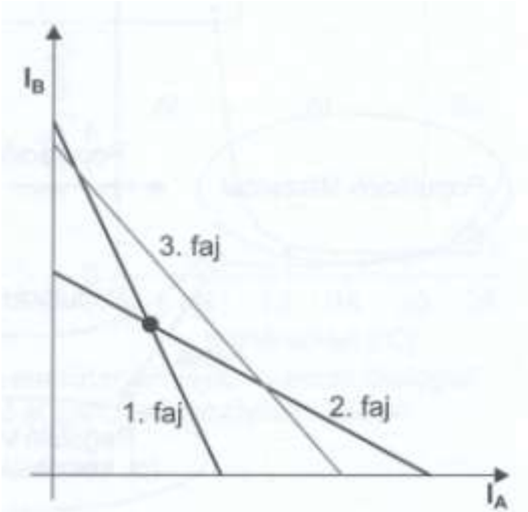
Two species which compete for the same limited resource cannot coexist at constant population values



How many species could live together permanently?

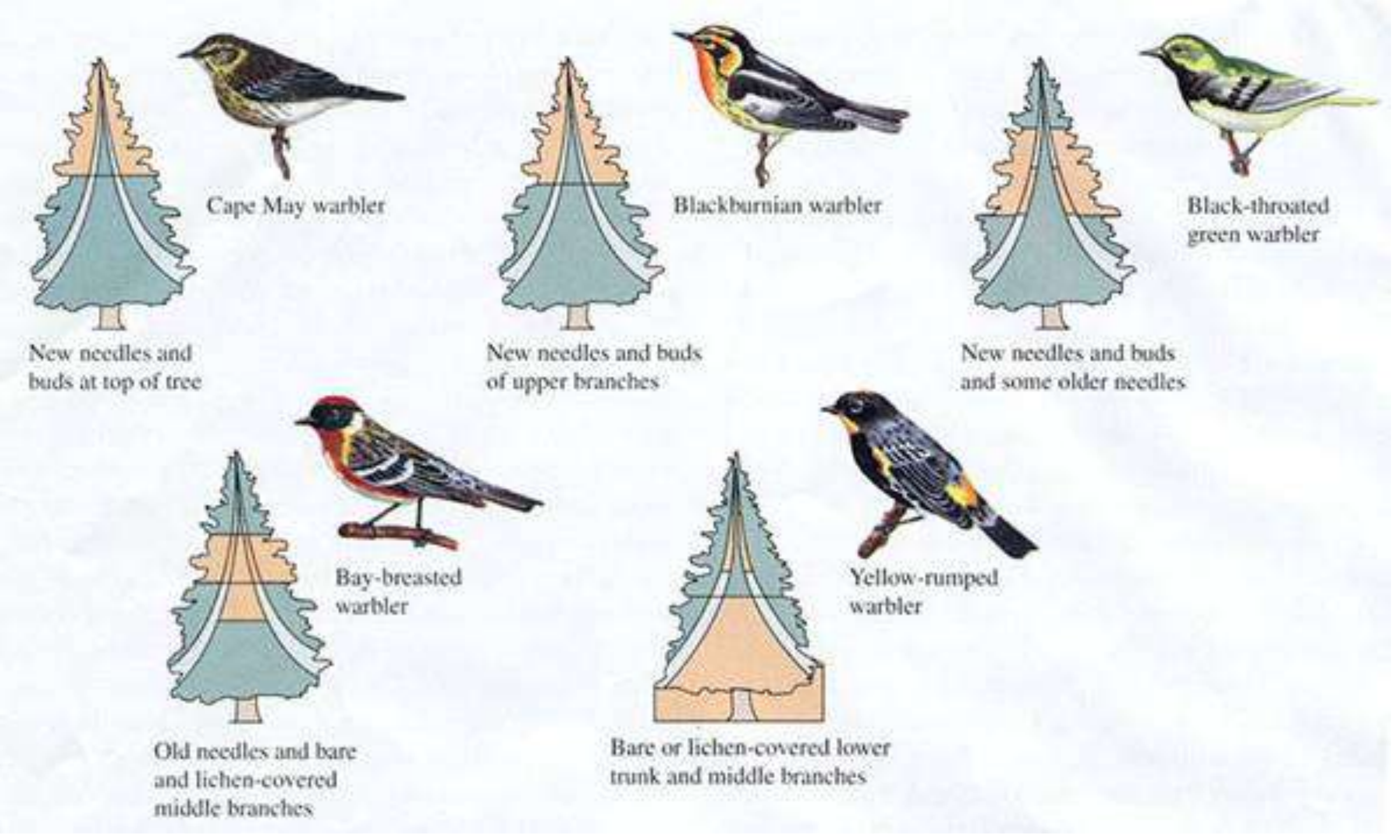
The number of permanently coexisting population of species could not be more than the number of regulatory factors

(In the case of C pieces of regulatory factors,maximum C species could live together)



Regulatory component of growth of competing population need to be enough different for permanent coexisting

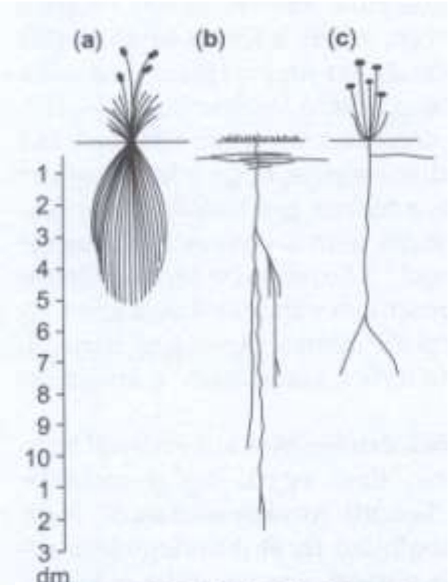
Niche segregation



Feeding positions of five species of warblers (Dendroica sp)

In heterogeneous (space and/or time) environment there is a chance for coexistence of species by niche segregation

- Environmental inhomogenetity



Roots of plants

Predator-prey model, food web

Interaction among species

- Competition	- / -
- Predation	**+/-**
- Commensalism,	+/0
- Amensalism, allelopathy	0/-
- Mutualism	+/+
- Neutralism	0/0

Predator-prey model

Form of Predation:

- Carnivory
- Herbivory

  „Prey” mostly alive

- Parasitism <-> parasitoidism

Lotka-Volterra predator-prey model

Population change of the predator (1)

dN1

----- = (B1*N2-D1)*N1

dt

Population change of the prey (2)

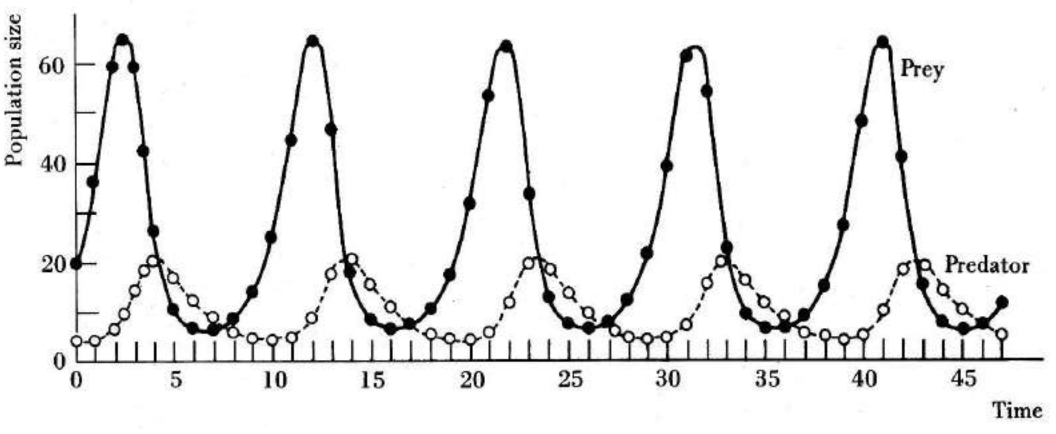
dN2

----- = (B2-D2*N1)*N2

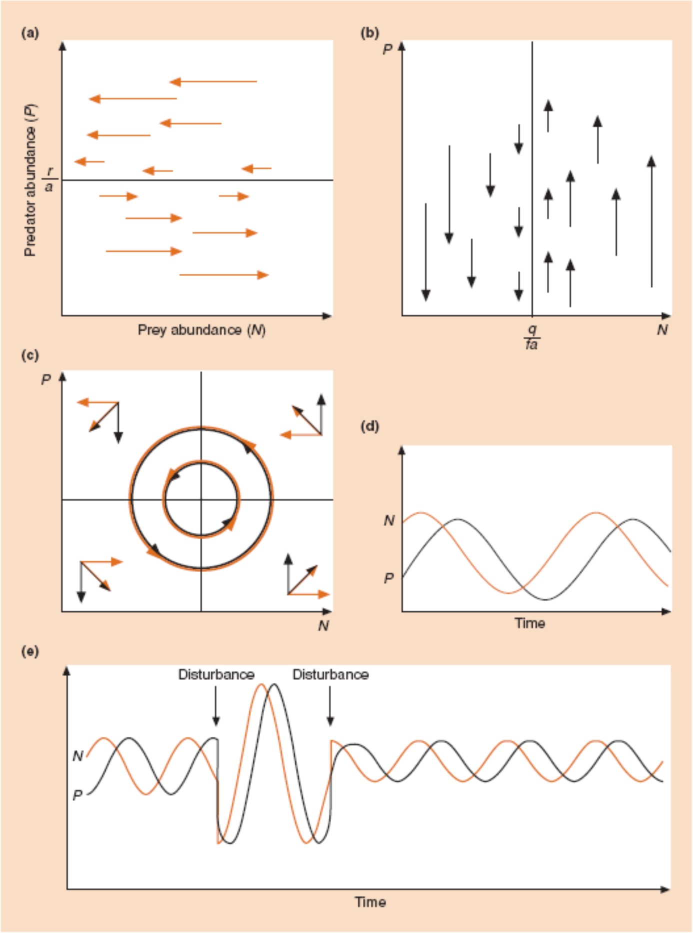
dt

B: birth rate

D: death rate



Lotka-Volterra predator-prey model



Predator:

dN1
----- = (B1*N2-D1)*N1
dt

Prey:

dN2
----- = (B2-D2*N1)*N2
dt

The paradox of the pesticides is a paradox that states that applying pesticide to a pest may end up increasing the abundance of the pest if the pesticide upsets natural predator–prey dynamics in the ecosystem.

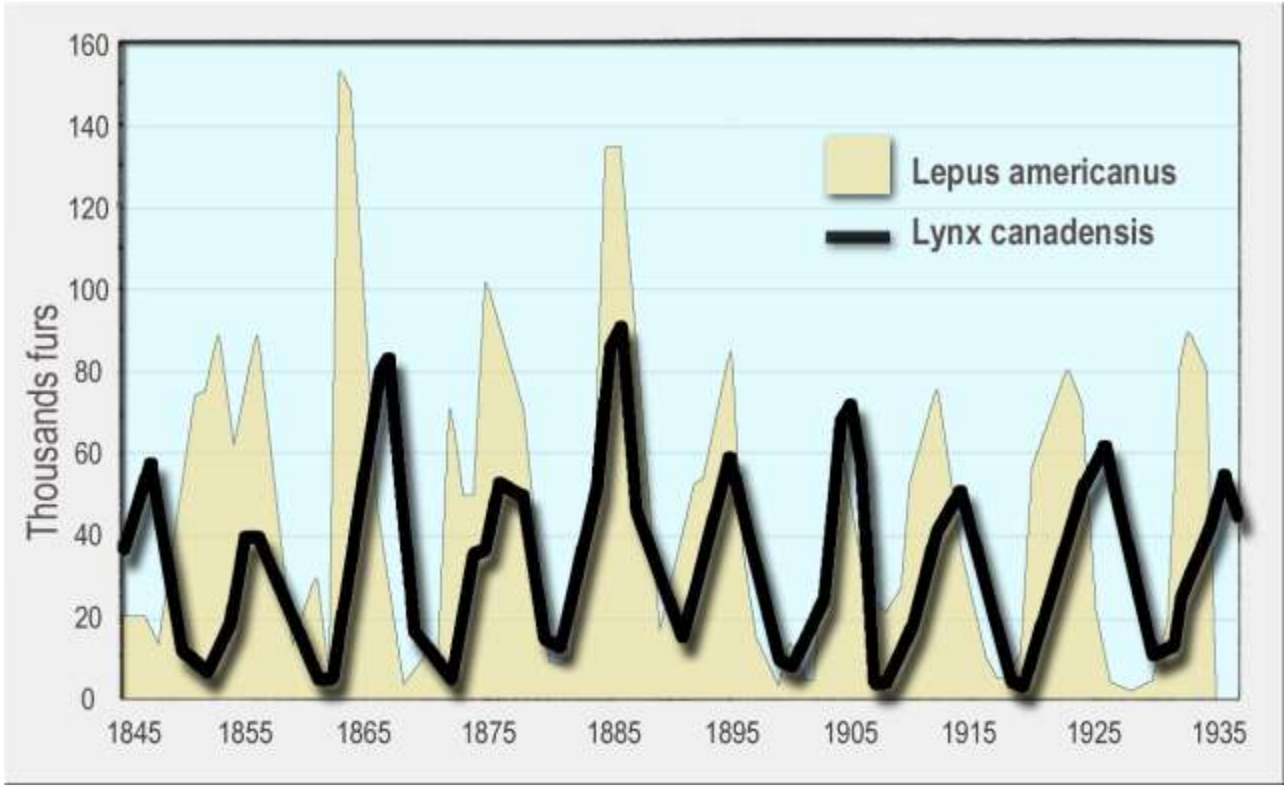
Lotka-Volterra predator-prey model

Predator:

dN1
----- = (B1*N2-D1)*N1
dt

Prey:

dN2
----- = (B2-D2*N1)*N2
dt



Fluctuating numbers of predators and prey have been observed in natural populations, such as the lynx and snowshoe hare data of the Hudson's Bay Company. The hare fluctuate in numbers because of interactions with their food plants, which plants produce more toxic compound at large hare density

Food web - stability

Stability increase:

- With larger spatial heterogeneity of the habitat - decrease the dispersal of the predators
- Timing of life stage (e.g. large gradation, mass seed/fruit production)

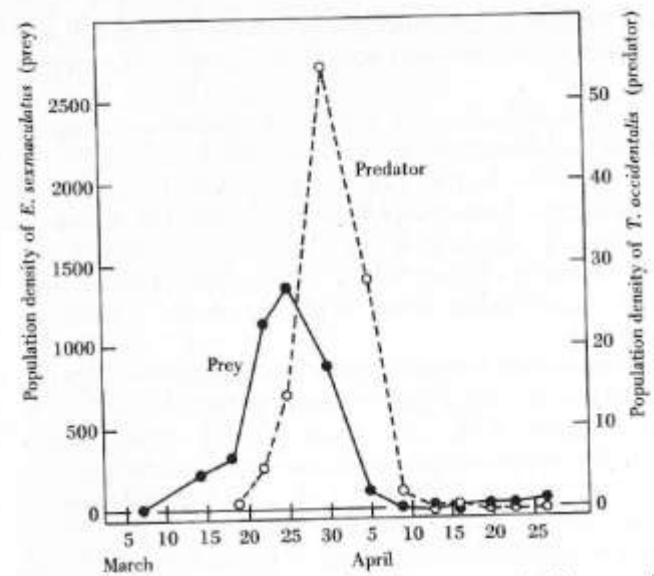


Figure 14.6 Densities per orange area of the prey mite, *Eotetranychus sexmaculatus*, and the predator mite, *Typhlodromus occidentalis*, with 20 small areas of food for the prey (orange surface) alternating with 20 foodless positions. (After Huffaker 1958.)

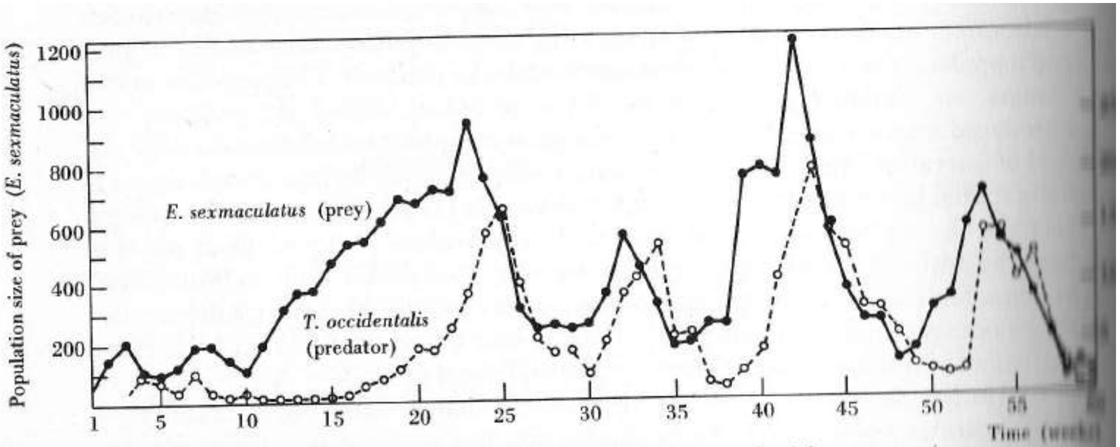


Figure 14.7 Predator-prey interaction between two mites in a complex laboratory environment with a 252-orange system with one-twentieth of each orange exposed for possible feeding by the prey. (After Huffaker et al. 1963.)

Food web - stability

Stability increase:

- With larger spatial heterogeneity which decrease the dispersal of the predators
- Timing of life stage (e.g. large gradation, mass seed/fruit production)
- With more prey and predator species – more diverse food web

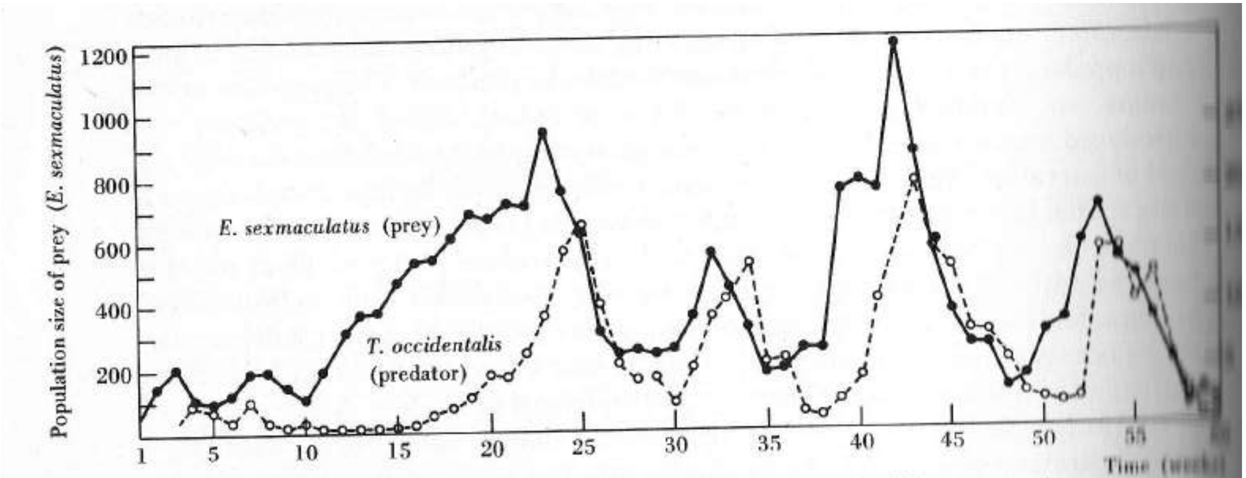
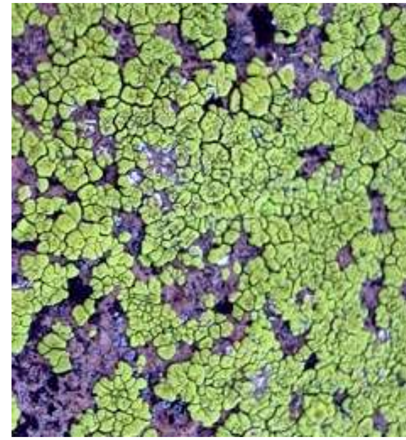


Figure 14.7 Predator-prey interaction between two mites in a complex laboratory environment with a 252-orange system with one-twentieth of each orange exposed for possible feeding by the prey. (After Huffaker et al. 1963.)

Interaction among species

- Competition	- / -
- Predation	+/-
- Commensalism,	+/0
- Amensalism, allelopathy	0/-
- Mutualism	**+/+**
- Neutralism	0/0

Mutualism



Endosymbiont->

- Mitochondria in the eukaryotic cell
- Lichen

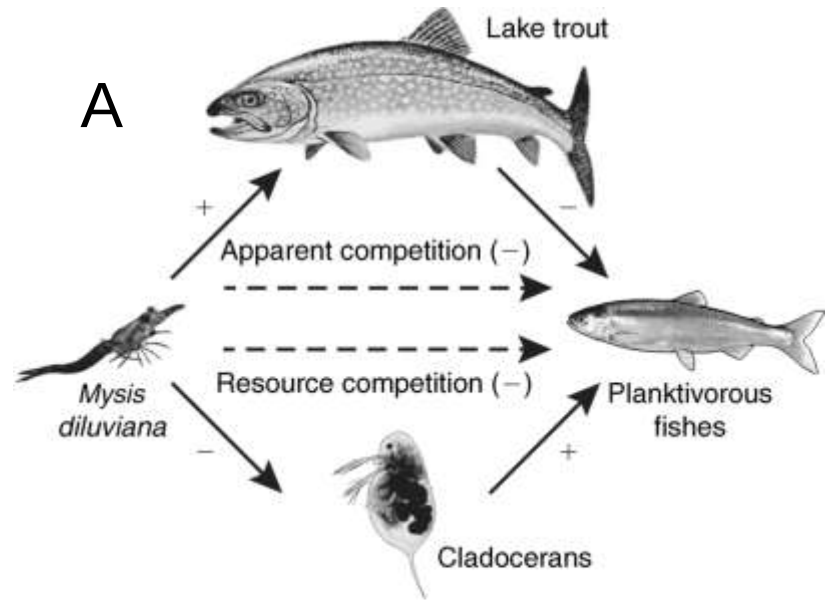
- Vascular plants engaged in mutualistic interactions with mycorrhiza
- Ant protection of aphids, where the aphids trade sugar-rich honeydew
- Rhizobia bacteria that fix nitrogen in leguminous plants

Pollination

Coevolution

- Trophic connection
  - Predator-prey, herbivore-plant, parasite-host
- Non-trophic connection
  - All others
- Indirect effects among species
  - **Resource competition, trophical cascade**

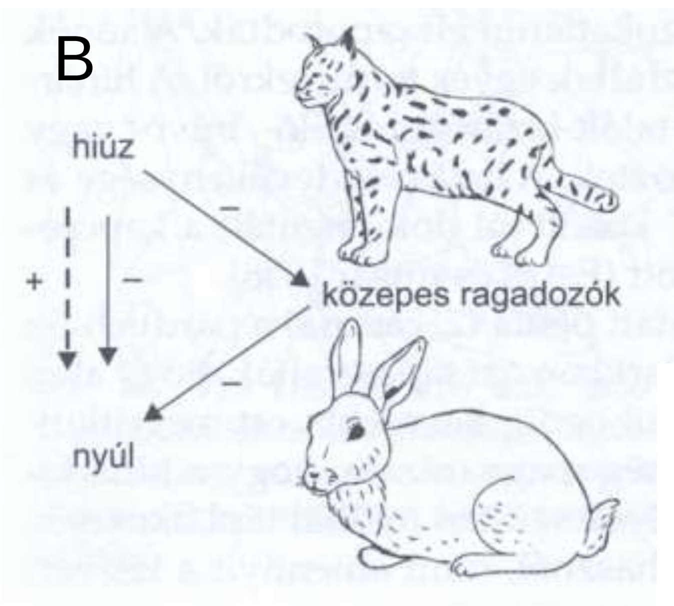
A



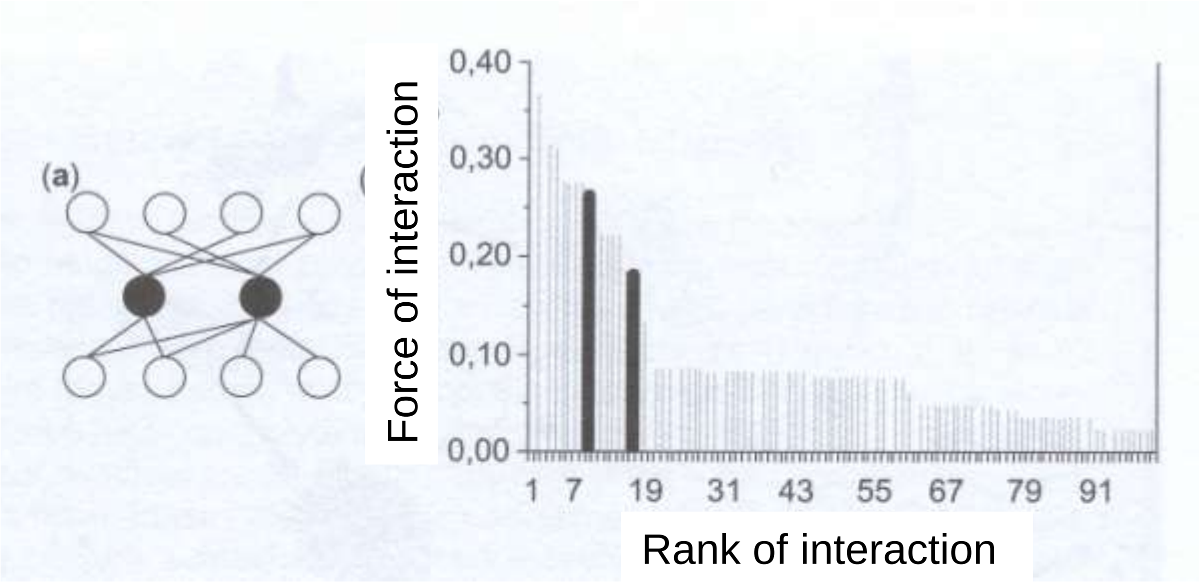
Direct and indirect effects among species

A- Resource competition
B- Trophical cascade

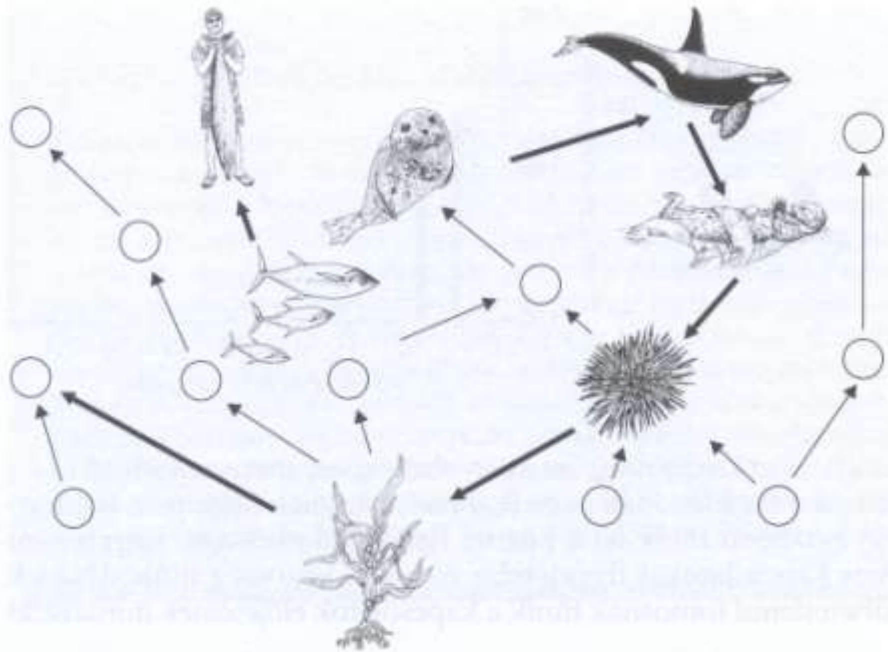
B



# of Lynx (hiúz) and rabbit (nyúl) after reintroduction of the Lynx



Example:10 species with 12 direct effects among them could produce ~ 100 indirect interactions among the 10 species >>> hard to estimate all direct and indirect effects of one species in the food web



7. ábra Egy meglepően hosszú hatásláncolat a fontos fajok kiemelésével. A körök a nem kiemelt fajokat jelölik (Estes és mtsai 1998 nyomán).

Trophic cascade

- More intense fishing along the coast of Alaska 1980-1990
- Less fish – less seals – less Orca
- Orca hunt more southern part of the ocean, predated more sea otter which is the main predator of sea urchin
- Sea urchin number is increased
- Seaweed forests disappeared

Biological communities

Community

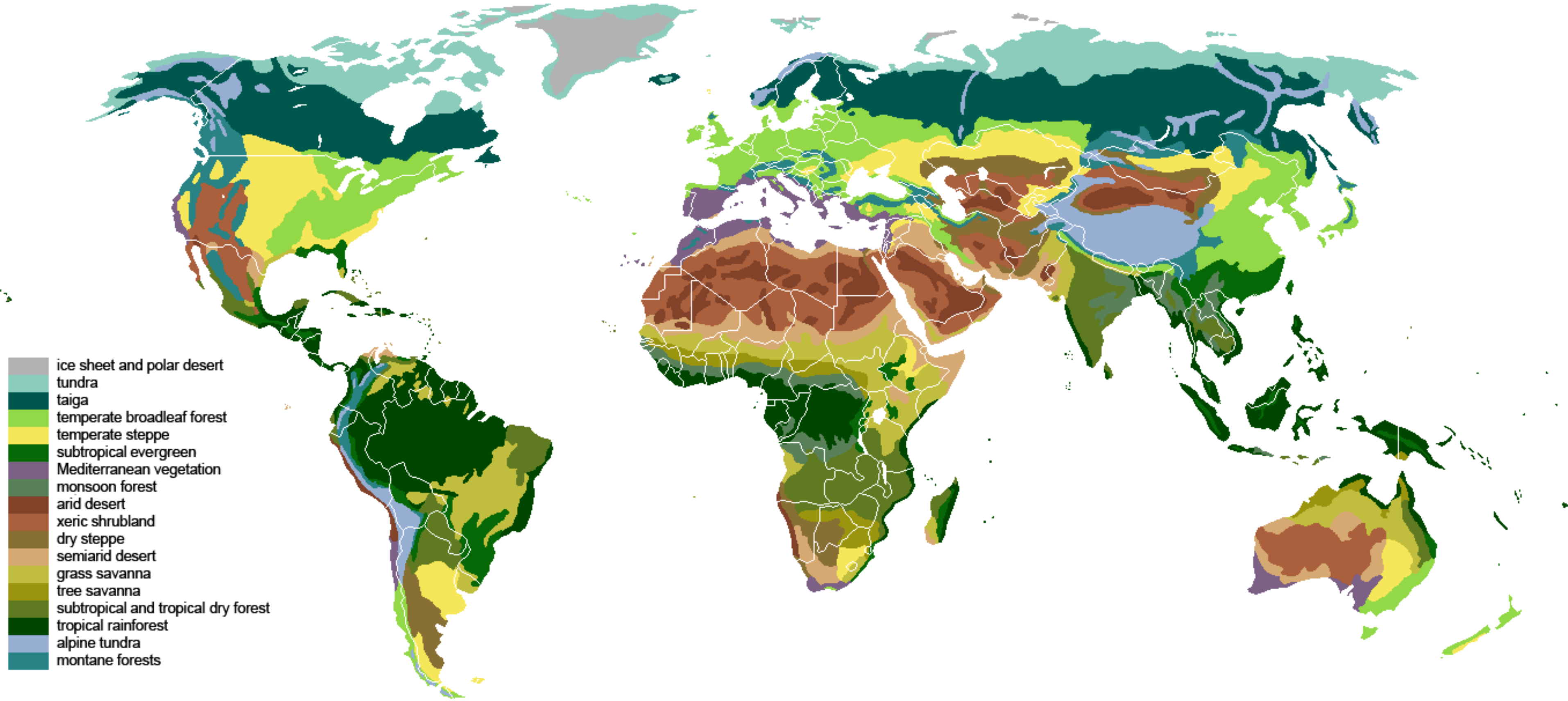
Community is a group or association of populations of two or more different species occupying the same geographical area at the same time.

- Biome is a biogeographical unit consisting of a biological community that has formed in response to the physical environment in which they are found and a shared regional climate.

- Coenosis is a kind of community groups of species of that are usually found together

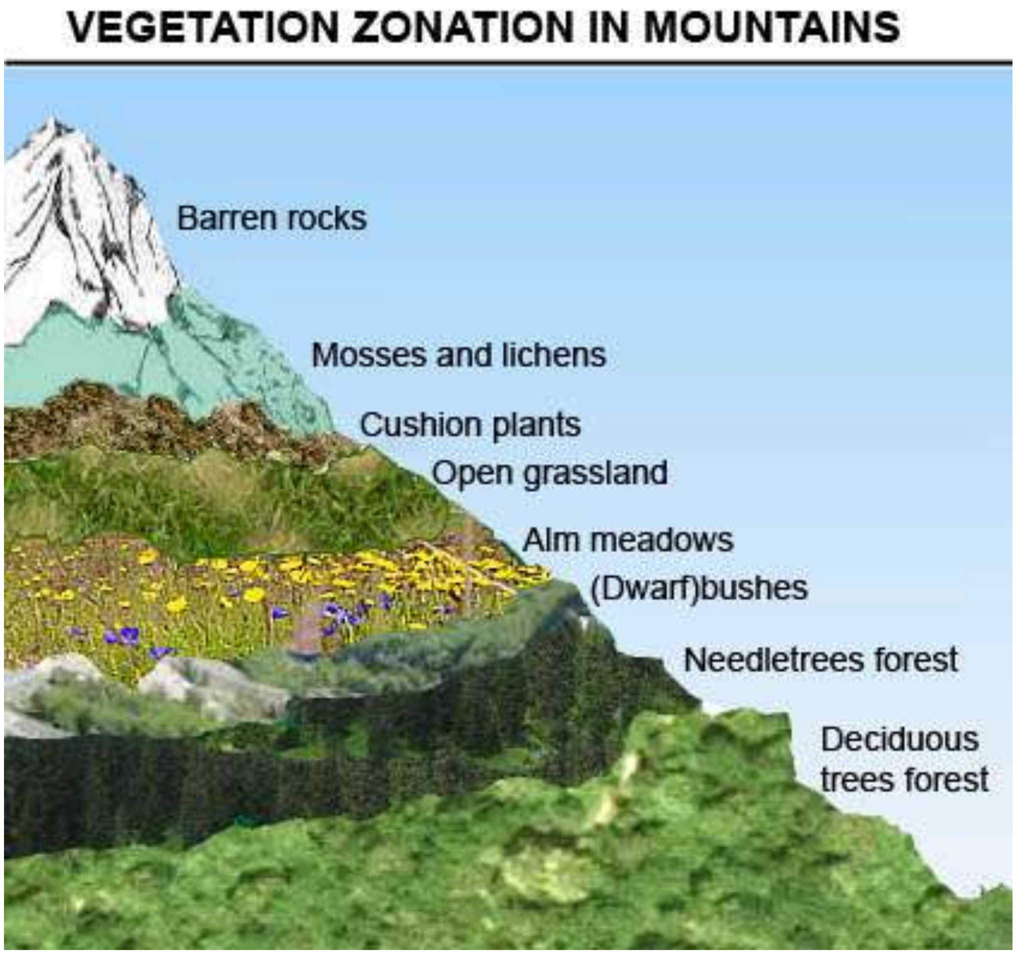
- Guild: a group of species in the community that utilize the same resources in a similar way e.g. insectivorous birds in the forest

Biomes


ice sheet and polar desert
tundra
taiga
temperate broadleaf forest
temperate steppe
subtropical evergreen
Mediterranean vegetation
monsoon forest
arid desert
xeric shrubland
dry steppe
semiarid desert
grass savanna
tree savanna
subtropical and tropical dry forest
tropical rainforest
alpine tundra
montane forests

Zonation

The broad distribution of vegetation according to latitude and altitude.



Phytocoenosis

Description of community composition

Biodiversity

- # of species – species richness

- Rank –abundance diagram

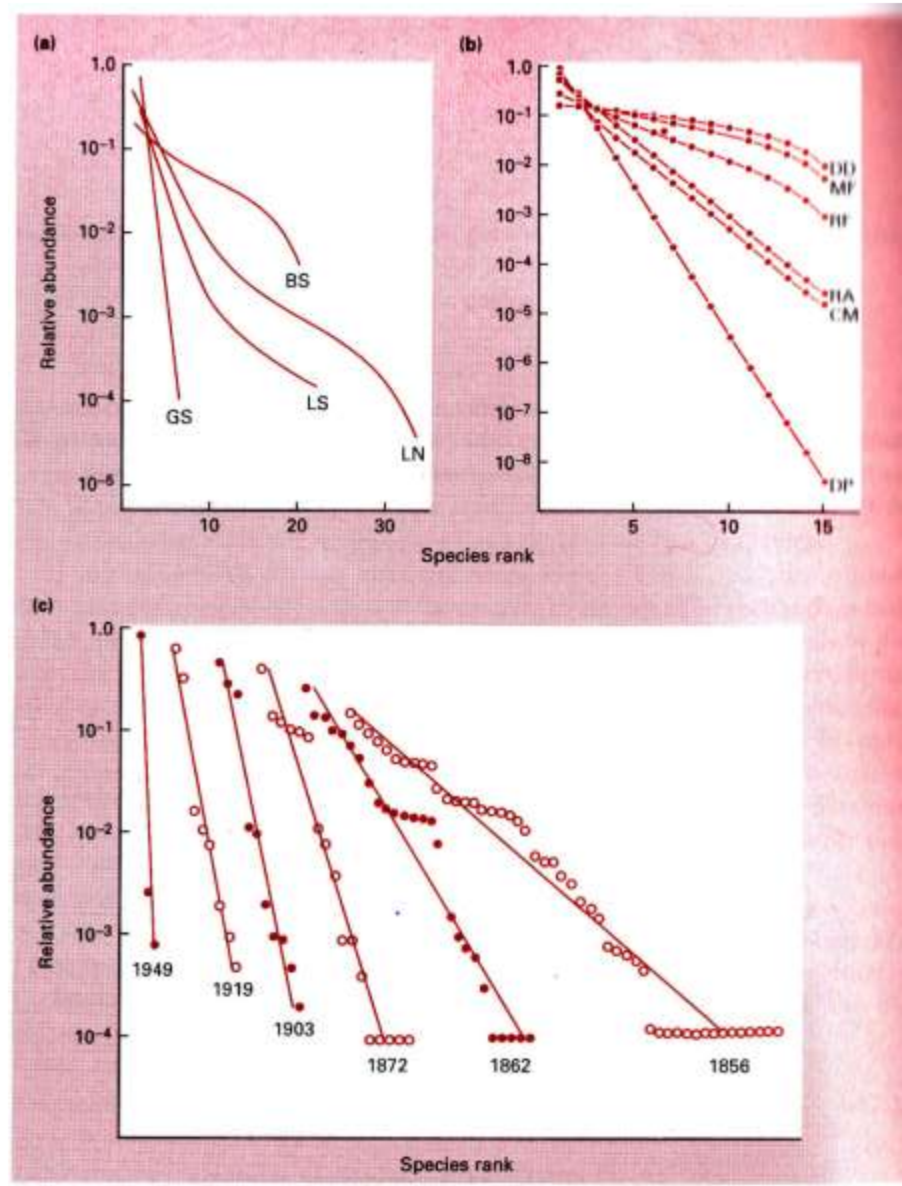


Figure 17.4 (a, b) Rank–abundance patterns of various models. Two are statistically orientated (LS and LN), whilst the rest can be described as niche orientated. (a) BS, broken stick; GS, geometrical series; LN, log-normal; LS, log series. (b) CM, composite; DD, dominance decay; DP, dominance pre-emption; MF, MacArthur fraction; RA, random assortment; RF, random fraction. (c) Change in the relative abundance pattern (geometrical series fitted) of plant species in an experimental grassland subjected to continuous fertilizer from 1856 to 1949. (After Tokeshi, 1993.)

Description of community composition

Biodiversity

- # of species – species richness

Shannon diversity index

$$H = -\sum_{i=1}^{n} pi * \ln pi$$

Consider number of species and proportion of species in the community

n: # of species

pi: the proportion of individuals belonging to the *i*th species

Bird community of the same forest in two different years

A

Species	**Ni**	**pi**	**ln pi**	**pi * ln pi**	**1/S**	**ln (1/S)**	**(1/S) * ln (1/S)**
Great tit	13	0.406	-0.901	-0.366	0.143	-1.946	-0.278
Blue tit	8	0.250	-1.386	-0.347	0.143	-1.946	-0.278
Blackbird	4	0.125	-2.079	-0.260	0.143	-1.946	-0.278
Nuttach	3	0.094	-2.367	-0.222	0.143	-1.946	-0.278
G.Woodpecker	2	0.063	-2.773	-0.173	0.143	-1.946	-0.278
Jay	1	0.031	-3.466	-0.108	0.143	-1.946	-0.278
Buzzard	1	0.031	-3.466	-0.108	0.143	-1.946	-0.278
S	**7**						
N	32						
H				**1.584**			
Hmax							1.946
E							**0.814**

B

species	**Ni**	**pi**	**ln pi**	**pi * ln pi**	**1/S**	**ln (1/S)**	**(1/S) * ln (1/S)**
Great tit	20	0.625	-0.470	-0.294	0.143	-1.946	-0.278
Blue tit	5	0.156	-1.856	-0.290	0.143	-1.946	-0.278
Blackbird	3	0.094	-2.367	-0.222	0.143	-1.946	-0.278
Nuttach	1	0.031	-3.466	-0.108	0.143	-1.946	-0.278
G.Woodpecker	1	0.031	-3.466	-0.108	0.143	-1.946	-0.278
Jay	1	0.031	-3.466	-0.108	0.143	-1.946	-0.278
Buzzard	1	0.031	-3.466	-0.108	0.143	-1.946	-0.278
S	**7**						
N	32						
H				**1.239**			
Hmax							1.946
E							**0.637**

Dynamics of the communities

1. Cyclic change

- **Aspect**

  change with period of the year (e.g. spring, summer, autumn,..)

- **Fluctuation**

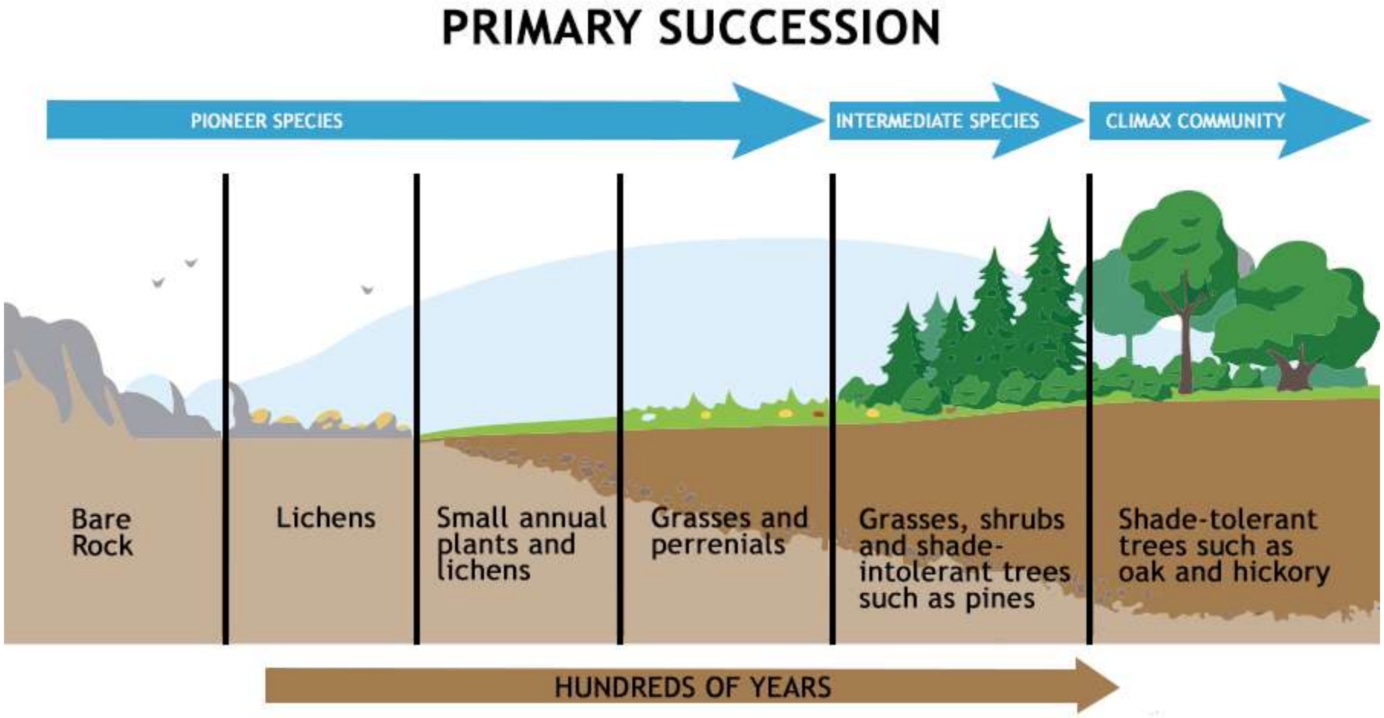
  Depends on hard to predict climate changes (e.g. droughts, floods,…)

2. Directional change

- **Succession**
- **Degradation**

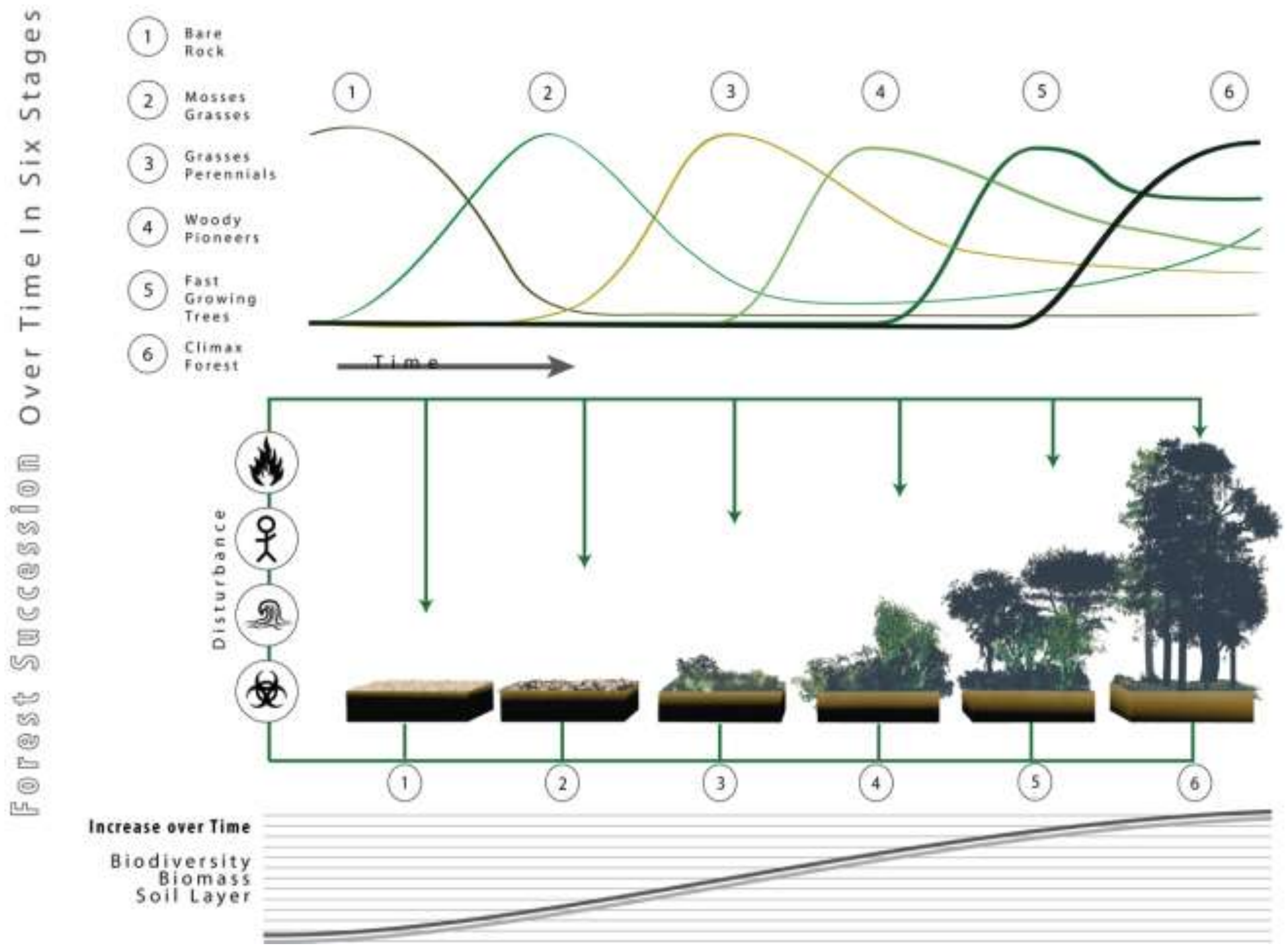
Succession

The process of change in the species that make up an ecological community over time.



- Successional dynamics beginning with colonization of an area that has not been previously occupied by an ecological community are referred to as **primary succession**
  - biotic succession, in steady macroclimatique condition
  - natural succession, without human effects

Succession



Start: Pioneer community – few, dominantly R strategist species – low biodiversity

Finish: Climax community – the highest biodiversity, dominantly K strategist species.

primary succession

Areas of Melting glaciers

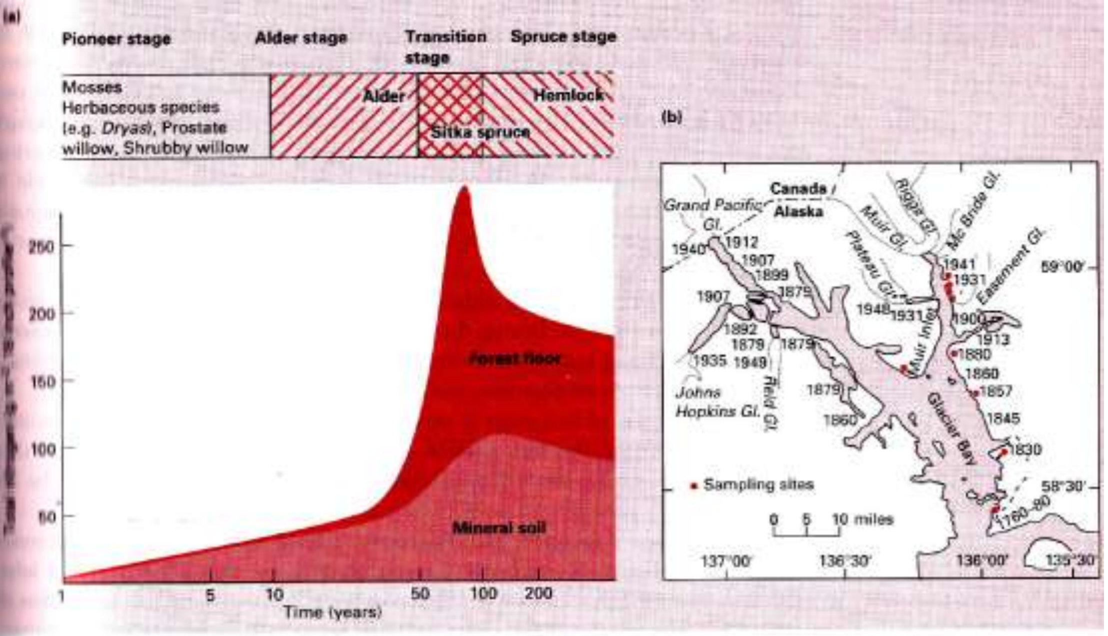


Figure 17.11 (a) Plant succession after glacial retreat in Glacier Bay, Alaska, and changes in total nitrogen content of the soils. (b) History of ice recession at Glacier Bay. (After Crocker & Major, 1955.)

Seral stage	Pioneer	*Dryas*	Alder	Spruce
Time (years) since glacial retreat	5	40	60	200
Soil depth (cm)	5.2	7.0	8.8	15.1
Soil N (g/m^2)	3.8	5.3	21.8	53.3
Soil pH	7.2	7.3	6.8	3.6
Litterfall (g/m^2 /yr)	1.5	2.8	277	261

(a) Cyanobacteria, Moss, Lichens

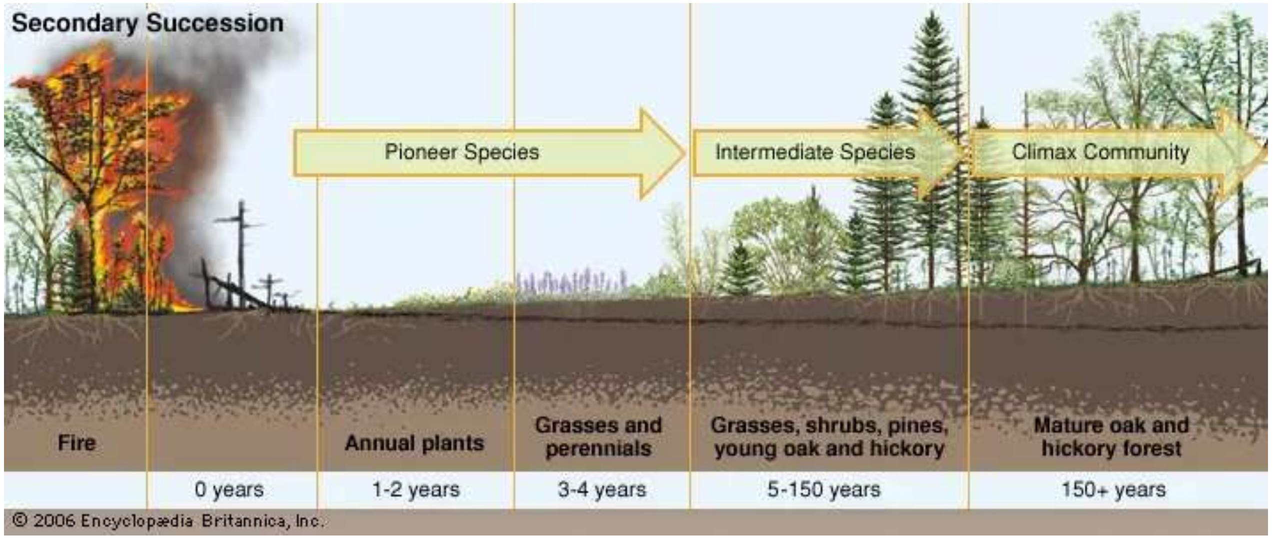
(b) Mountain avens (*Dryas drummondii*)

(c) Alder (*Alnus sinuata*)

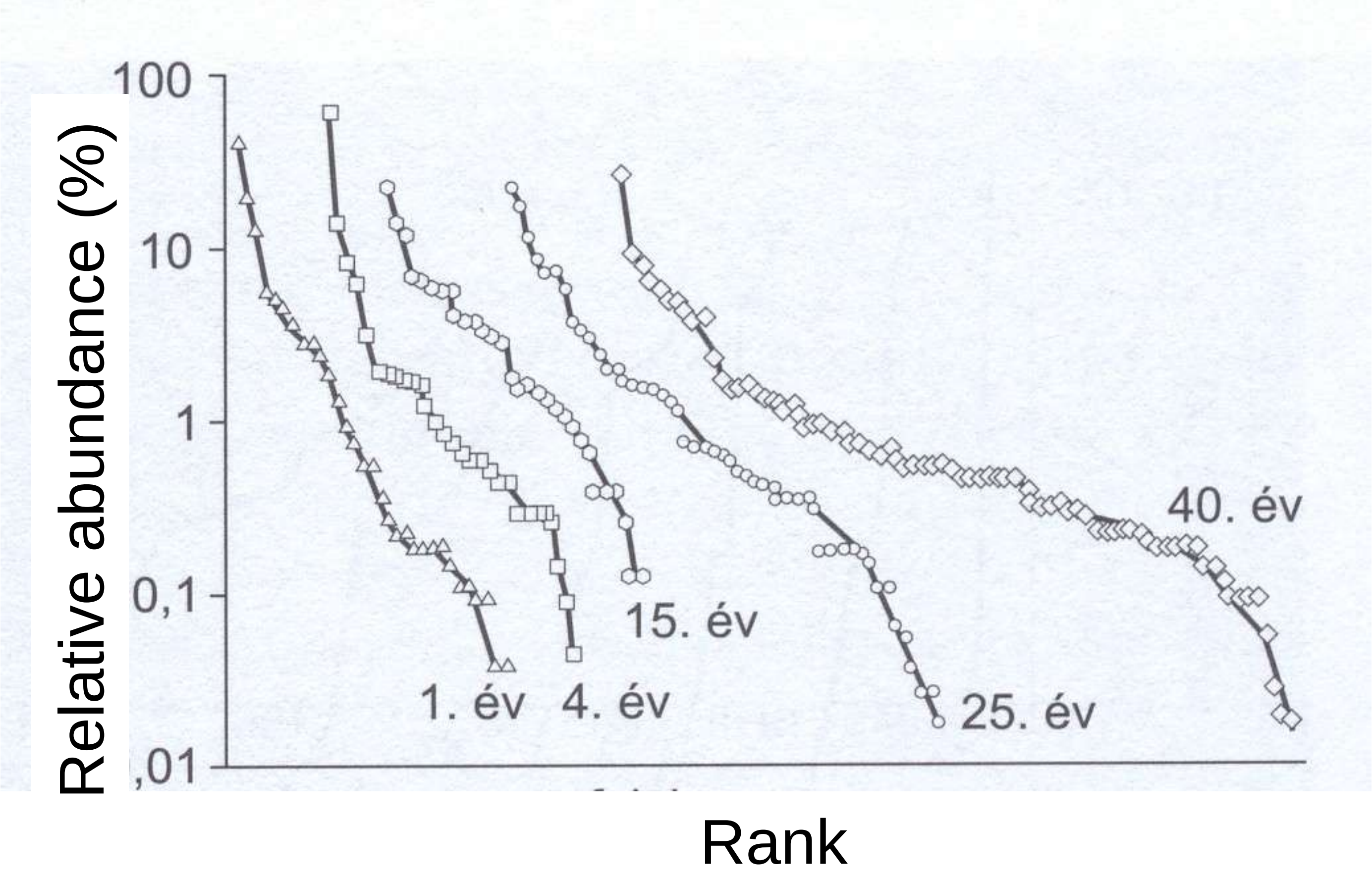
(d) Spruce (*Picea sitchensis*), Western hemlock (*Tsuga heterophylla*)

Succession

Secondary succession is the ecological succession that occurs after the initial succession has been disrupted and some plants and animals still exist. It is usually faster than primary succession as soil is already present, and seeds, roots, and the underground vegetative organs of plants may still survive in the soil



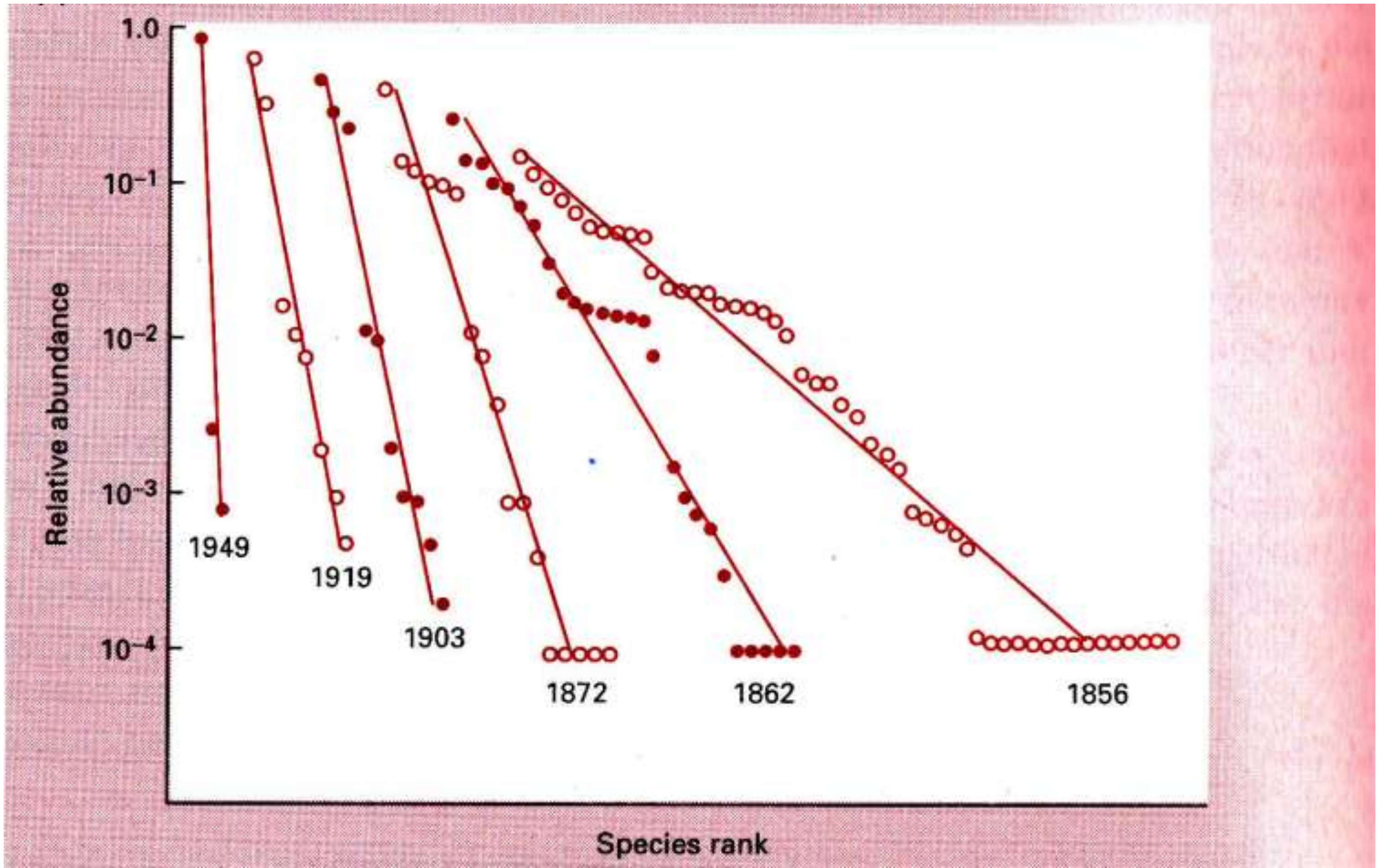
- It is called progressive when the process is in the direction of climax community
- Degradation when the direction is opposite



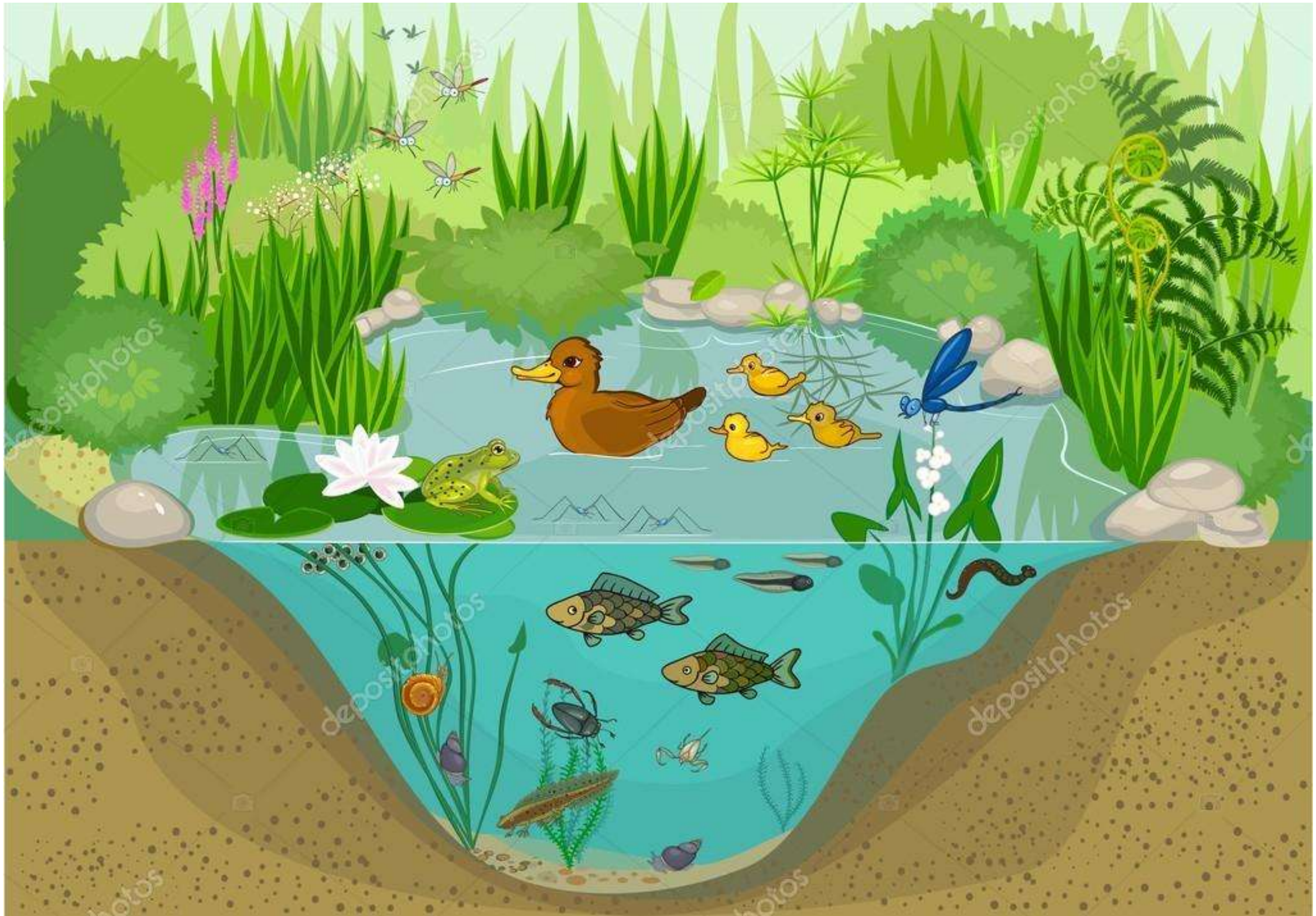
Change of rank abundance pattern in an out of crop field in USA during 40 year (év) – secondary succession

Degradation

Change by continuous usage of fertiliser between 1856-1949



Flux on energy and matter in the Ecosystem



Flux on energy and matter in the Ecosystem

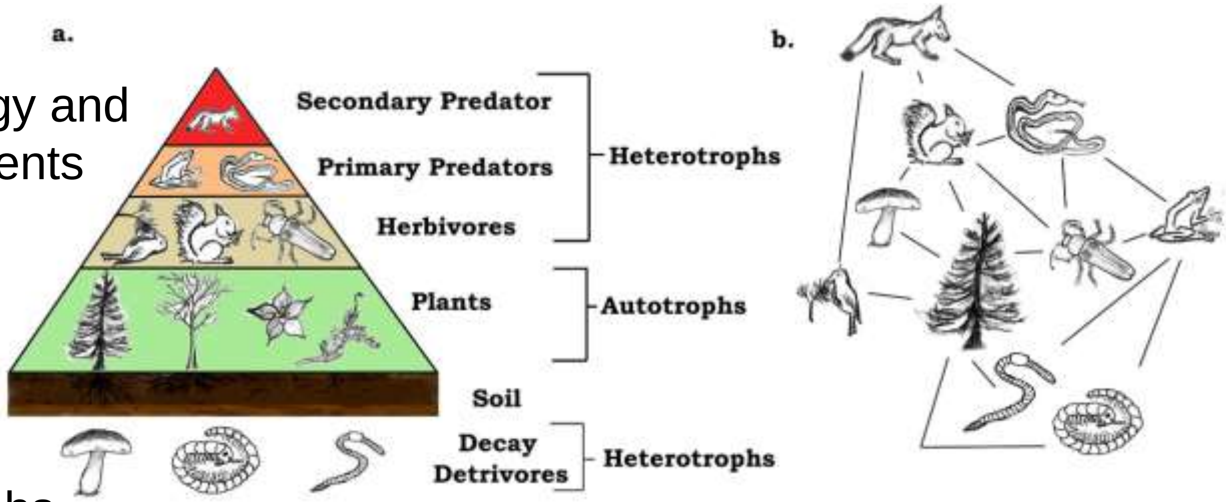
Ecosystem - consists of all the organisms and the physical environment with which they interact

- Open system

Investigations of flux of energy and matter among Compartments

Compartments:

- Abiotic environment
- Biotic
    - Producens - Autotrophs
    - Consumers - Heterotrophs
    - Detrivores - Heterotrophs



- Self-regulatory system, importance of negative feedback

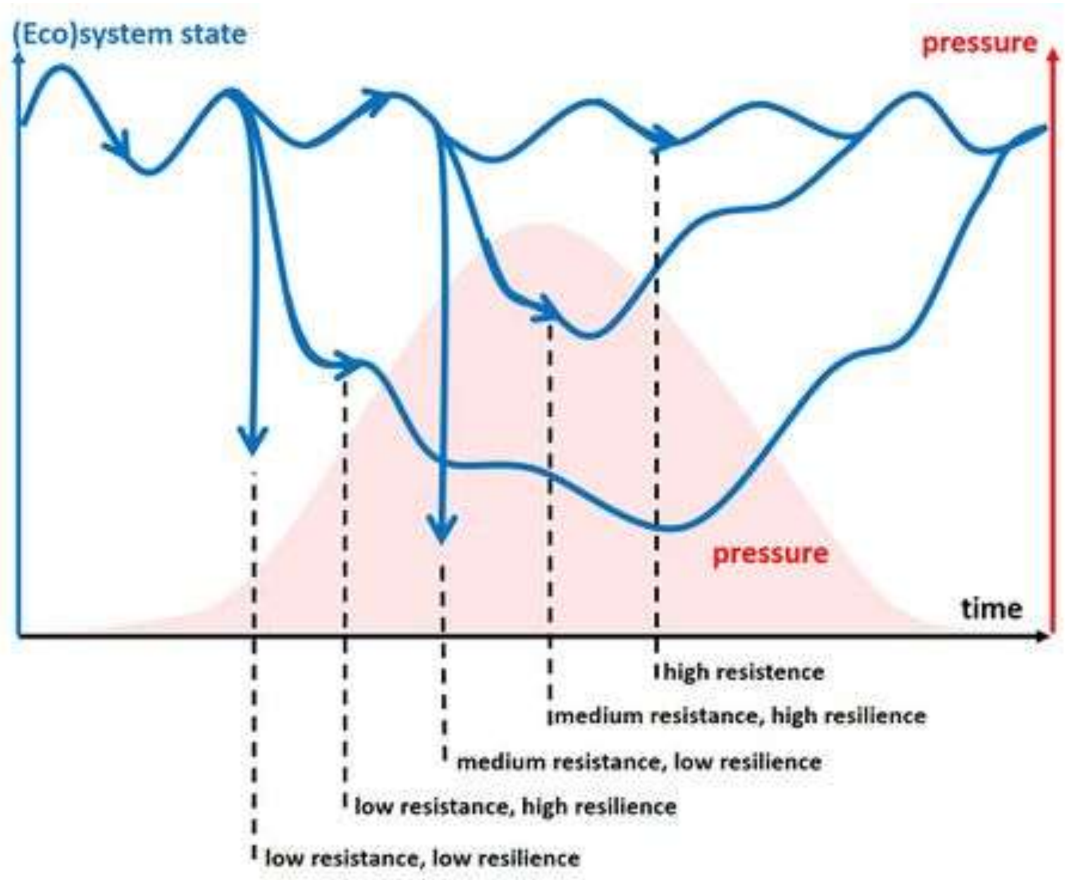
Materials -> ~ circular flow

Energy -> unidirectional

Ecosystems are dynamic entities.

They are subject to periodic disturbances and are always in the process of recovering from past disturbances

- The tendency of an ecosystem to remain close to its equilibrium state, despite that disturbance, is termed its resistance.
- The capacity of a system to absorb disturbance and reorganize while undergoing change so as to retain essentially the same function, structure, identity, and feedbacks is termed its ecological resilience.



Biomass

Biomass is the mass of living biological organisms in a given area or ecosystem at a given time (g/m^2, C g/m^2)

Primary production – Basement of any Ecosystem

- Synthesis of organic compounds from atmospheric or aqueous carbon dioxide.

- It principally occurs through the process of photosynthesis, which uses light as its source of energy, but it also occurs through chemosynthesis, which uses the oxidation or reduction of inorganic chemical compounds as its source of energy.

- Phytomass (plant biomass)

  Nekromass- mass of phytomass (e.g. timber) which not produce biomass

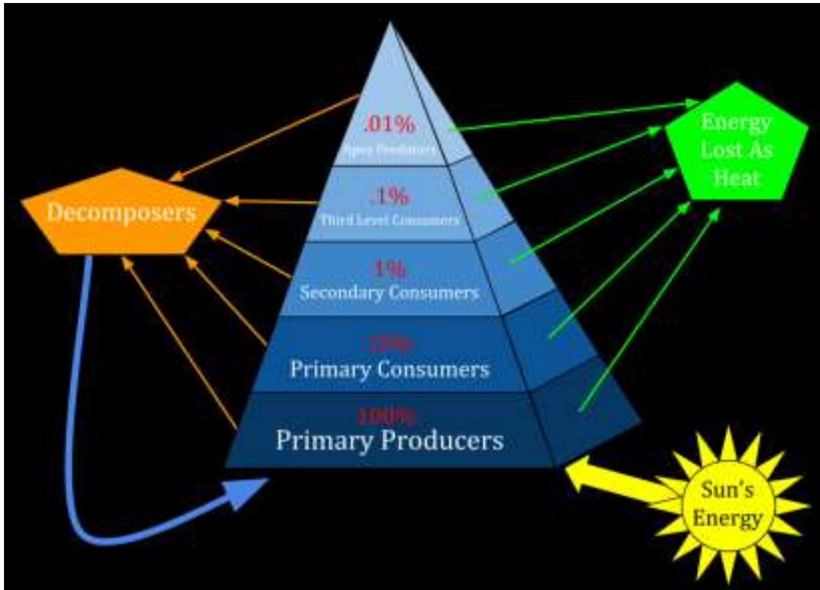
Secunder production, biomass produced by consumers

- Zoomass

Phytomass 120 times more comparing to Zoomass in the terrestrial ecosystems

In forest, 70-80% above the soil

In grassland 50-70% in the soil



Biomass

Gross Primary Production (GPP) - Production of biomass within a year

Net Primary Production (NPP) = GPP - respiration [by plants]

Some fraction of GPP is used by primary producers for cellular respiration and maintenance of existing tissues (i.e., "growth respiration" and "maintenance respiration")

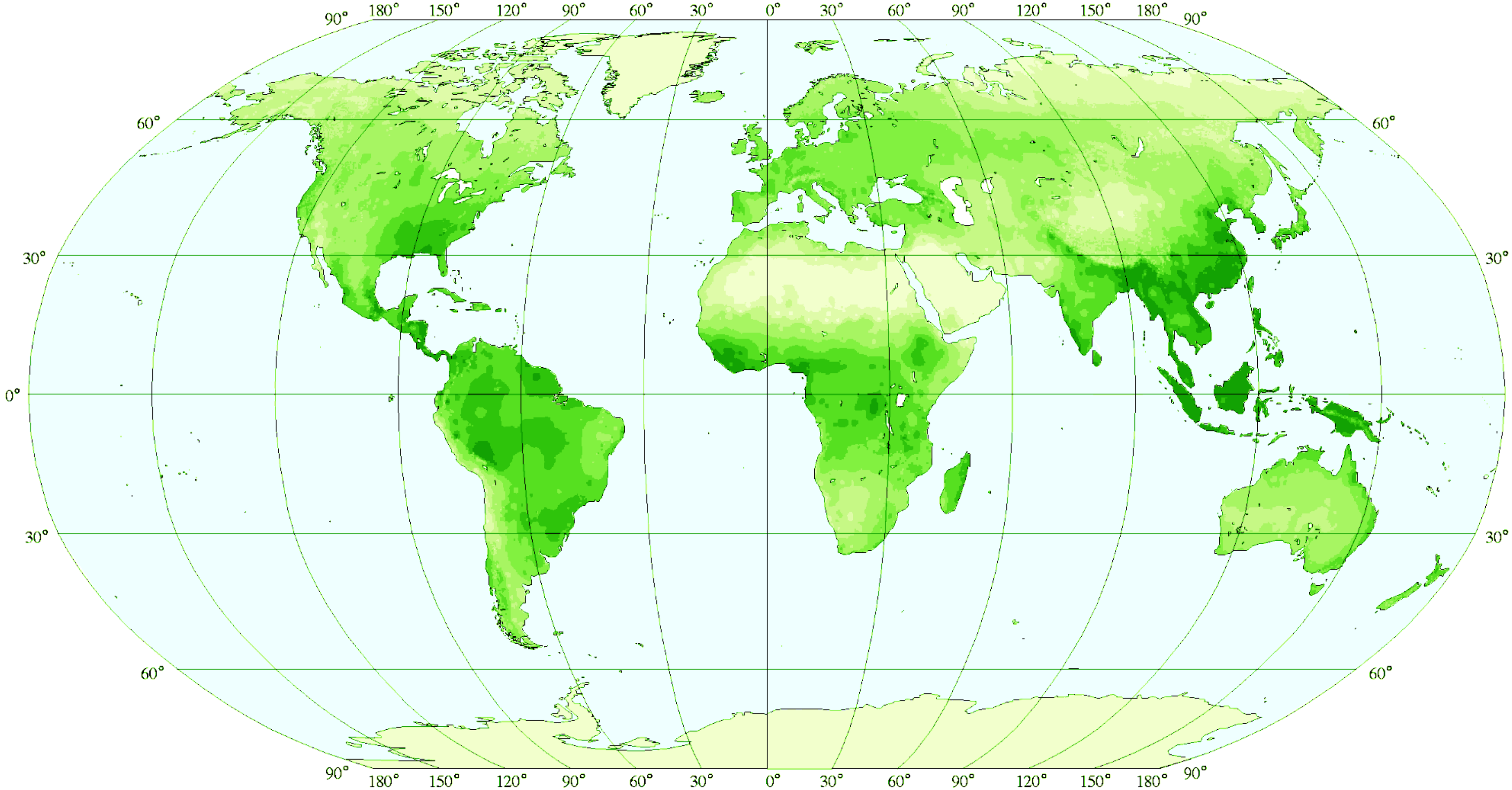
Respiration of plants vary between 15-75% of GPP 15-75% (grassland:15-25%, temperate forest: 50-60%, tropical forest: 70-75%)

GPP of the Biosphere 223 gigaT C/year, Continents: 120 gigaT/year, Oceans: 103 gigaT/year

NPP of the Biosphere 112 gigaT C/year

Net Secondary Production (NSP) 1-2 order of magnitude less comparing to NPP

Global net primary productivity



Land NPP [g / m²/ a]			
	nodata		1000 –1500
	< 50		1500 –2000
	50 –250		2000 –2500
	250 –500		> 2500
	500 –1000		

Ozean NPP [g / m²/ a]	
	< 80
	80 –120
	120 –200
	200 –400
	> 400

NPP pattern on land calculated from temperature and precipitation averages with the equations of the MIAMI–MODELL (LIETH 1973) and corrected for soil fertility by a table function based on the FAO/UNESCO–world soil map from S. Stegmann.

NPP pattern on the ocean adapted from KOBLENTZ–MISHKE, VOLKOVINSKI and KABANOVA (1970).

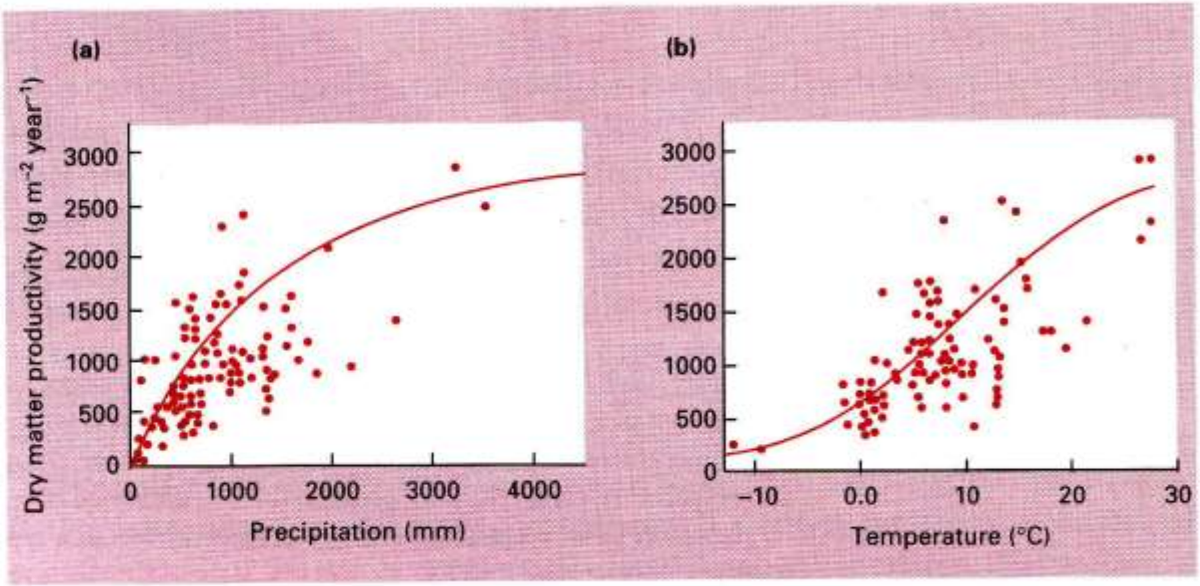
Map source : http://www.usf.Uni-Osnabrueck.DE/~hlieth

J. Berlekamp
S. Stegmann
H. Lieth

Institute of Environmental Systems Research
Universität Osnabrück
D-49069 Osnabrück
Germany

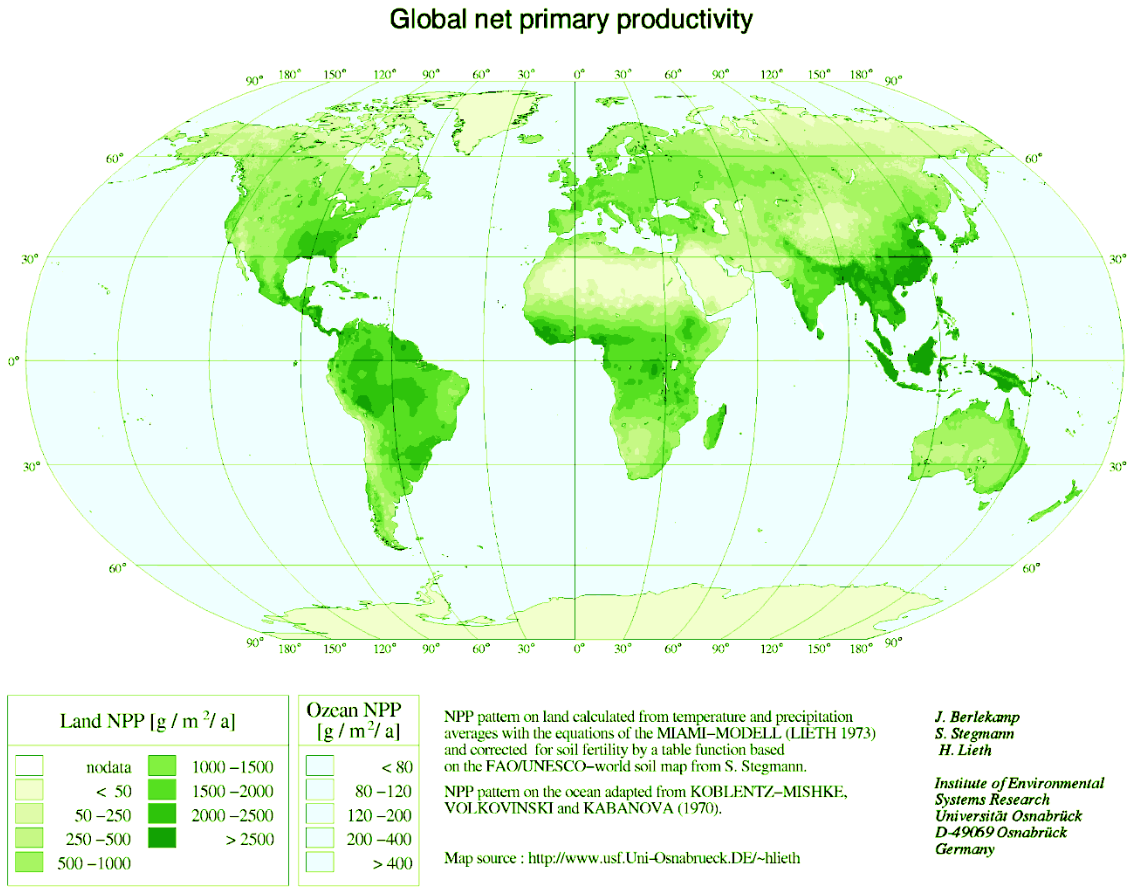
Table 18.1 Annual net primary productivity (NPP) and standing crop biomass estimates for contrasting communities of the world. (After Whittaker, 1975.)

Ecosystem type	Area (10^6 km^2)	NPP, per unit area (g m^{-2} *or* t km^{-2}) Normal range	Mean	World NPP (10^9 t)	Biomass per unit area (kg m^{-2}) Normal range	Mean	World biomass (10^9 t)
Tropical rainforest	17.0	1000–3500	2200	37.4	6–80	45	765
Tropical seasonal forest	7.5	1000–2500	1600	12.0	6–60	35	260
Temperate evergreen forest	5.0	600–2500	1300	6.5	6–200	35	175
Temperate deciduous forest	7.0	600–2500	1200	8.4	6–60	30	210
Boreal forest	12.0	400–2000	800	9.6	6–40	20	240
Woodland and shrubland	8.5	250–1200	700	6.0	2–20	6	50
Savannah	15.0	200–2000	900	13.5	0.2–15	4	60
Temperate grassland	9.0	200–1500	600	5.4	0.2–5	1.6	14
Tundra and alpine	8.0	10–400	140	1.1	0.1–3	0.6	5
Desert and semi-desert shrub	18.0	10–250	90	1.6	0.1–4	0.7	13
Extreme desert, rock, sand and ice	24.0	0–10	3	0.07	0–0.2	0.02	0.5
Cultivated land	14.0	100–3500	650	9.1	0.4–12	1	14
Swamp and marsh	2.0	800–3500	2000	4.0	3–50	15	30
Lake and stream	2.0	100–1500	250	0.5	0–0.1	0.02	0.05
Total continental	149		773	115		12.3	1837
Open ocean	332.0	2–400	125	41.5	0–0.005	0.003	1.0
Upwelling zones	0.4	400–1000	500	0.2	0.005–0.1	0.02	0.008
Continental shelf	26.6	200–600	360	9.6	0.001–0.04	0.01	0.27
Algal beds and reefs	0.6	500–4000	2500	1.6	0.04–4	2	1.2
Estuaries	1.4	200–3500	1500	2.1	0.01–6	1	1.4
Total marine	361		152	55.0		0.01	3.9
Full total	510		333	170		3.6	1841



Main factors influence the NPP: rain, temperature, minerals, quantity of leaf

- Low level of biomass on the 80% on the Earth (oceans, deserts)
- Tropical forest covers only 11% of the Earth but 40% of the NPP and biomass, other forests provide 20-30% of the NPP.
- Grasslands has 20% of the biomass of the Biosphere, but has 40% of the NPP



Measurement of NPP:

- various methods of estimating dry-weight biomass changes over time
- variation in oxygen concentration (aquatic)

- Remote sensing, NDVI index (Normal Different Vegetation Index), which is related to the proportion of photosyntetically active radiation, is calculated from atmospherically corrected reflected from the near infrared and red of remote sensing data

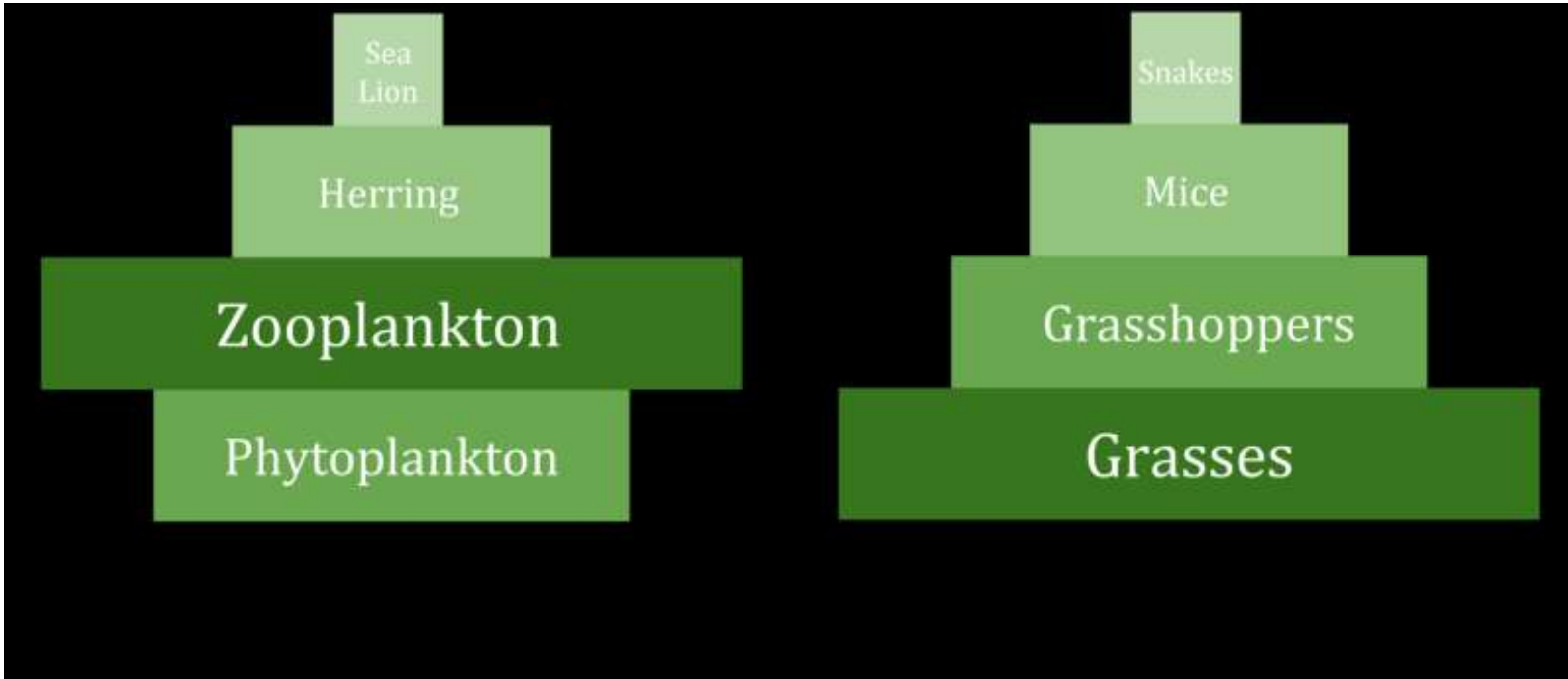
http://earlywarning.usgs.gov/fews/africa/index.php

Net Primary Production (NPP)

- NPP/Biomass ratio (P/B)
    - In aquatic ecosystems – high magas (P/B: 20)
    - In terrestrial ecosystems – low (P/B: 0.13)
    - In terrestrial ecosystems decreasing during the succession

Large difference between terrestrial and aquatic ecosystems

Biomass pyramid aquatic terrestrial



Net Ecosystem Production (NEP)

NEP - The difference between gross primary production (GPP) and net ecosystem respiration

In tropical forests: 70-590 g C/m^2/year, temperate forest 80-700 g C/m^2/year, Biosphere: 10 gigaT C/year

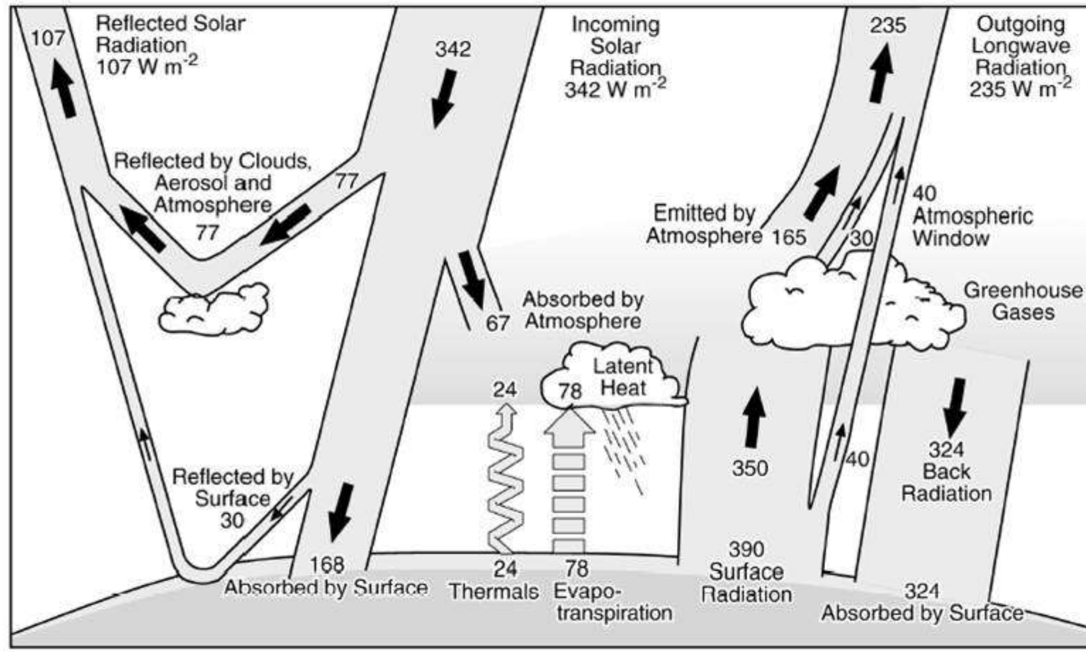
- Disturbance (fire, forest cutting, harvesting,..stb) decrease the NEP, but after it increasing by regeneration

- NEP depend on the seasonal changes of GPP
  - Vegetation period – C - sink (NEP increasing)
  - Dry/Winter period – C – sources (NEP decreasing)

Flux of Energy

Solar energy the main energy source of the photoautotroph (plants) organism

Plant able to use only 0.2-5% of the solar energy



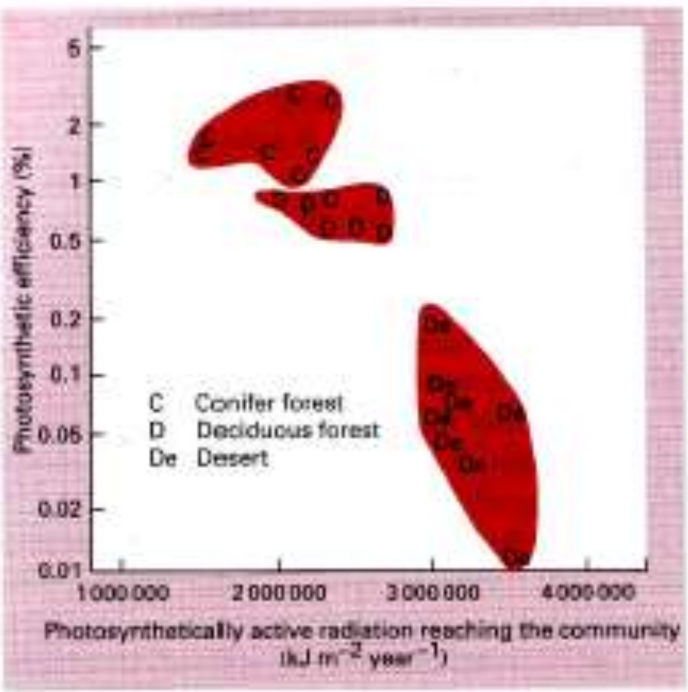


Figure 18.7 Photosynthetic efficiency (percentage of incoming photosynthetically active radiation converted to above-ground net primary productivity) for three sets of terrestrial communities in the USA. (After Webb *et al.*, 1983.)

Trophic Level energy Transfer Efficiency between trophic compartments (TLTE):

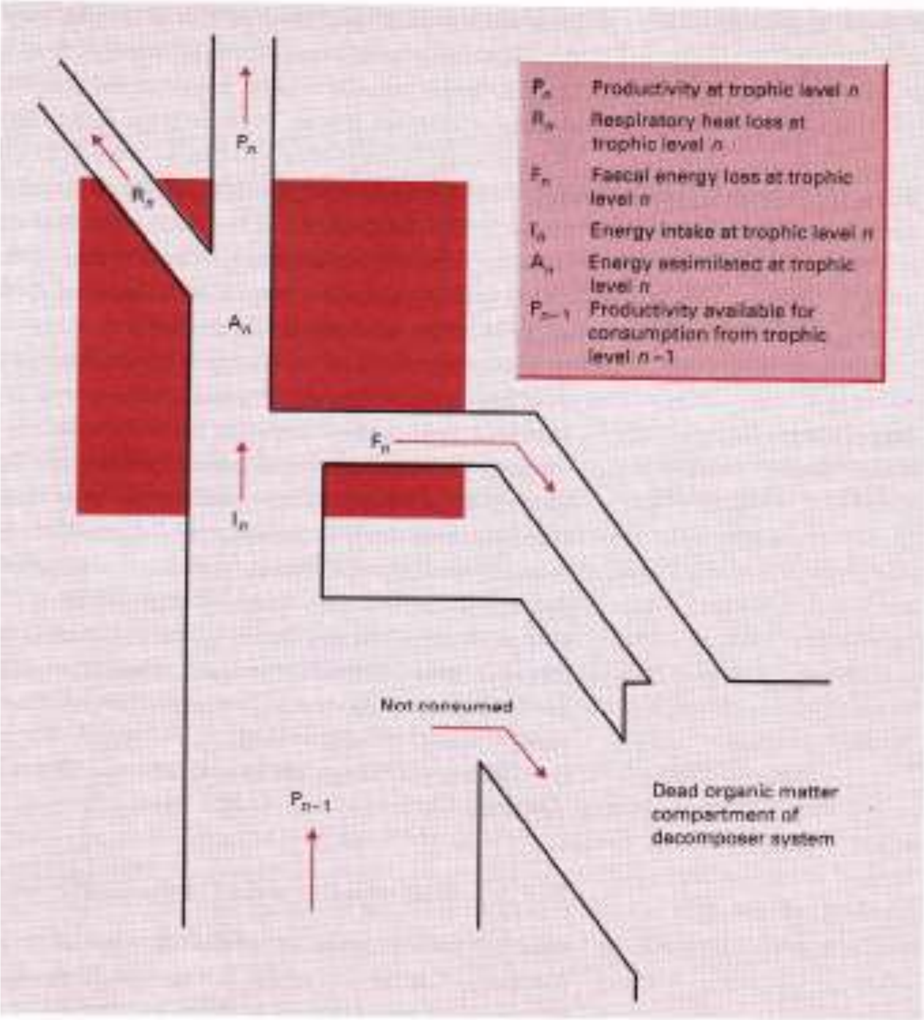
TLTE = CE * AE * PE

Between 2-24%, an average 10%

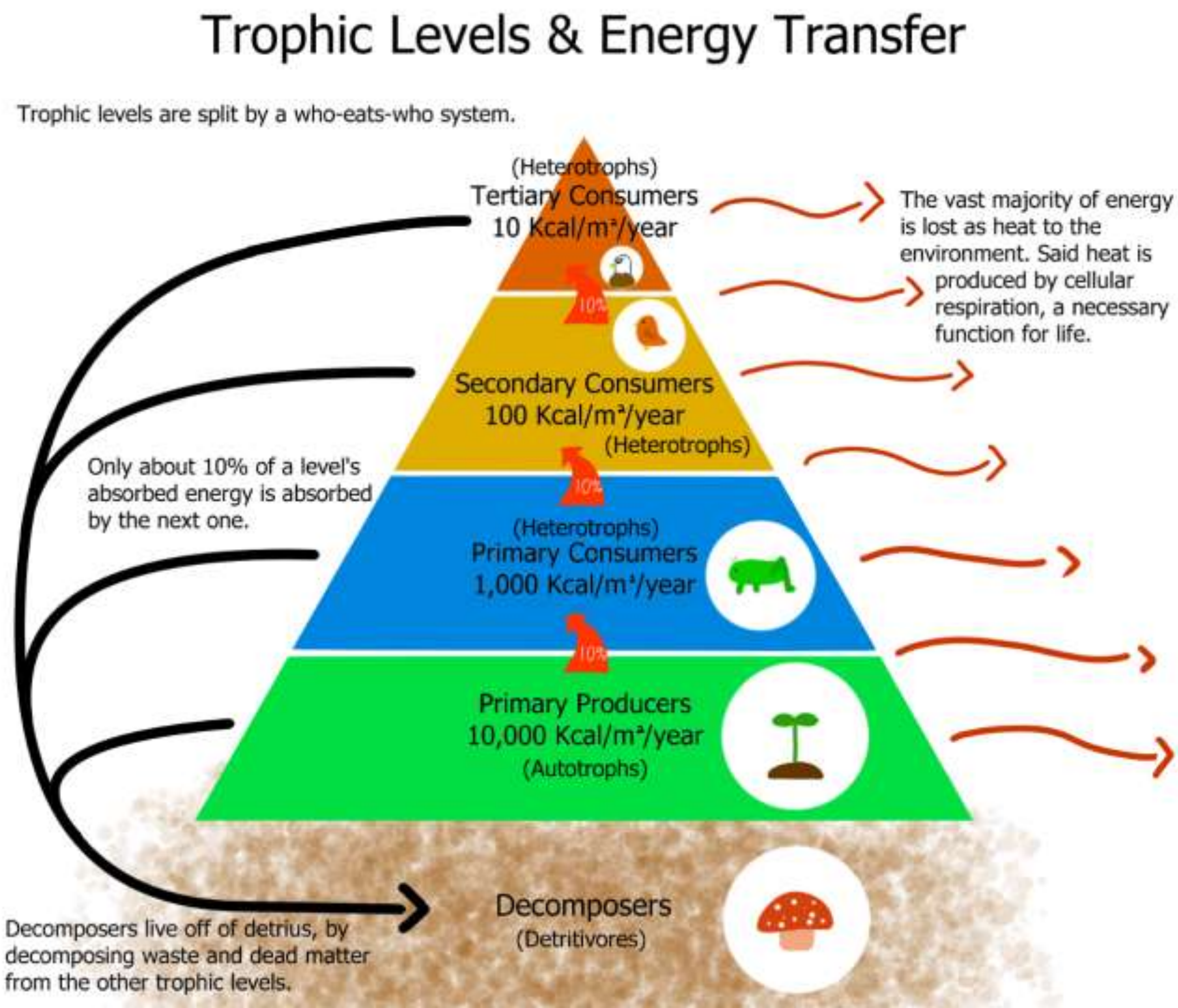
- Consumption efficieny (CE) (5-50%)
- Assimilation efficiency (AE) (herbivore: 20-50%, carnivore: 80%)
- Production efficiency (PE) part of assimilated energy used for production biomass (1-60%)

Table 18.4 Production efficiency (P / A × 100) of various animal groups ranked in order of increasing efficiency. (After Humphreys, 1979.)

Group	P / A (%)
1 Insectivores	0.86
2 Birds	1.29
3 Small mammal communities	1.51
4 Other mammals	3.14
5 Fish and social insects	9.77
6 Non-insect invertebrates	25.0
7 Non-social insects	40.7
Non-insect invertebrates	
8 Herbivores	20.8
9 Carnivores	27.6
10 Detritivores	36.2
Non-social insects	
11 Herbivores	38.8
12 Detritivores	47.0
13 Carnivores	55.6



- Ecosystems are open systems – needs of continuous energy intake
- Food chain length is limited by the energy assimilated by the primary producers
- Stored energy is decreasing in higher trophic level both in terrestrial and aquatic ecosystems



Flux of Matter

Living organism needs macro elements (C, N, H, O, P) which contains more than 1% of their dry weight, and micro elements (e.g. S, K, Na, Ca, Mg, Fe, Cu,..stb) which contains less than 1% of their dry weight.

Most elements cycled in the ecosystem, depending on the spatial distribution

- Gaseous cycles elements (N,C,O) – main store in atmosphere
- Sedimentary cycles element (Ca, P, S) but C – main store in lithosphere

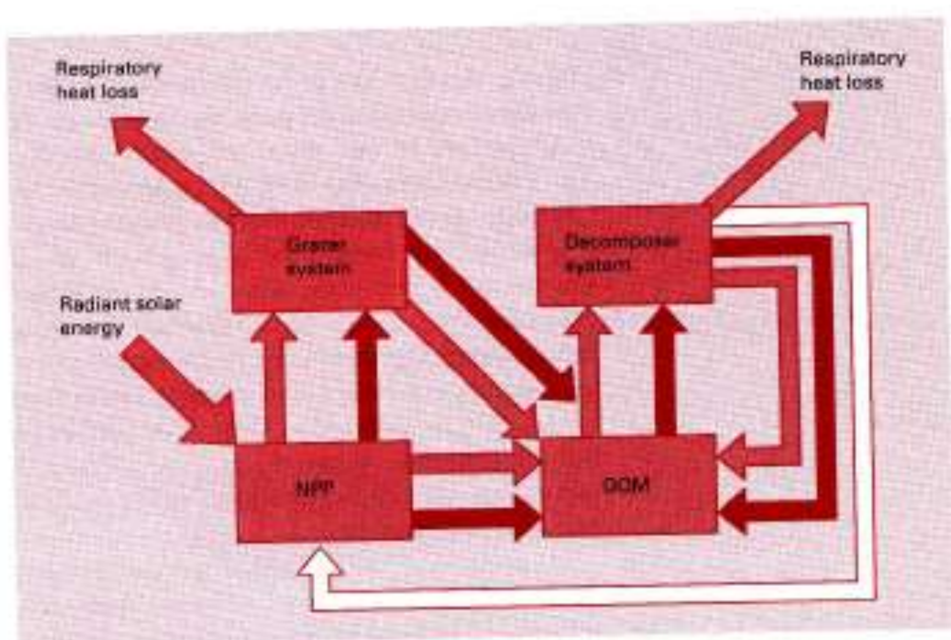
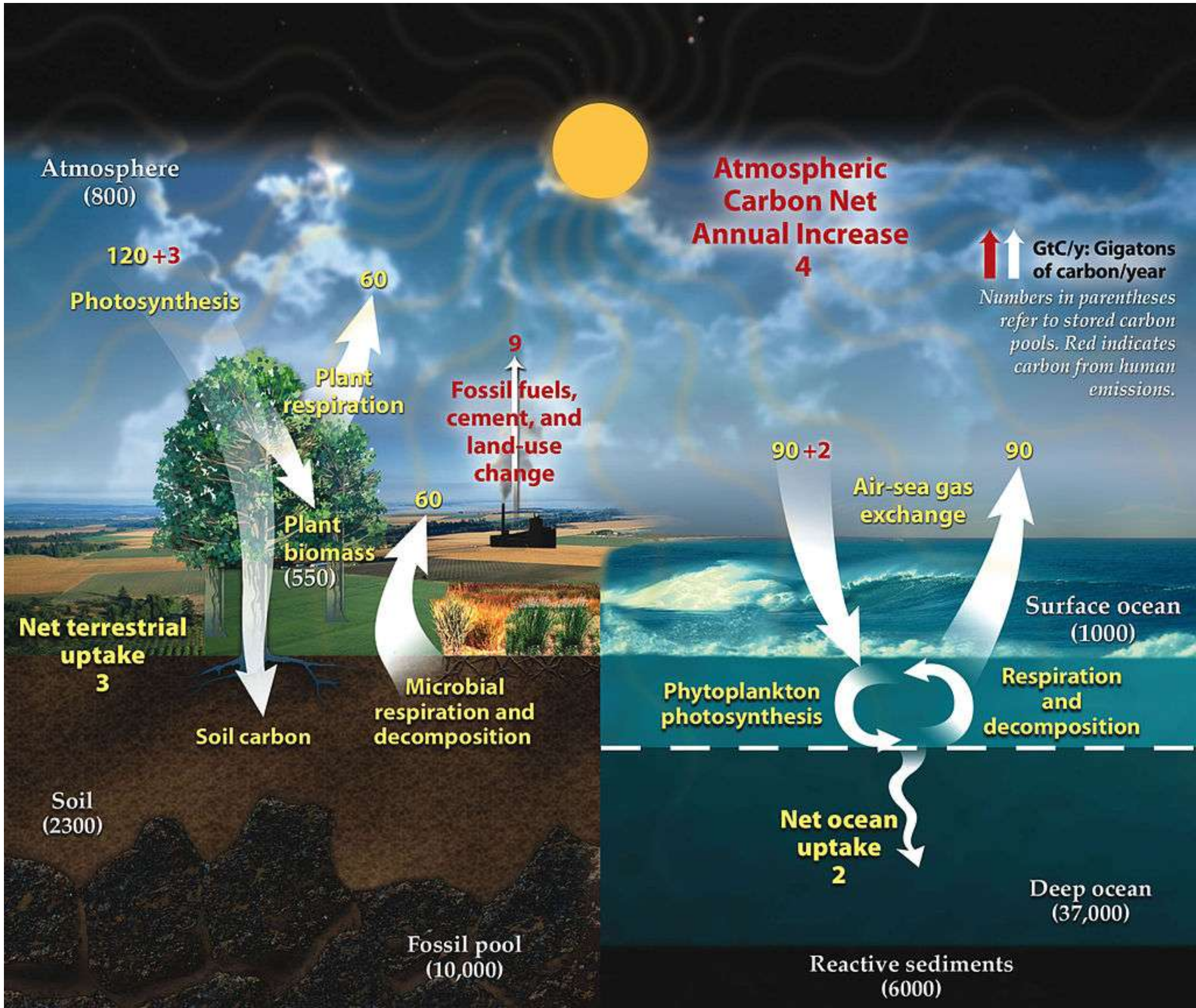


Figure 19.1 Diagram to show the relationship between energy flow (■) and nutrient cycling. Nutrients locked in organic matter (■) are distinguished from the free inorganic state (□). NPP, Net primary production; DOM, dead organic matter.

Biogeochemical cycle

C - Carbon

- Atmosphere
- Terrestrial biosphere
- Ocean, including dissolved inorganic carbon and living and non-living marine biota
- Sediments, including fossil fuels, freshwater systems, and non-living organic material.

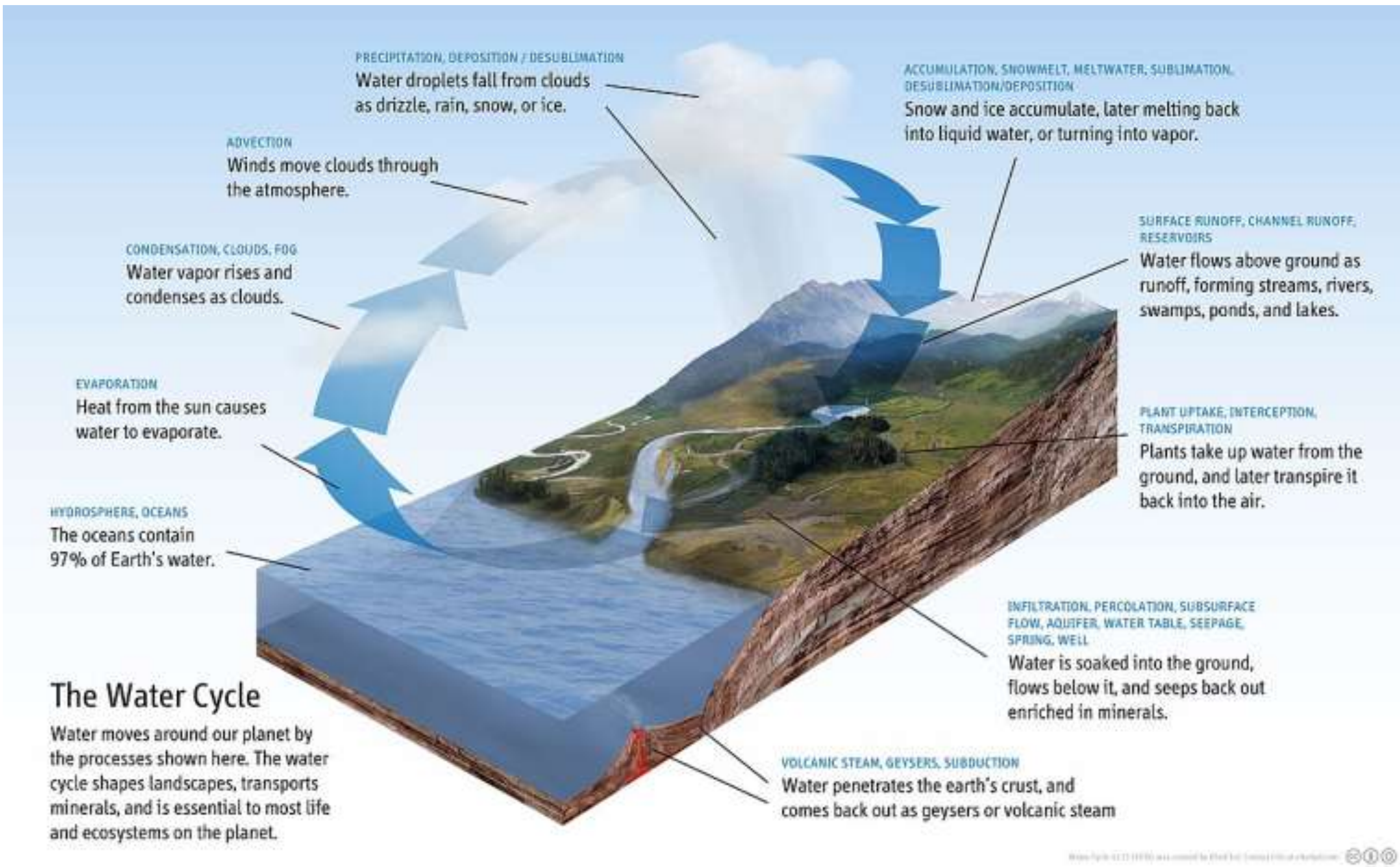


Biogeochemical cycle

Water – The largest quantity in movement

Main store: oceans (97%), ice (2.5%), atmosphere (0.08%), river,lakes (0.01%)

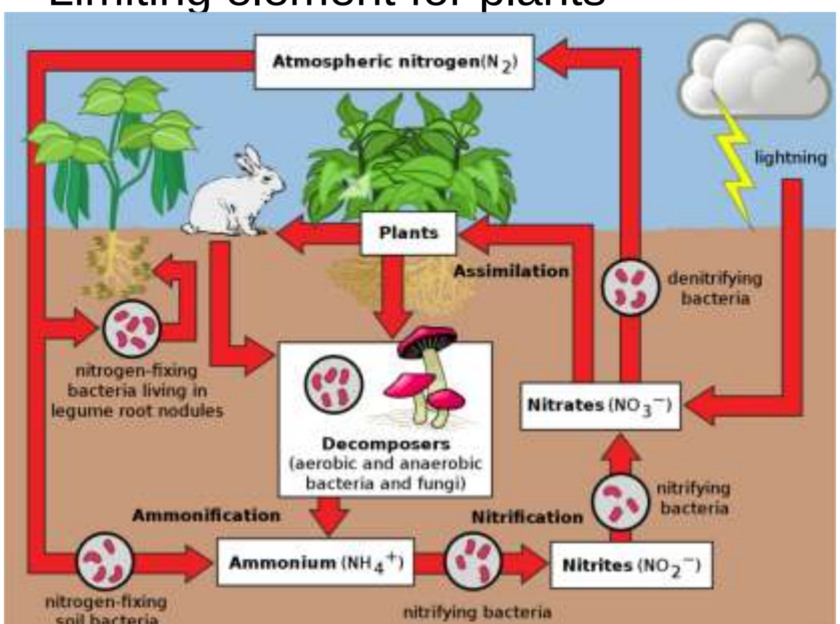
By human influence (agriculture, urbanisation) the water cycle accelerated, storage in ecosystems decreased

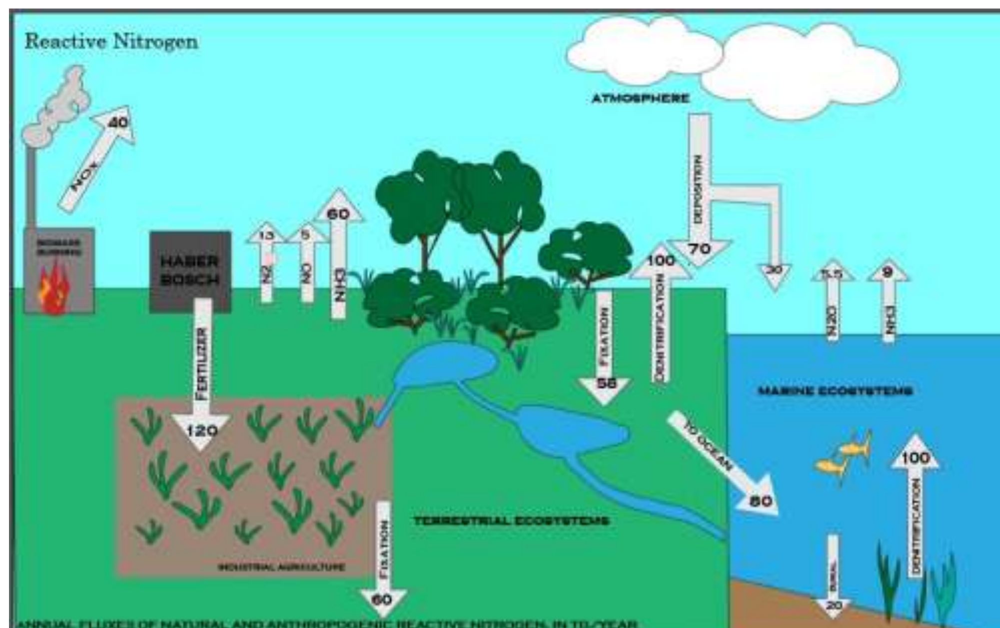


Biogeochemical cycle

N - Nitrogen

- The majority of Earth's atmosphere (78%) is atmospheric nitrogen. However, atmospheric nitrogen has limited availability for biological use, leading to a scarcity of usable nitrogen in many types of ecosystems.
- The conversion of nitrogen gas (N2) into nitrates and nitrites through atmospheric, industrial and biological processes is called nitrogen fixation.
- Natural fixation by microbial N fixation, 30-300 millió t/year (aquatic), 90-150 millió t/year (terrestrila)
- Human influence (N fertiliser, burning fossils) large increase of N fixation
  - eutrophication, nitrate accumulation in drinking water, greenhouse effect, disturbance of natural plant communities
- Limiting element for plants

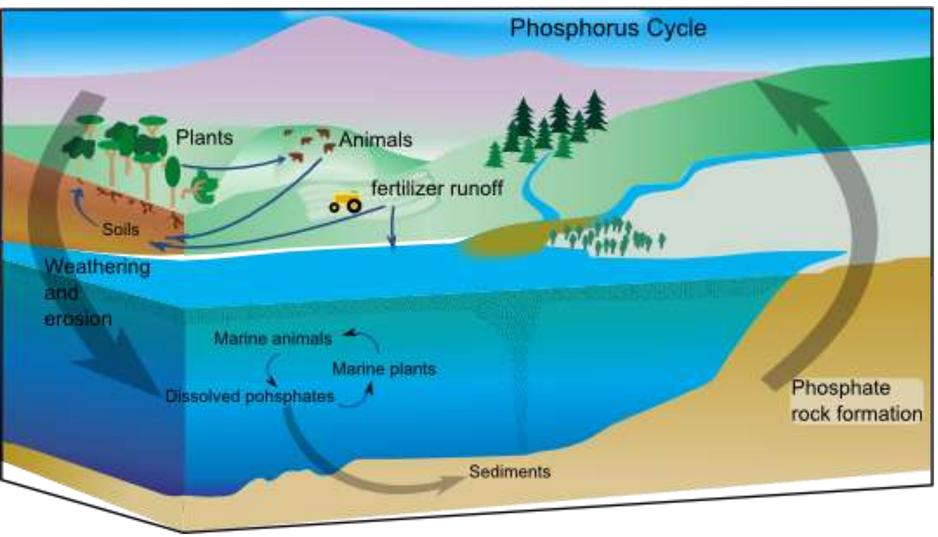


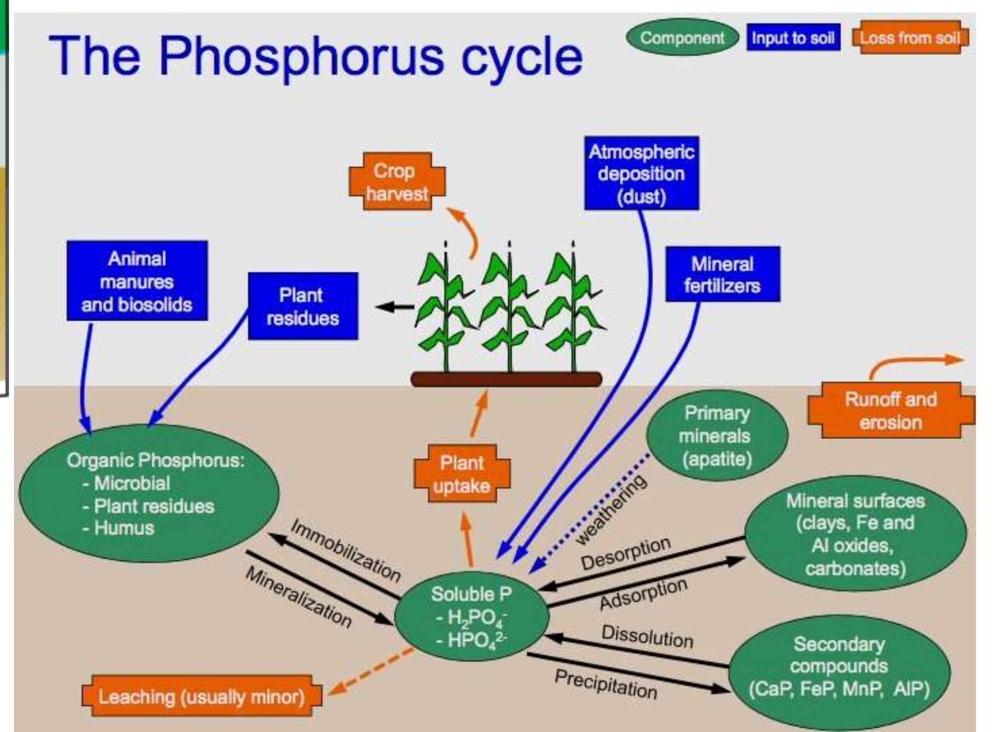


Biogeochemical cycle

P - Phosphor

- The most abundant primary phosphorus-mineral is apatite, which can be dissolved by natural acids generated by soil microbes and fungi
- Large human infuence by P fertilisers and Phosphorus detergents (for washing)
  - eutrophication, disturbance of natural plant communities
- Limiting element for plants



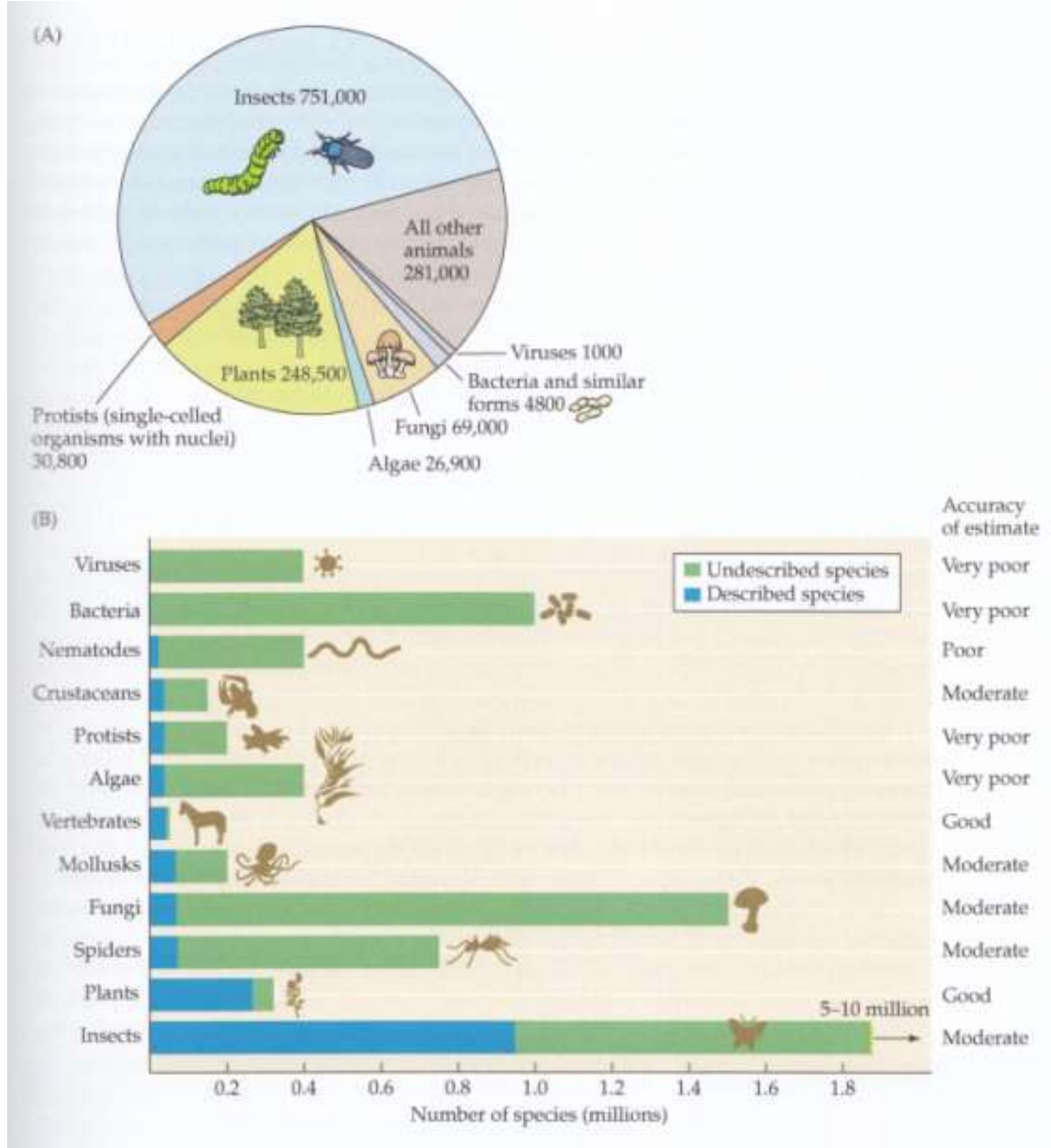


Natural and artificial ecological systems. Biological diversity

Biodiversity

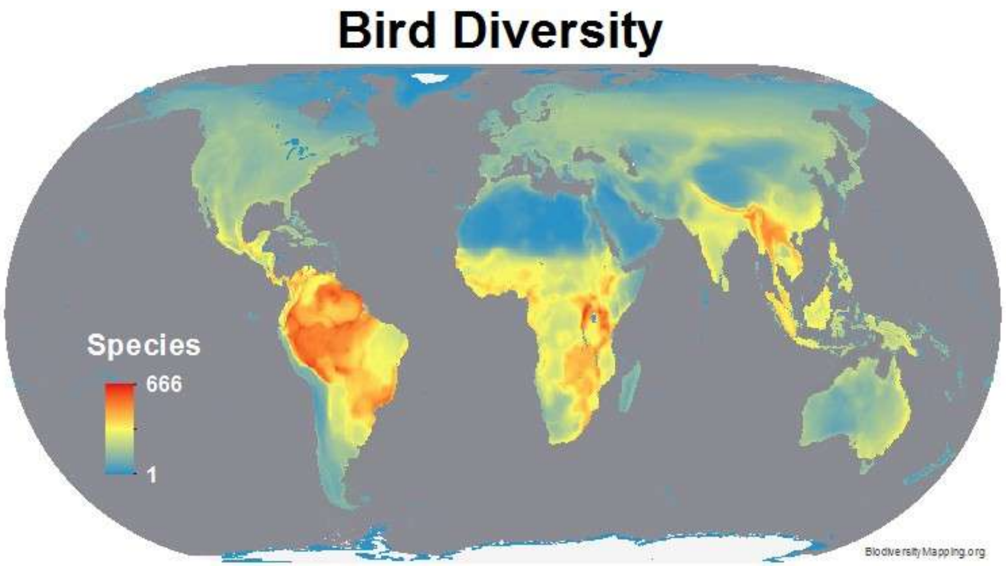
Recently the science described ~ 1.5 million species

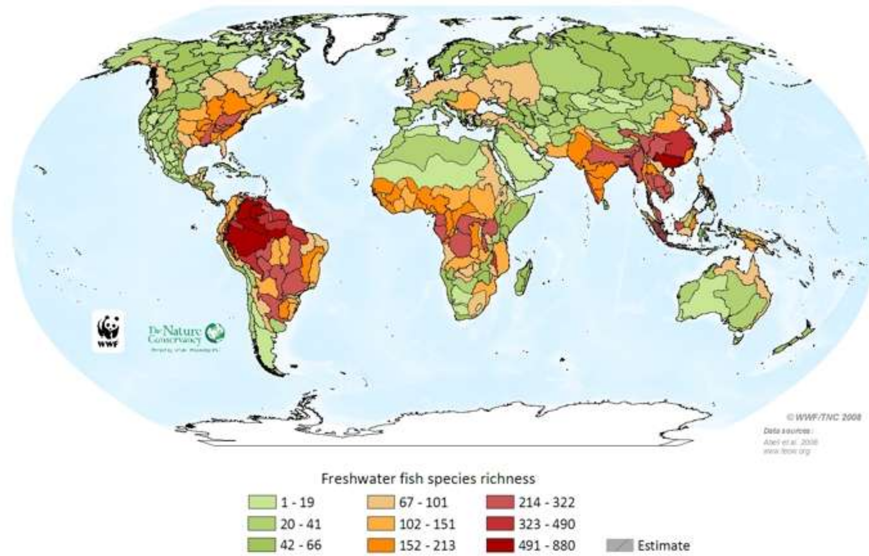
In the Earth, number of species ~ 10 million, but it could be up to 100 million.

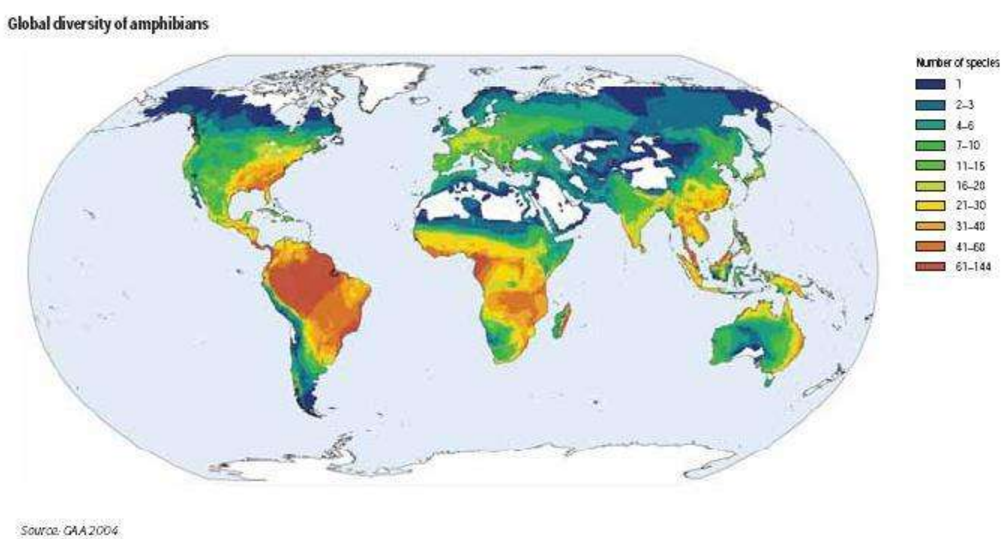


Distribution of the Biodiversity in the Earth

Fish

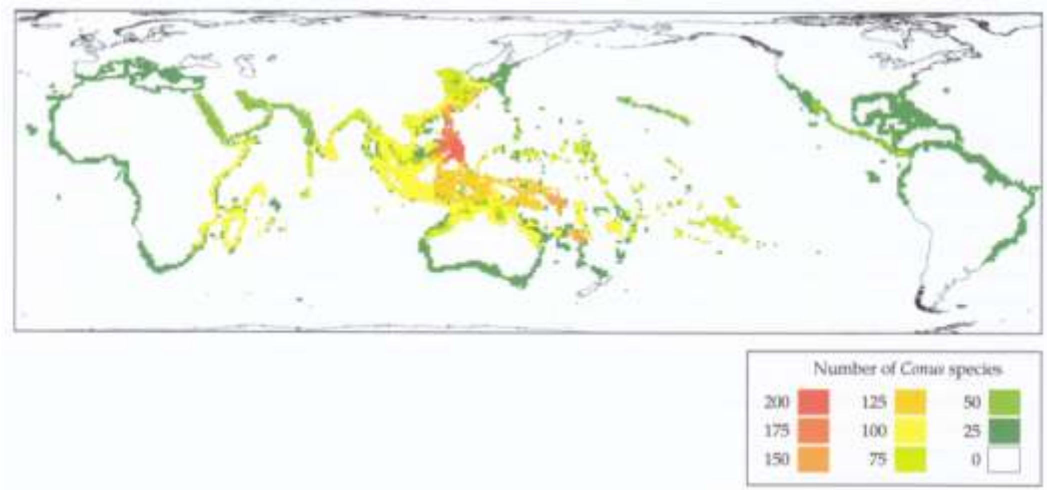




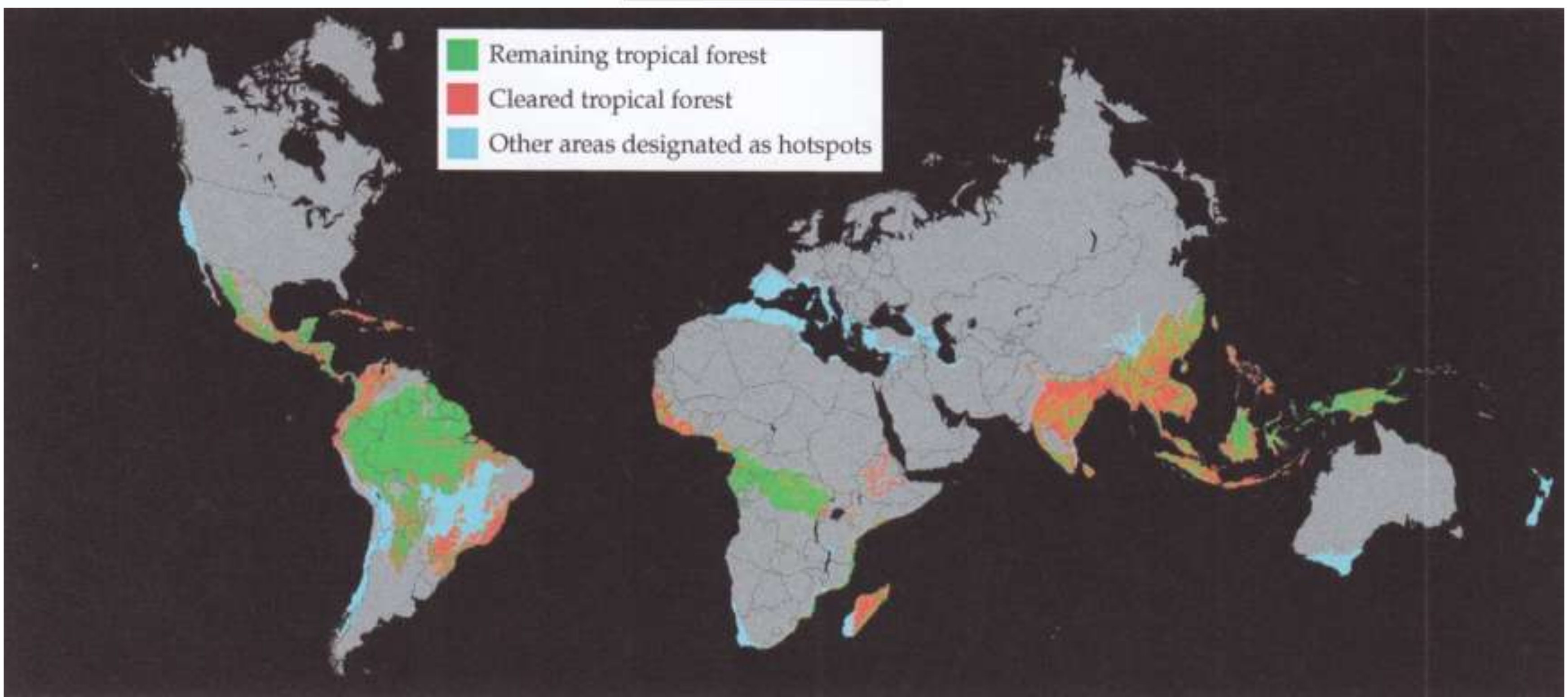


Plants

Distribution of the Biodiversity in the Earth – importance of tropical regions

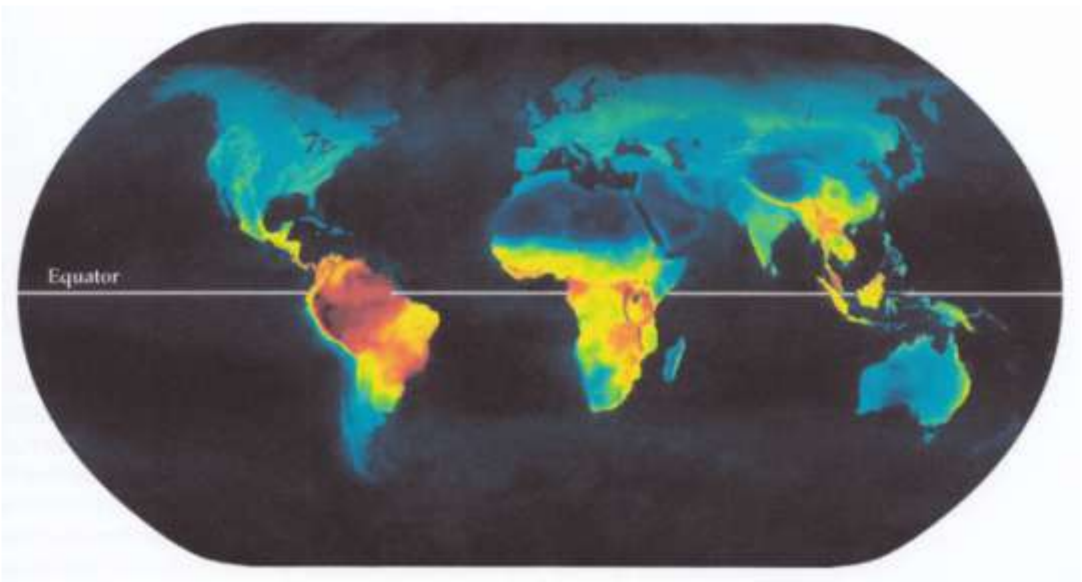


- Tropical rainforest only 7% of the surface but half of the known species live there (in the case of insects 90%, plants 66%, birds 30%-a
- Coral reefs and Mangrove forest are the most diverse aquatic areas



Why are there so many species in the tropics?

- The highest production of biomass, most solar energy and abundant rainfall. Great resource base that can support diverse ecosystems
- Tropical communities had longer stability than temperate ones, allowed greater degree of evolutionary specialisation and local adaptation
- Predictable environment, with intense species interactions (competition, predation, parasitism, mutualism) > niche specialisation, prevention of any single species or group of species dominating communities > numerous species coexist at low densities

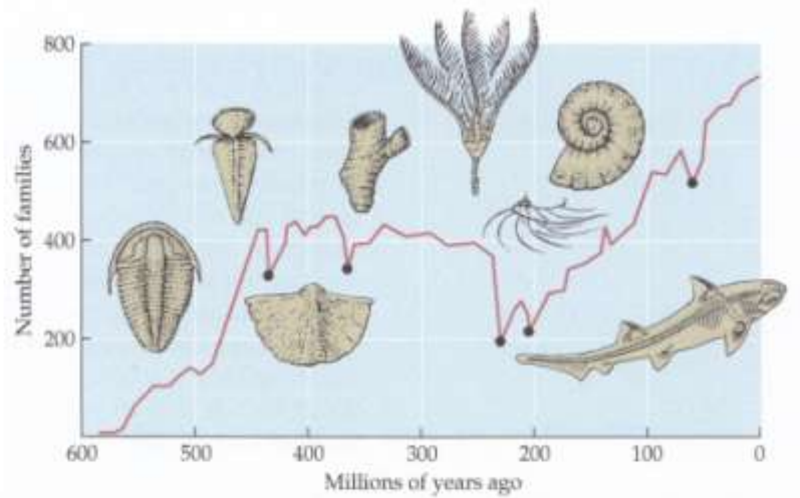


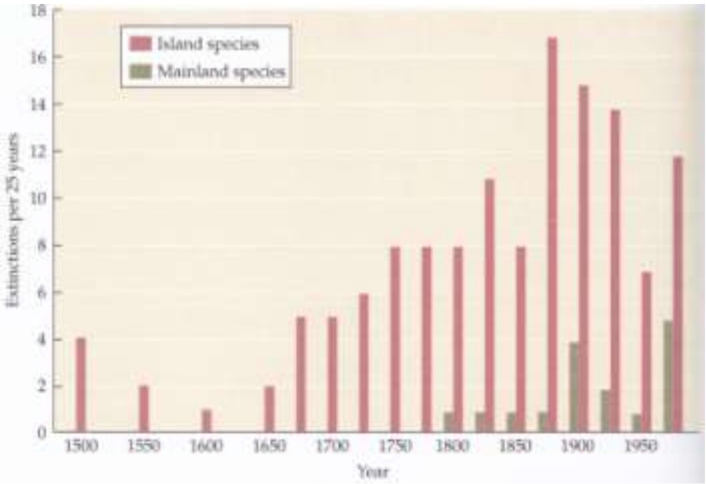
Loss of Biodiverisity

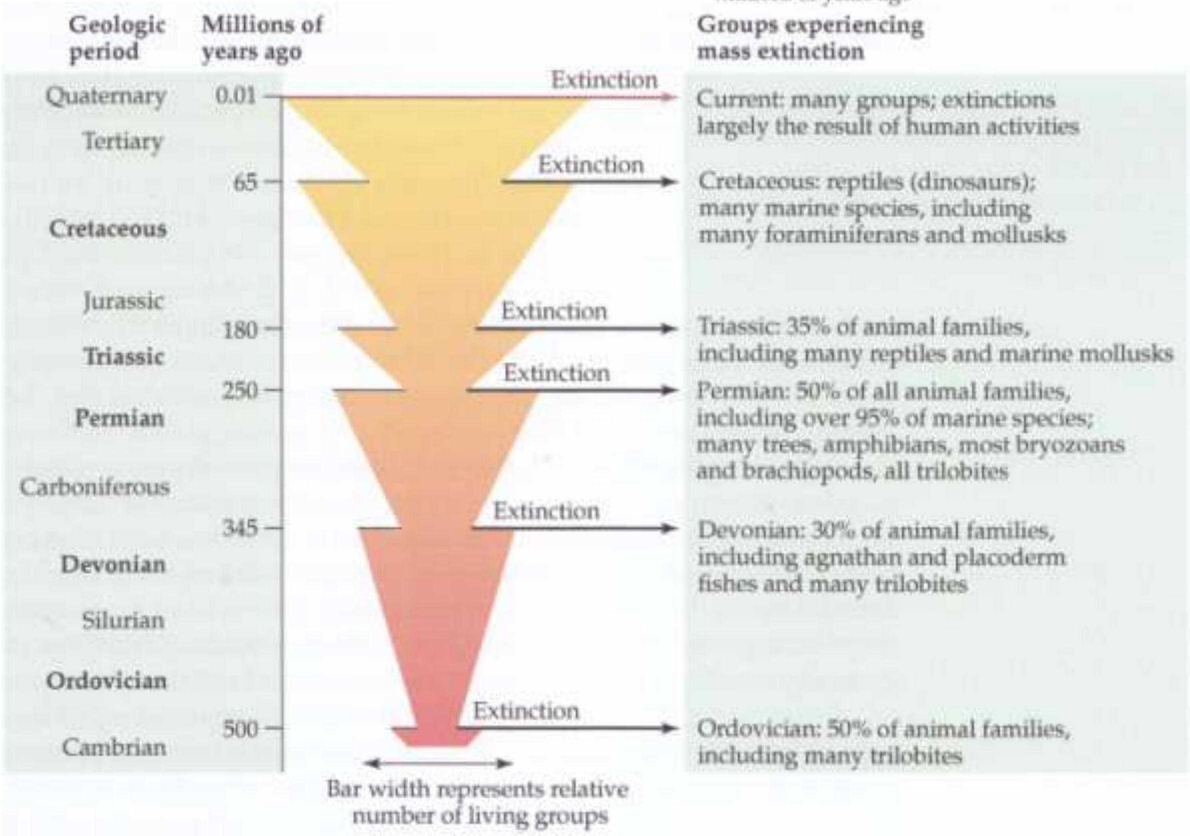
Mass extinction in the past

- Five mass extinctions before human

-The last, sixth extinction caused by the human populations







Loss of Biodiverisity

Dramatic process recently

Natural extiction rate (expecting 10 million species), ~1-10 species annually

During 1850-1950,100 mammalian and bird species extinct, 100-1000 times more than the natural rate

Rate of extinction today:

High importance of the loss of tropical rainforest in the estimation

1% of tropical rainforest cut annually > expecting 10 million species, 0.2-0.3% of the species extinct annually > 20-30000 species/year, 68 species daily, 3 species in every hour

The most species extinct without any information from them!

TABLE 7.1 | Some Species and Subspecies That Have Gone Extinct since 1985

Species	Common name	Date of extinction	Original range
Amphibians			
Atelopus ignescens	Jambato toad	1988 (last record)	Ecuador
Bufo baxteri	Wyoming toad	Mid 1990s[a]	United States
Bufo periglenes	Monteverde golden toad	2004	Costa Rica
Rheobatrachus vitellinus	Northern gastric brooding frog	1985 (last record)	Australia
Cynops wolterstorffi	Yunnan Lake newt	1986 (last record)	China
Birds			
Corvus hawaiiensis	Hawaiian crow	2002[a]	Hawaiian Islands
Cyanopsitta spixii	Spix's macaw	2000 (last record)	Brazil
Gallirallus owstoni	Guam rail	1987[a]	Guam
Melamprosops phaeosoma	Black-faced honeycreeper	2004 (last record)	Hawaiian Islands
Moho braccatus	Kaua'i	1987 (last report of vocalizations)	Hawaiian Islands
Myadestes myadestinus	Kama'o	2004	Hawaiian Islands
Tachybaptus rufolavatus	Alaotra Grebe	2010	Madagascar
Mammals			
Diceros bicornis longipes	West African black rhinoceros	2013	Cameroon
Lutra lutra whiteleyi	Japanese river otter	2012	Japan
Neofelis nebulosa brachyuran	Formosan clouded leopard	2013	Taiwan
Oryx dammah	Scimitar-horned oryx	1996[a]	Chad
Plants			
Argyroxiphium virescens	Silversword	1996	Hawaiian Islands
Commidendrum rotundifolium	Bastard gumwood	1986[a]	St. Helena Island
Nesiota elliptica	St. Helena olive	2003	St. Helena Island

Source: IUCN 2013 (www.iucnredlist.org).
[a]Species still exists in captivity.











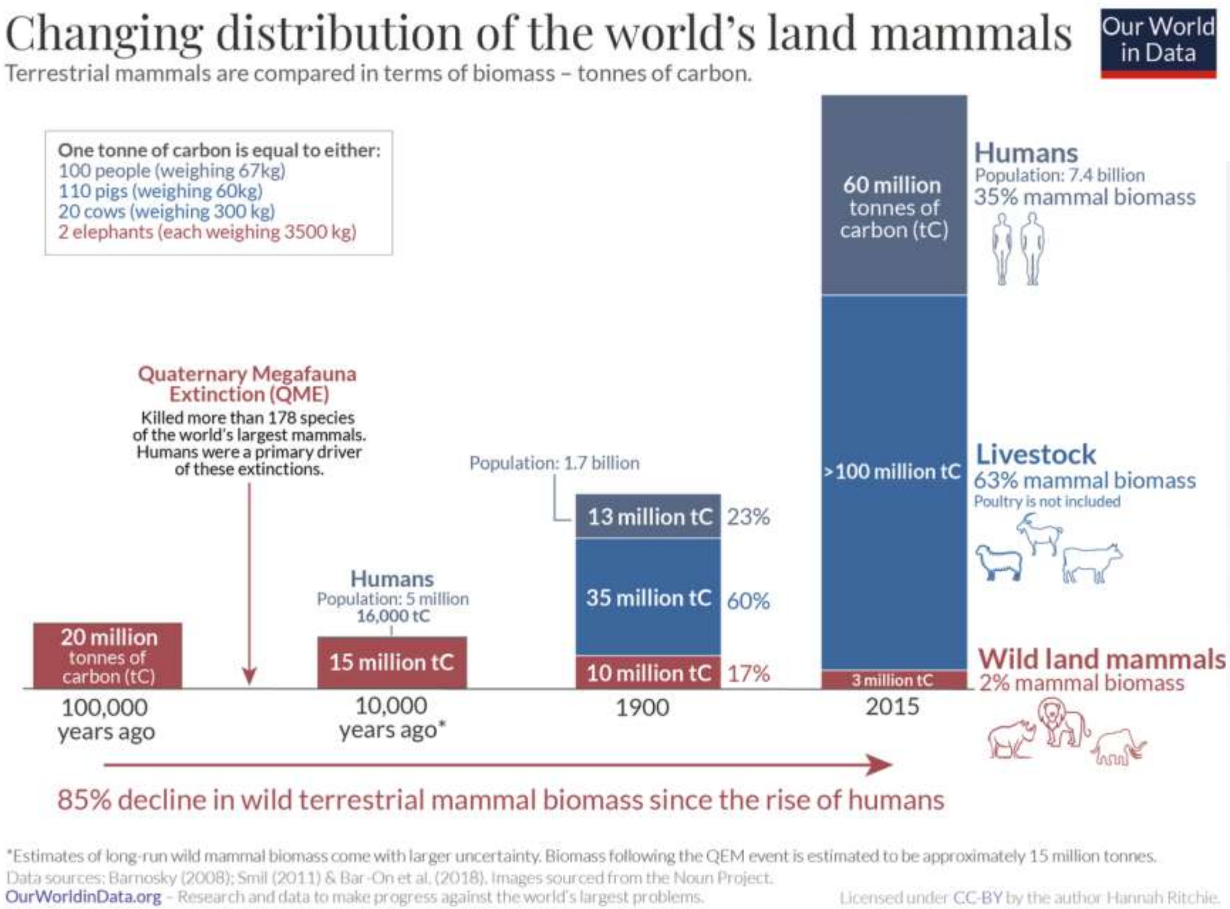


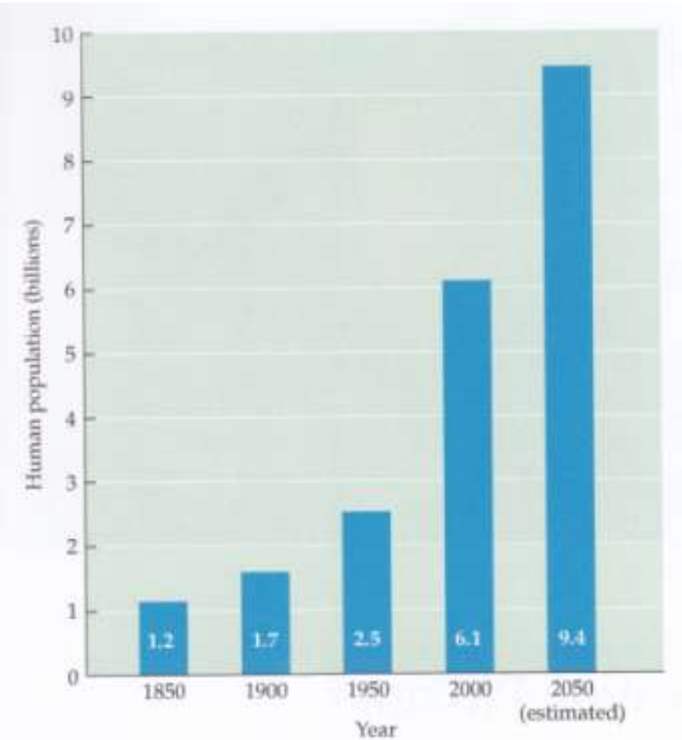



Loss of Biodiverisity

The main threats:

Human populations use 50% of the terrestrial Net Primary Production (NPP), the 25% of the entire Biosphere.





Loss of Biodiverisity

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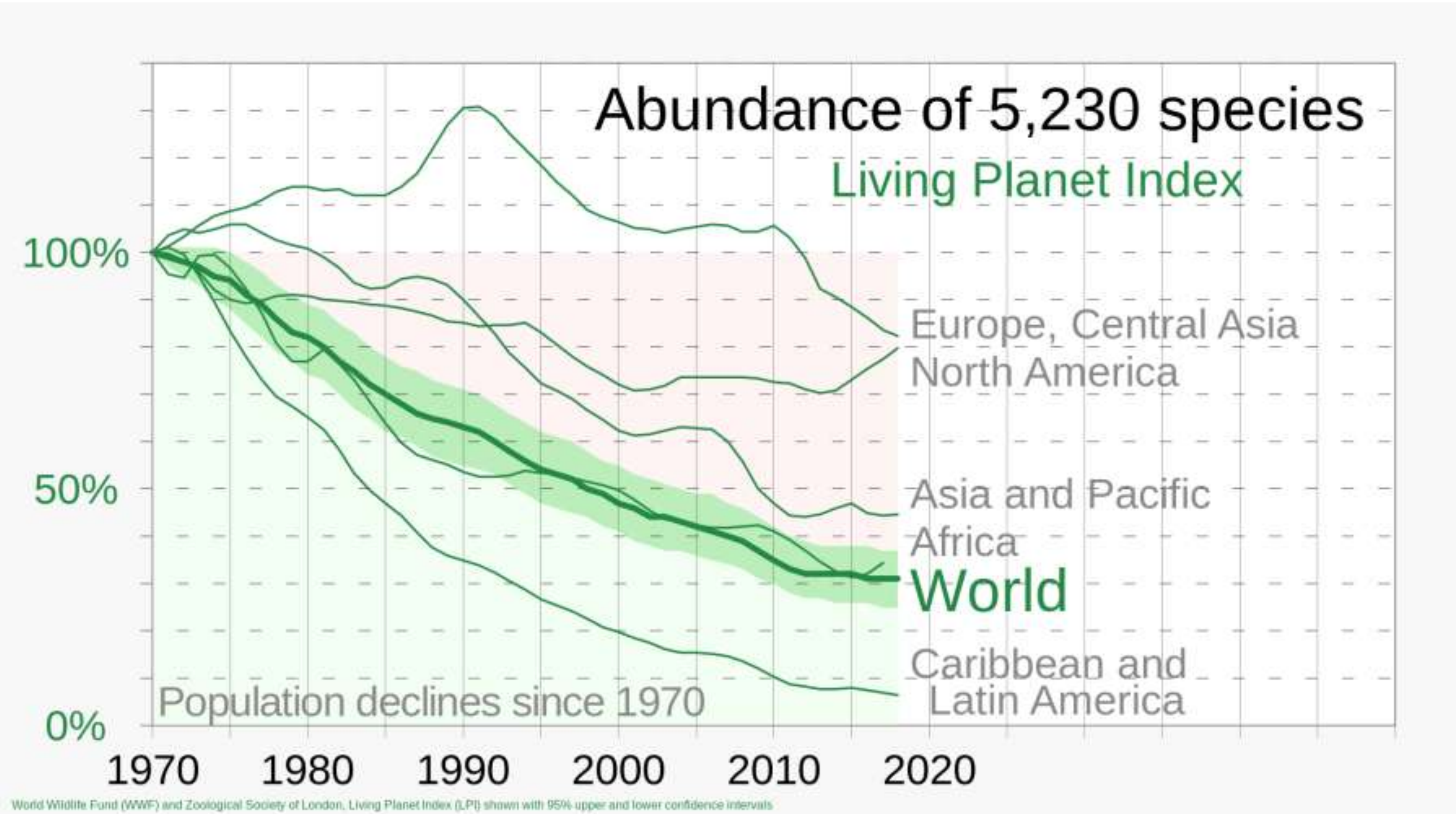
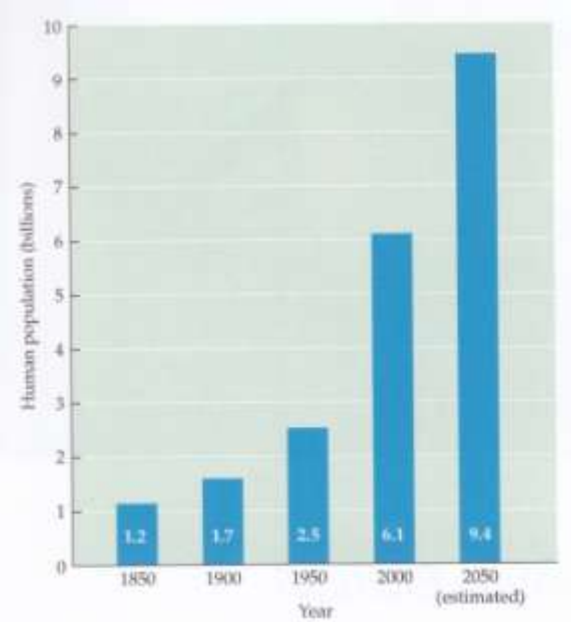
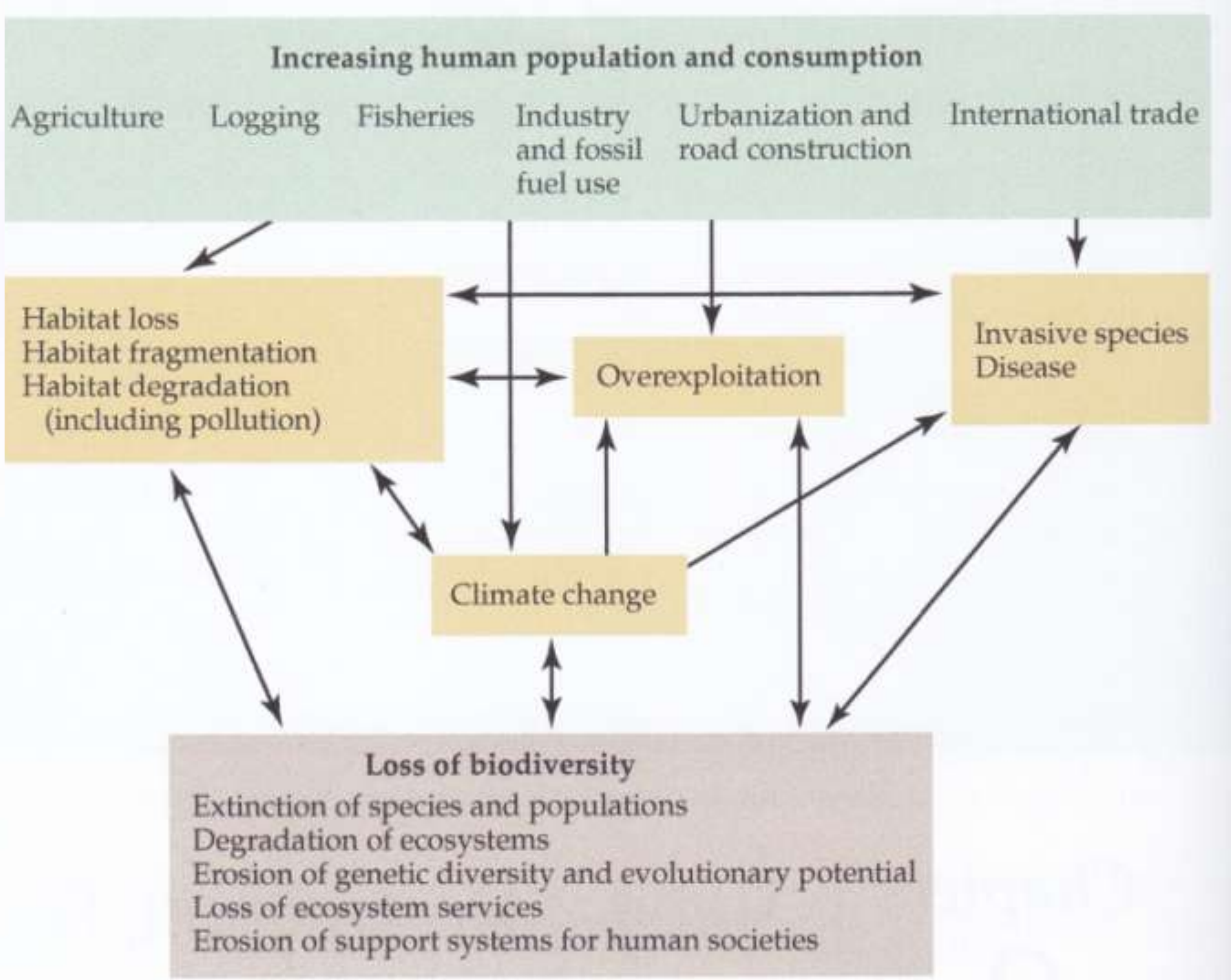


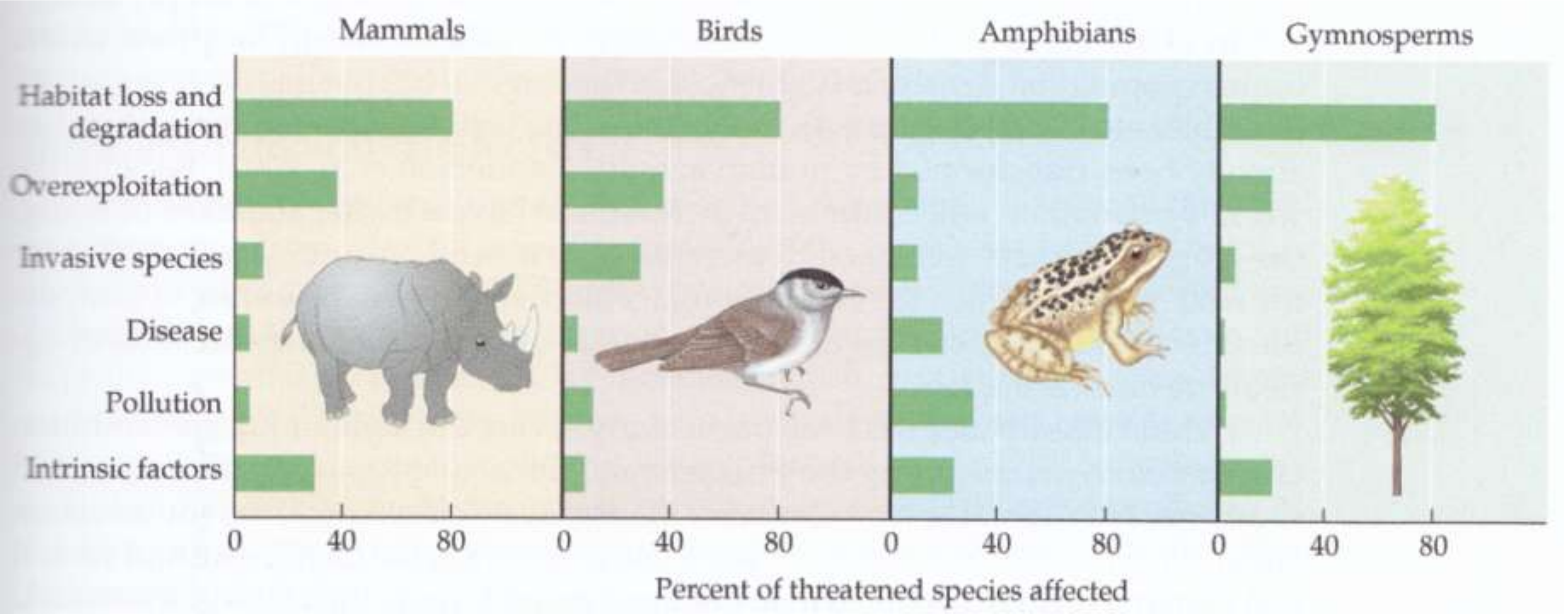
Loss of Biodiverisity

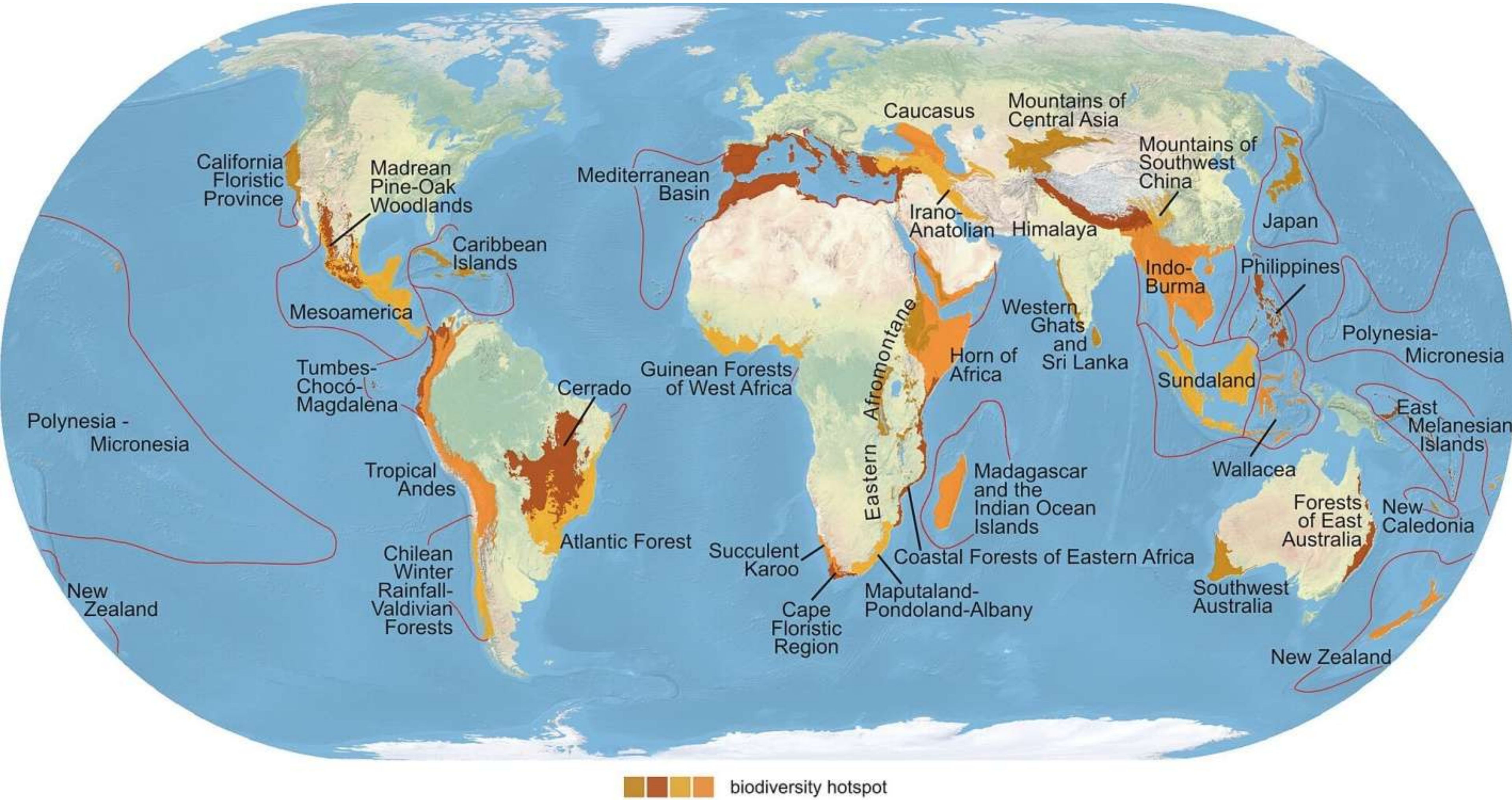
The main threats:





Loss of Biodiverisity



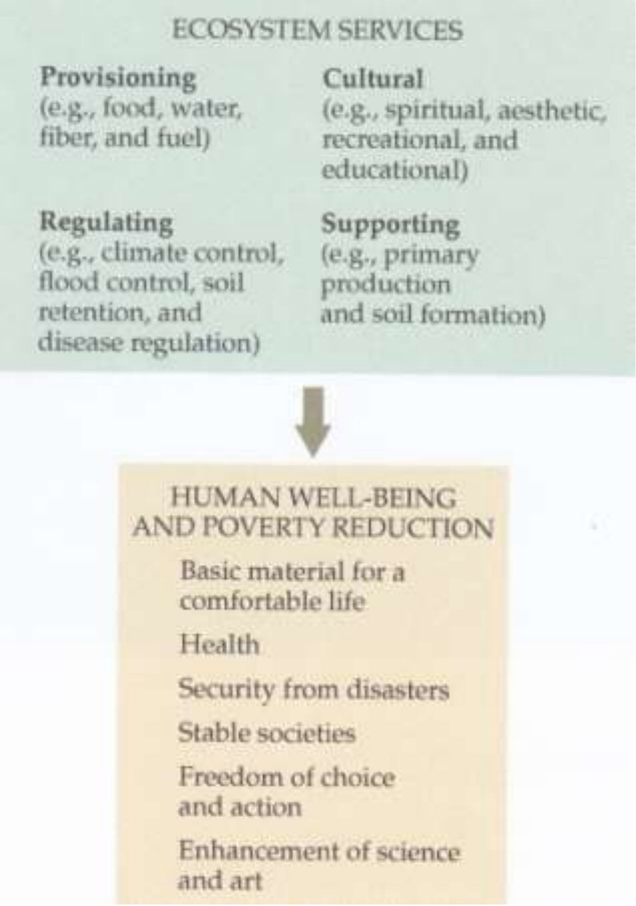


Conservation International (conservation.org) defines 35 biodiversity hotspots — extraordinary places that harbor vast numbers of plant and animal species found nowhere else. All are heavily threatened by habitat loss and degradation, making their conservation crucial to protecting nature for the benefit of all life on Earth.

Ecosystem – Biodiversity

- What is the roles/functions of biodiversity in the ecological system ?
  - Productivity increasing with biodiversity in the most cases
  - Niche complementarity increase the efficiency of usage the resources
  - Interspecific interactions > facilitation
  - Stability increasing with biodiversity
  - Large importance of diversity of functional groups of the ecosystems

- Ecosystems services



Ecosystems services - examples

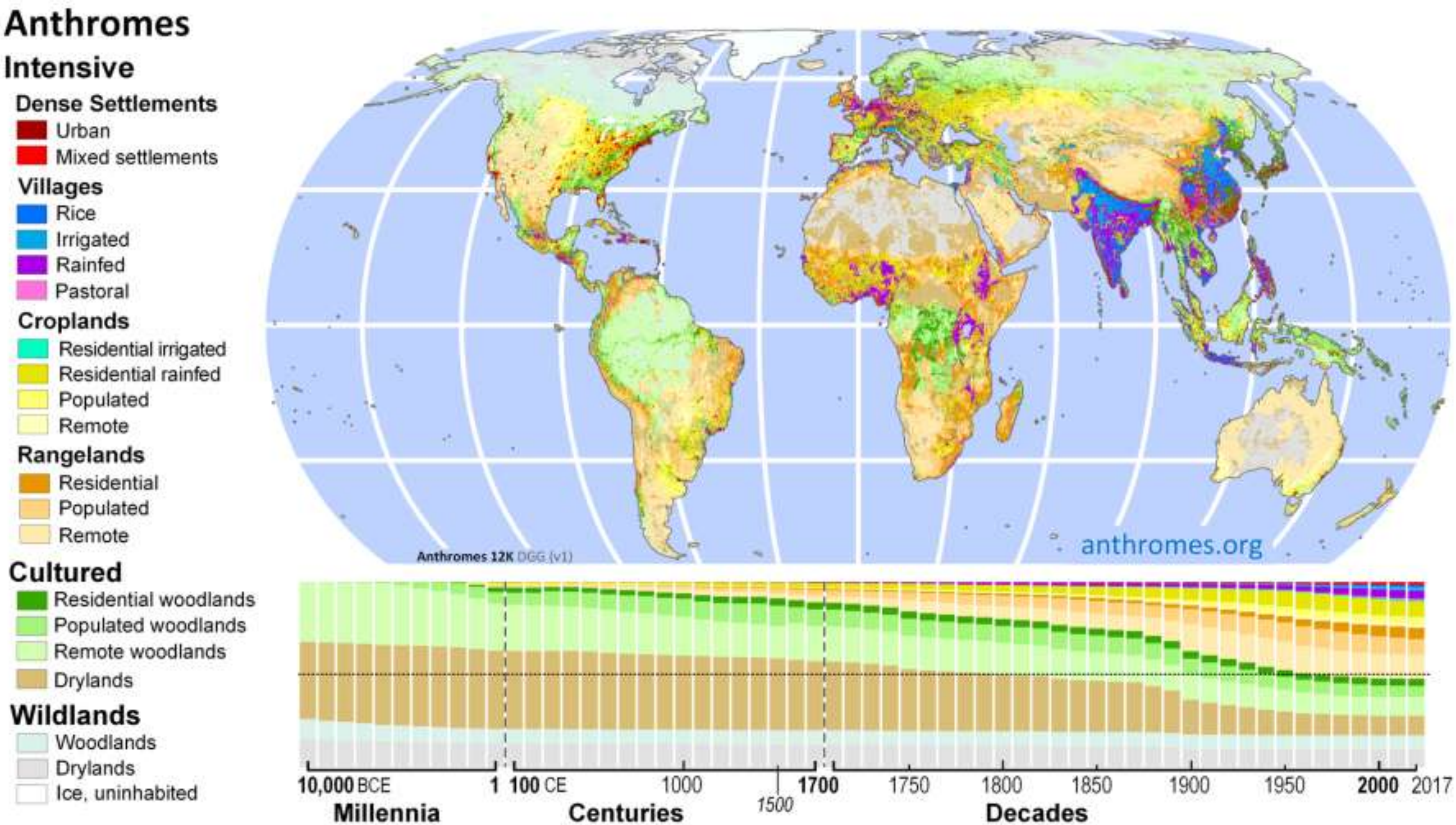
Providing water for 9 million people of New York

- 5 000 km^2 watershed
- Threats of growing pollutions by settlements and agricultures
- Decision (1996)
  - **Protect the natural ecological system of the watersheds, cost: 1.5 milliard $**
  - Alternative solution> no protection but need to built huge waste-water treatment facility, cost 6 milliard $

https://www.nycwatershed.org/about-us/overview/croton-catskilldelaware-watersheds/

Ecosystems

- Ecosystems formed by the last 3 milliard years without human
- Number of new, artifical ecosystems made by human populations replacing natural ones



Ecosystems

- Ecosystems formed by the last 3 milliard years without human

- Recently, the remaining **natural ecosystems** indirectly influenced by several human originated processes (e.g. acid rains, increasing CO_2 level, climate change, Ozone depletion)

- **Semi-natural ecosystems** organised basically by natural processes but these system are under direct human influence as forestry, grassing, hunting, tourisms and other activity

- **Agricultural ecosystems** – dominated by plantations of limited number of plant species

- **Urban or techno ecosystems** - artificial ecosystems, these ecosystems „heterotrophyy”, depend on other types of ecosystems

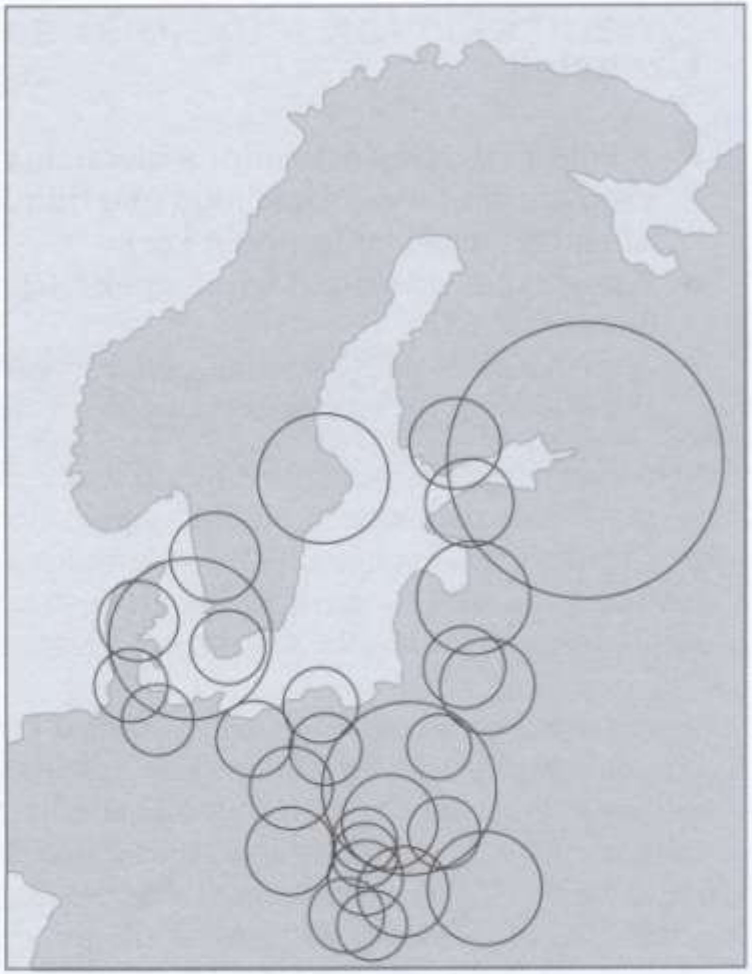
Agricultural ecosystems

- Formerly managed only by human and animal work, recently machines and chemicals, based on fossil energy, essential for cultivation
  - Energy used for managing is more than the energy of the agricultural products (~3 cal for producing >1 cal)
  - Very low biodiversity
  - Large instability (large influence of pests)
  - Very low genetic diversity of the species breed
  - Low primary production – no vegetation in large part of the year
  - Needs of external supply of materials
  - The recent agricultural ecosystem are not sustainable ecosystem

Urban or techno ecosystems :

- Covers 2% of the Earth
- Heterotrophy systems
- For sustaining it need many hundreds more areas of other ecosystem
- Parasite of the Biosphere

Ecological footprint of urban areas
In the Baltic Sea region



Biosphere 2 experiment

- to demonstrate the viability of closed ecological systems created by human to support and maintain human life as a substitute for Earth's biosphere
- 1.27ha, Arizona, 1991-1993
- 80% natural habitats
- 16% agricultural habitats
- 4 % for 8 people

http://www.youtube.com/watch?v=l4DX994NonE

https://www.youtube.com/watch?v=-yAcD3wuY2Q

Biosphere 2 experiment

- Most of the introduced vertebrate species and virtually all of the pollinating insects died, though there was reproduction of plants and animals.
- Insect pests, like cockroaches, flourished.
- Eutrophication in aquatic habitats
- Large decrease of oxygen concentration 21%->14%, large fluctuation of CO_2, increase of NO_2 level
- Finish after 2 years

Lessons:

- **We (human) not able to create stable long-running ecosystem proper for human life**
- **Our knowledge are too limited about natural ecosystems**
- **Replacing the natural ecosystems with our artificial ecosystems will generate catastrophic situation for human societies**

http://en.wikipedia.org/wiki/Biosphere_2

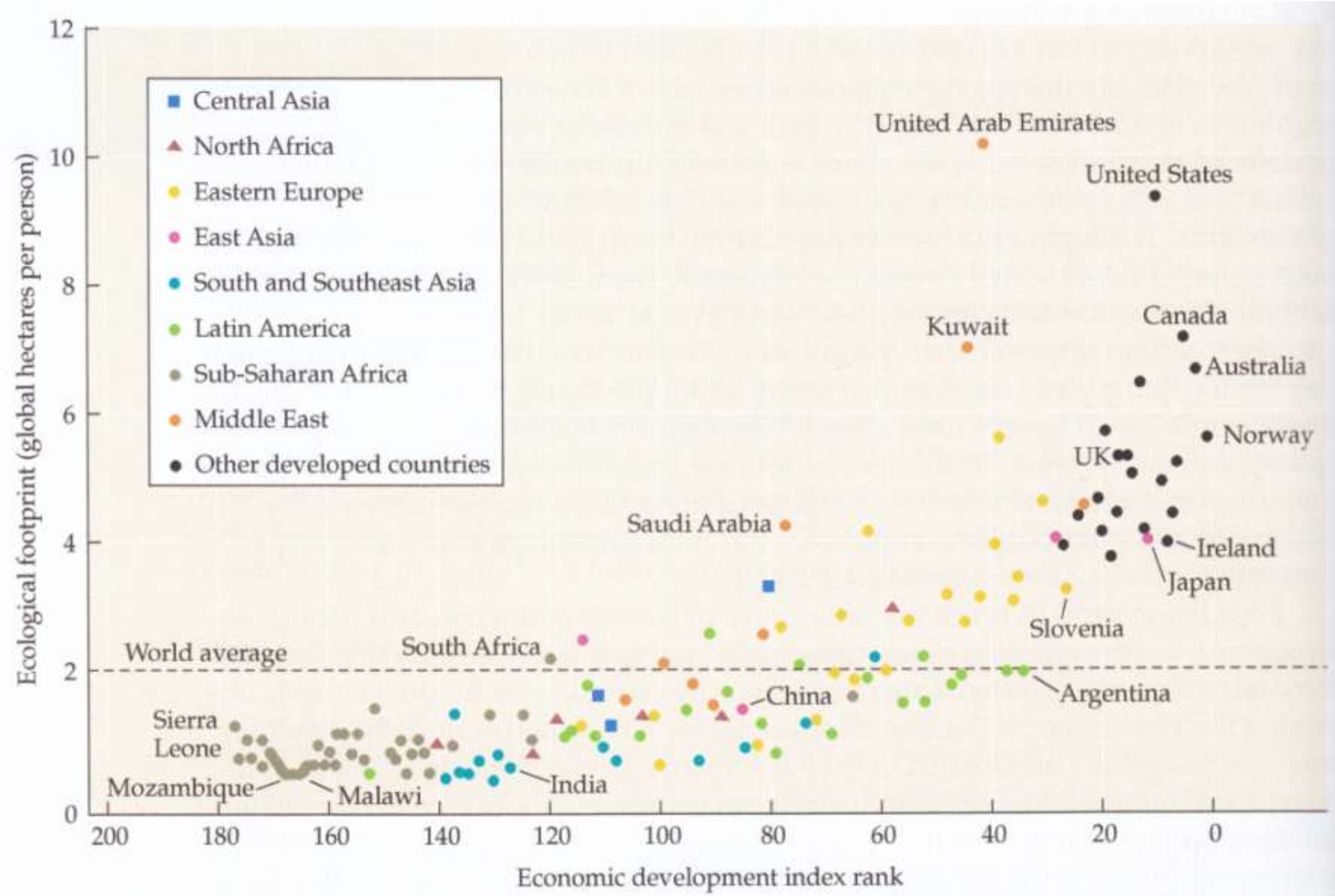
Global changes - relations

On the base of recent trends:

- Decrease of natural ecosystems – which ecosystems essentials for human populations
- Increase of artificial ecosystems
  - **These ecosystems are very instable and not sustainable – see Biosphere experiments!**
- Large decline of ecosystem services
  - Increasing threats and costs

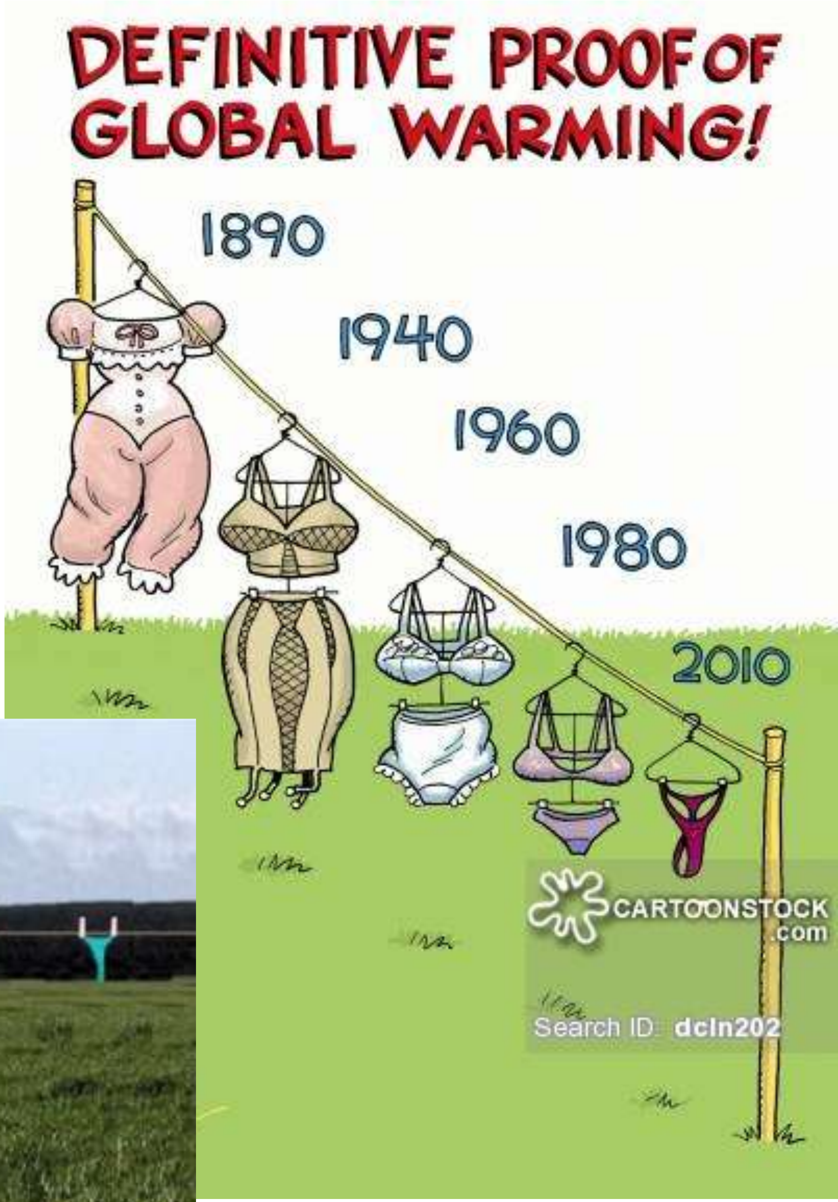
Option to halt these dangerous process – application of real the concept of Sustainable Life

Ecological footprint: area which able to sustain consuption/service for an individual (1.8 global ha/person)

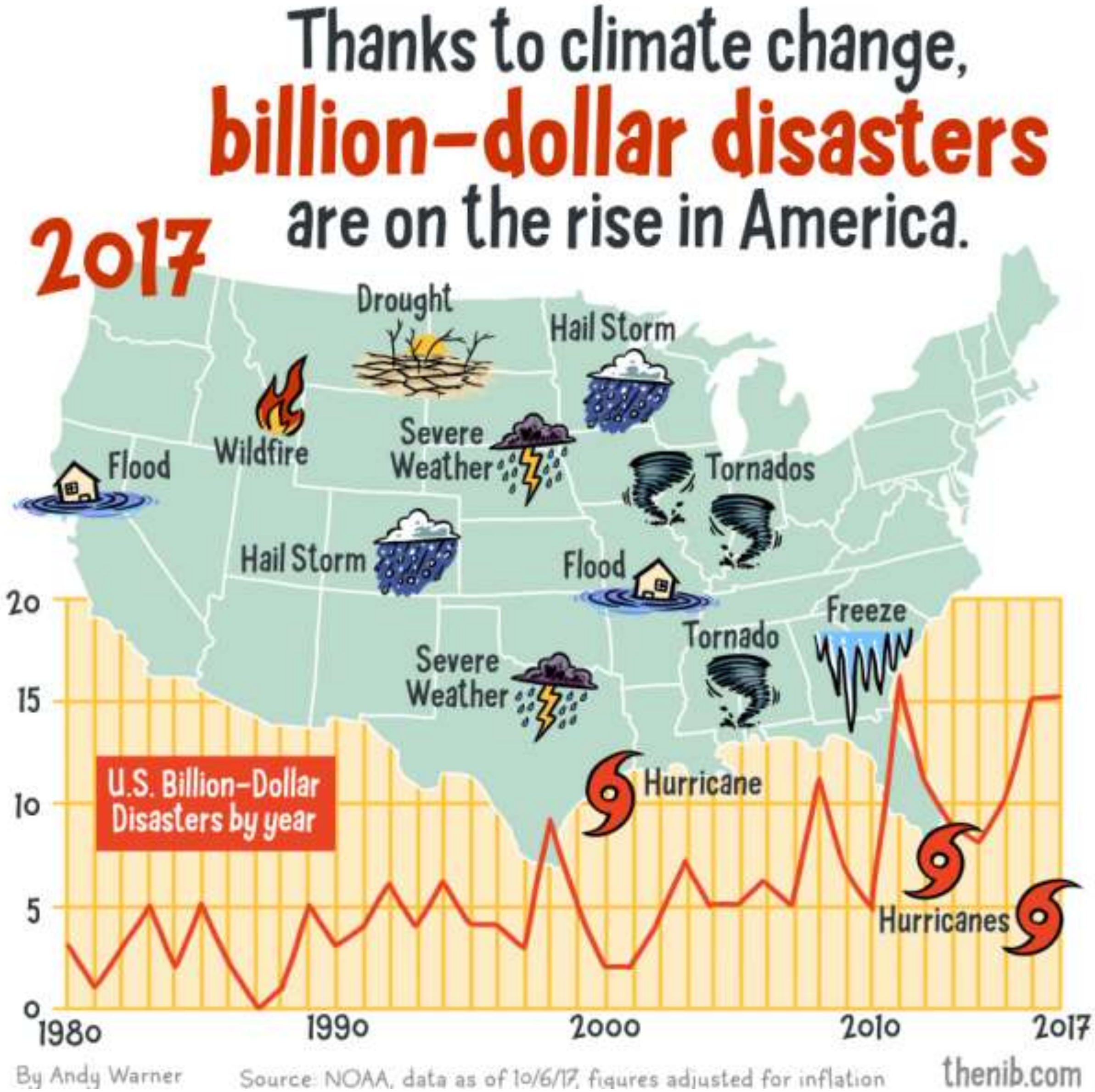


Climate change and its Ecological consequences

Climate change – is not joke



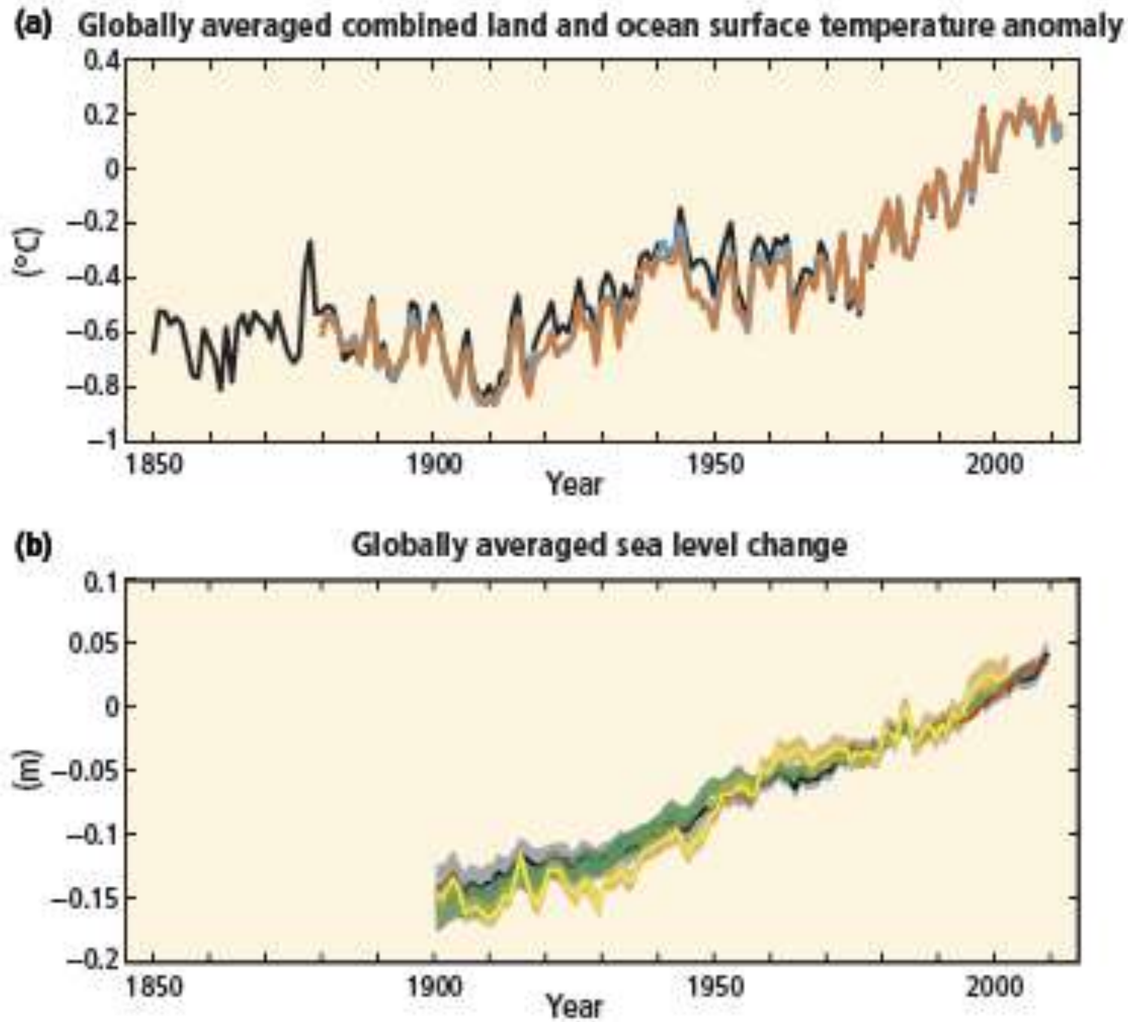
Increasing costs



Climate change

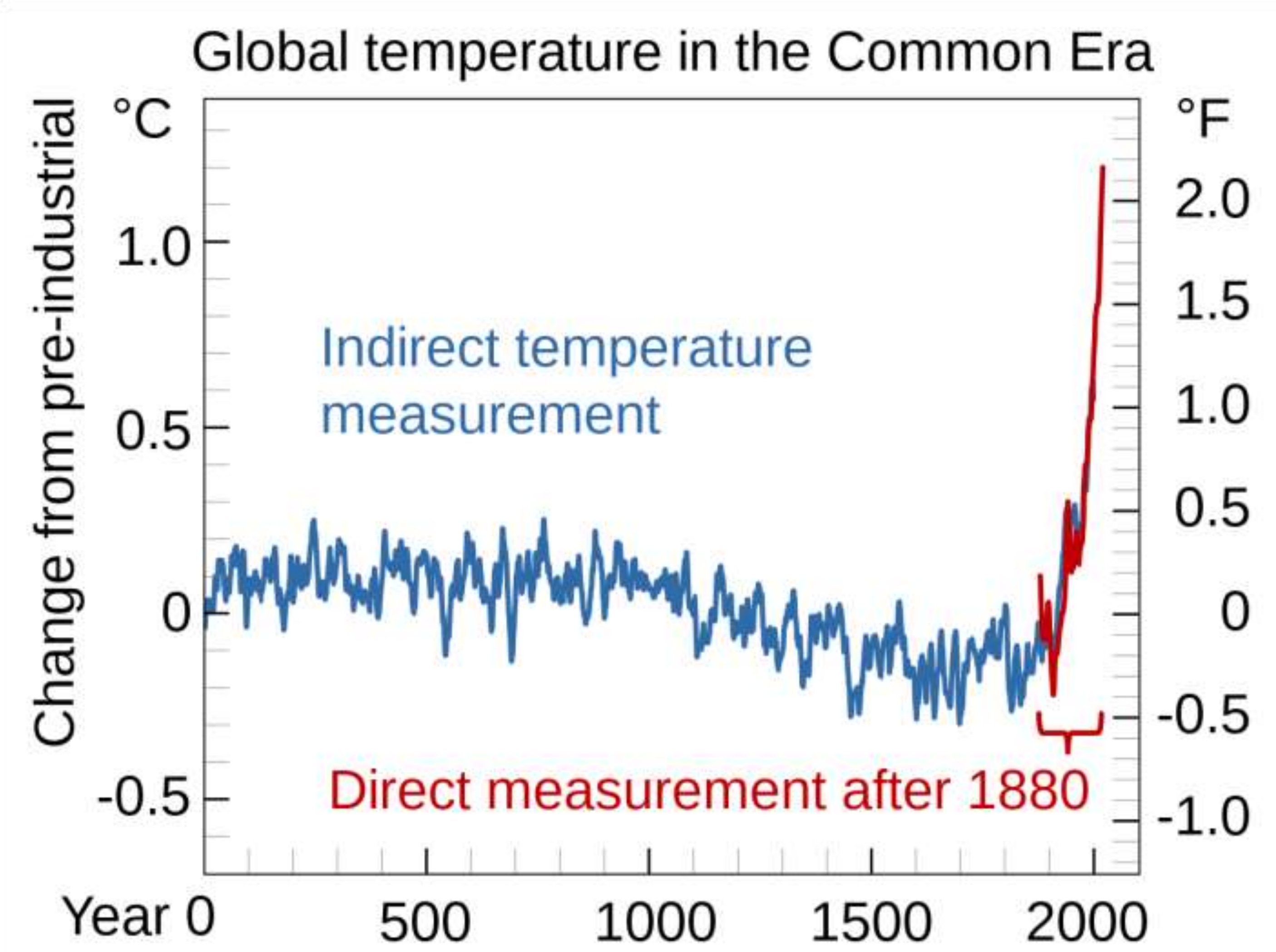
Meteorological data since middle of the XIX century – increasing temperature and sea level

http://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_FINAL_full.pdf



Climate change

- Average temperature in the Northern Hemisphere on the base of historical remarks, chronicles, data based on annual ring of trees

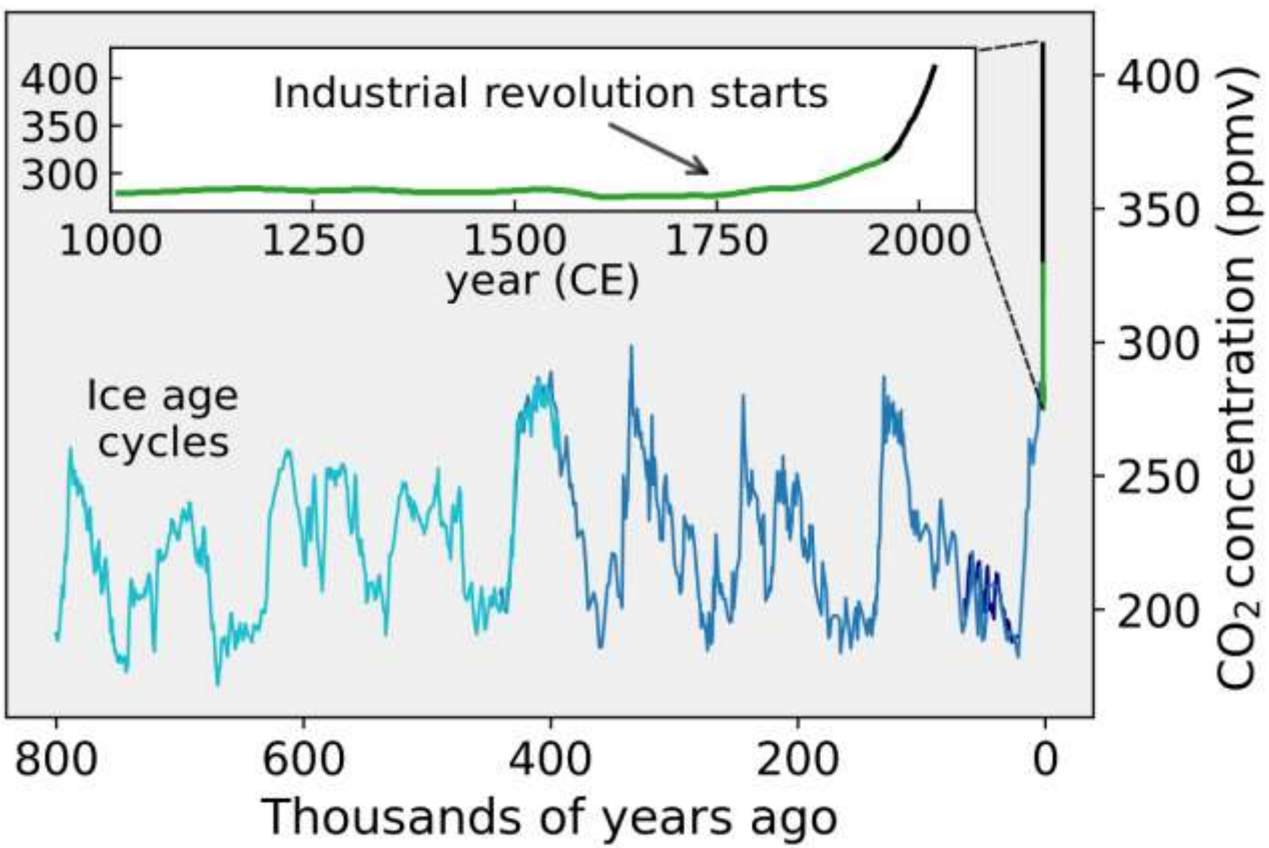


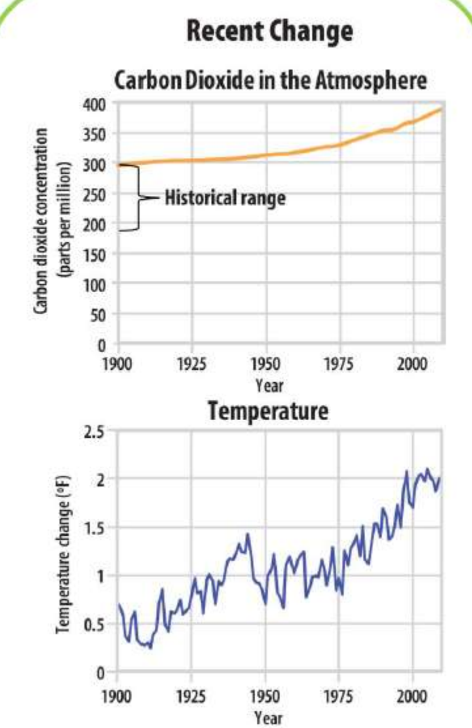
Ice samples from Antarctica and Greenland > data of concentration of CO_2 CH_4, temperature (ratio of hydrogen/deuterium) let to know the history for 800 000 years!

Very close relation between level of CO_2 CH_4 and temperature

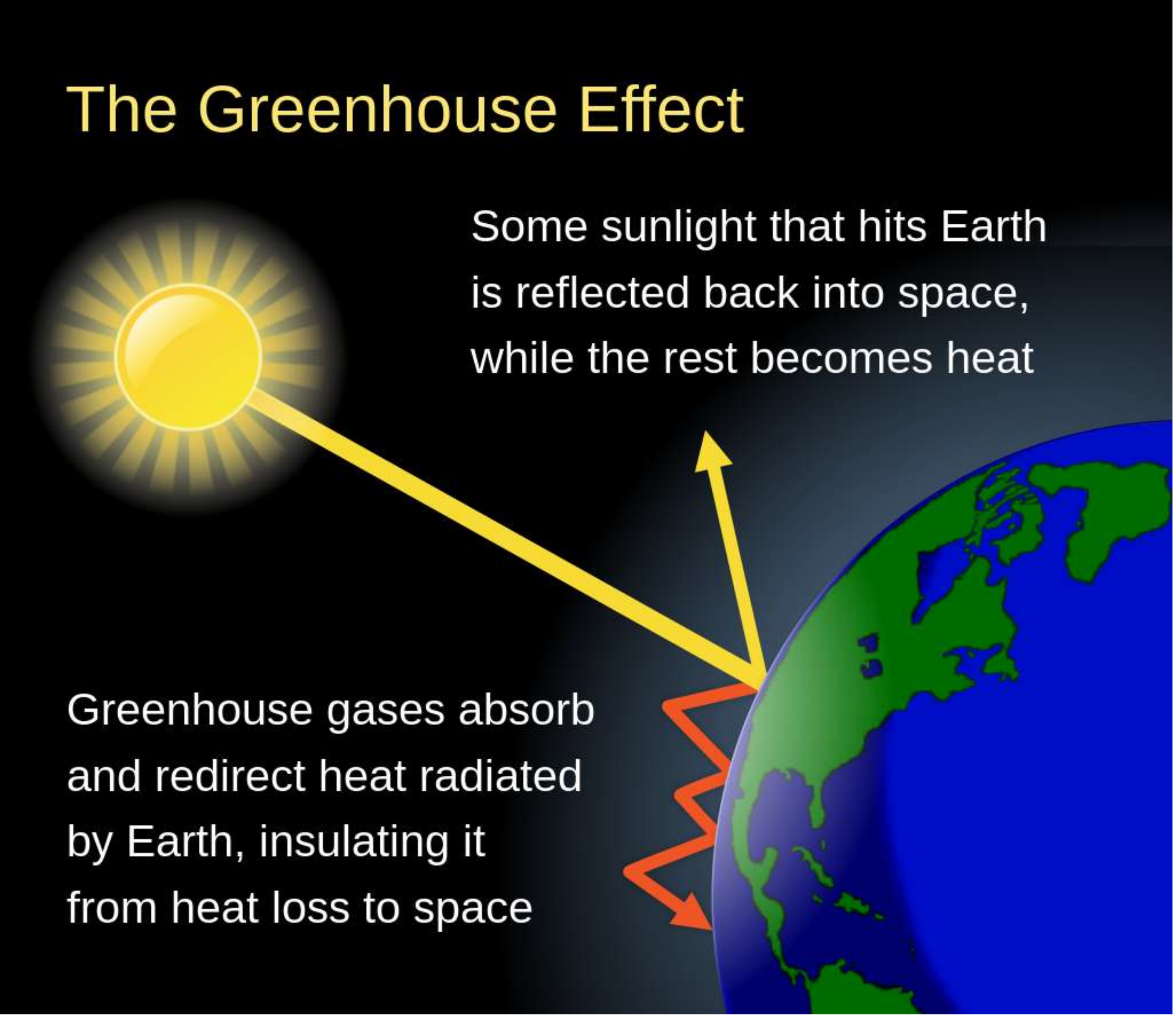
In 2022, level of CO_2 reached the 421 ppm!

1.5. ábra. Antarktiszi jégfuratminta a Dome C kutatóállomásról. (Fotó: La
CNRS/LGGE, Grenoble, France

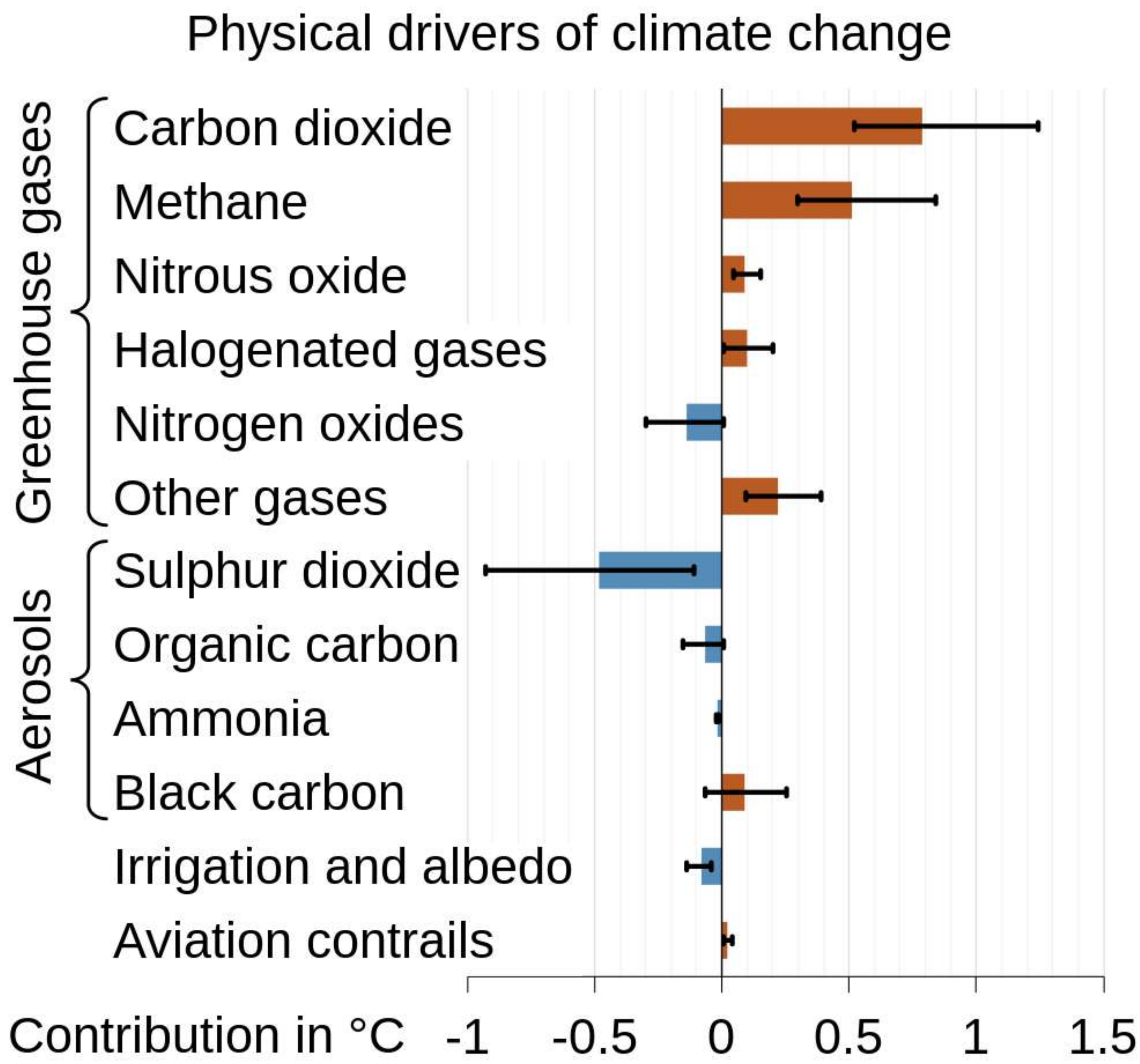




Source: U.S. EPA. *A Student's Guide to Global Climate Change*. http://www.epa.gov/climatechange/students.



Greenhouse gases: $C0_2$, CH_4, N_2O

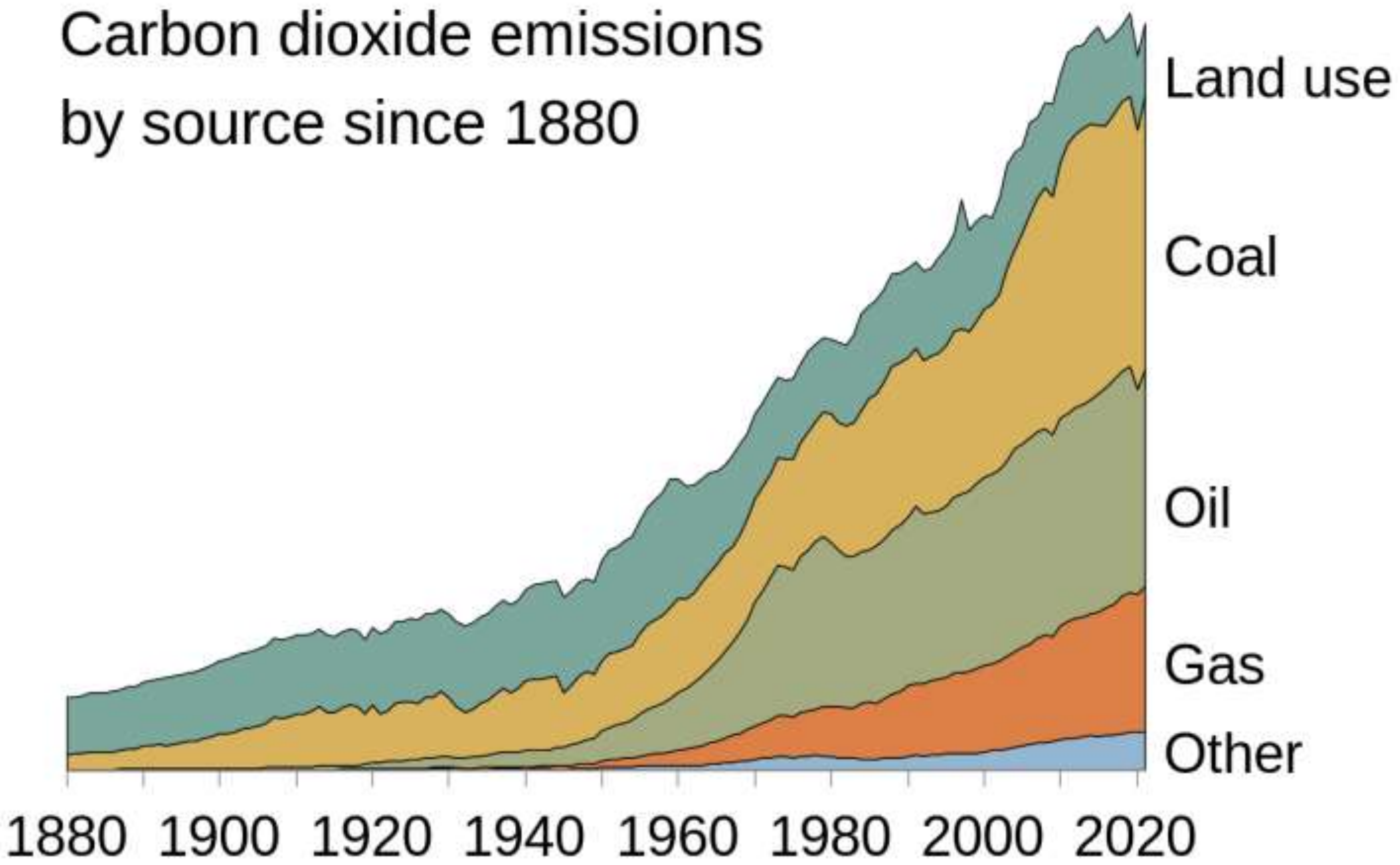


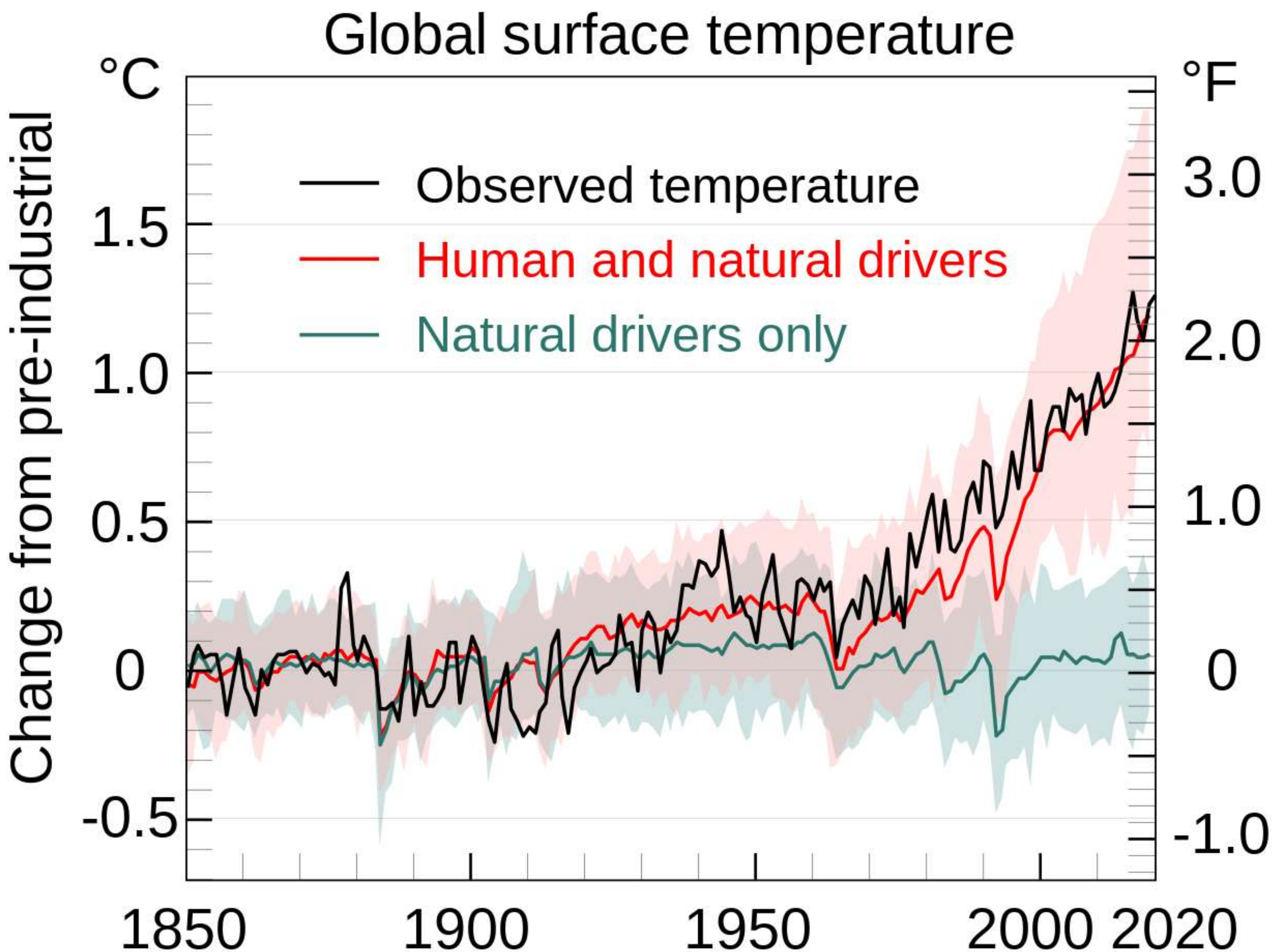
Physical drivers of climate change
Greenhouse gases
Carbon dioxide
Methane
Nitrous oxide
Halogenated gases
Nitrogen oxides
Other gases
Aerosols
Sulphur dioxide
Organic carbon
Ammonia
Black carbon
Irrigation and albedo
Aviation contrails
Contribution in °C
-1
-0.5
0
0.5
1
1.5

Climate change

Source of CO_2 emissions

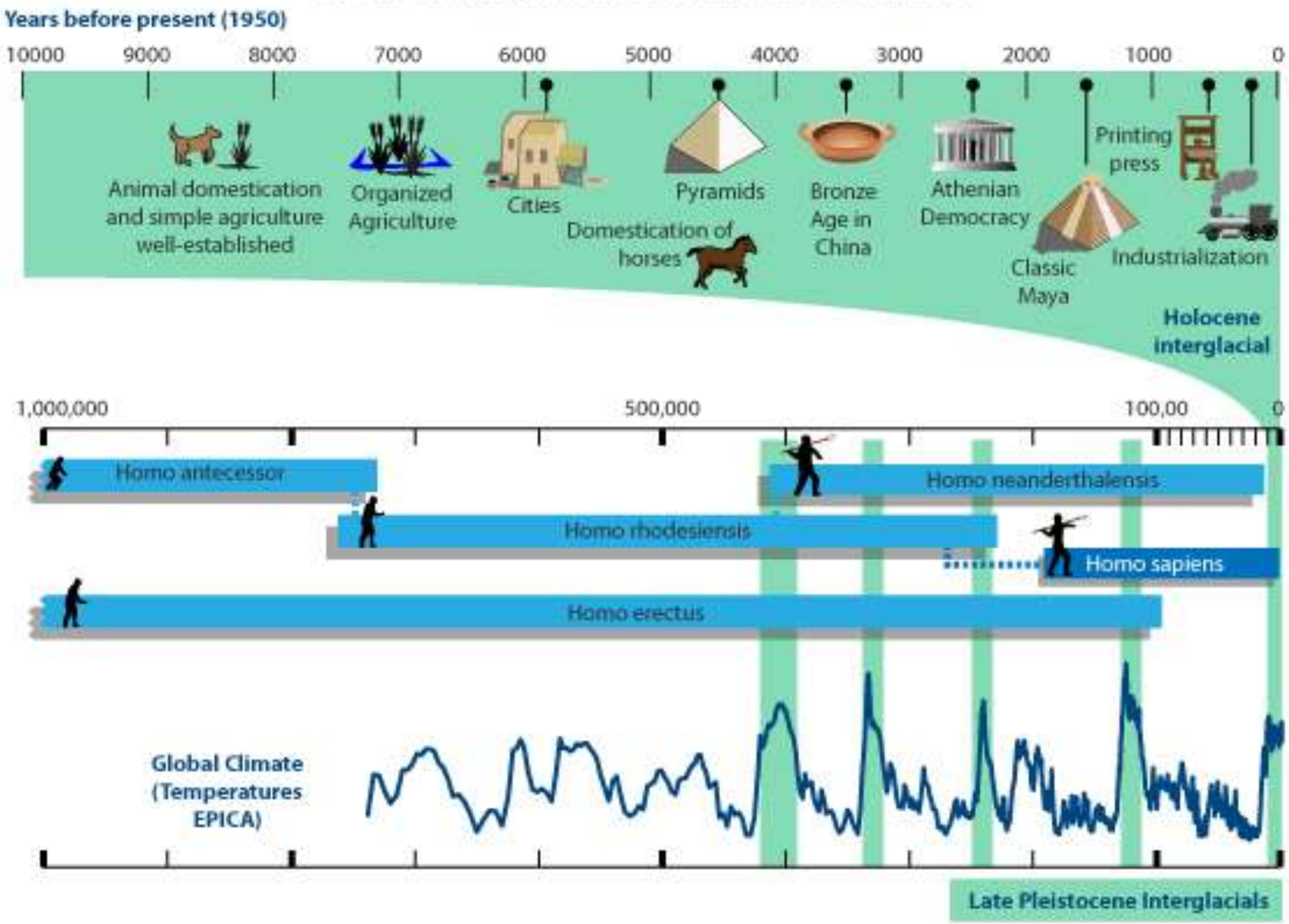
http://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_FINAL_full.pdf





Global surface temperature
°C
°F
Change from pre-industrial
Observed temperature
Human and natural drivers
Natural drivers only
1.5
1.0
0.5
0
-0.5
3.0
2.0
1.0
0
-1.0
1850
1900
1950
2000
2020

Global Climate, Human Evolution and Civilization

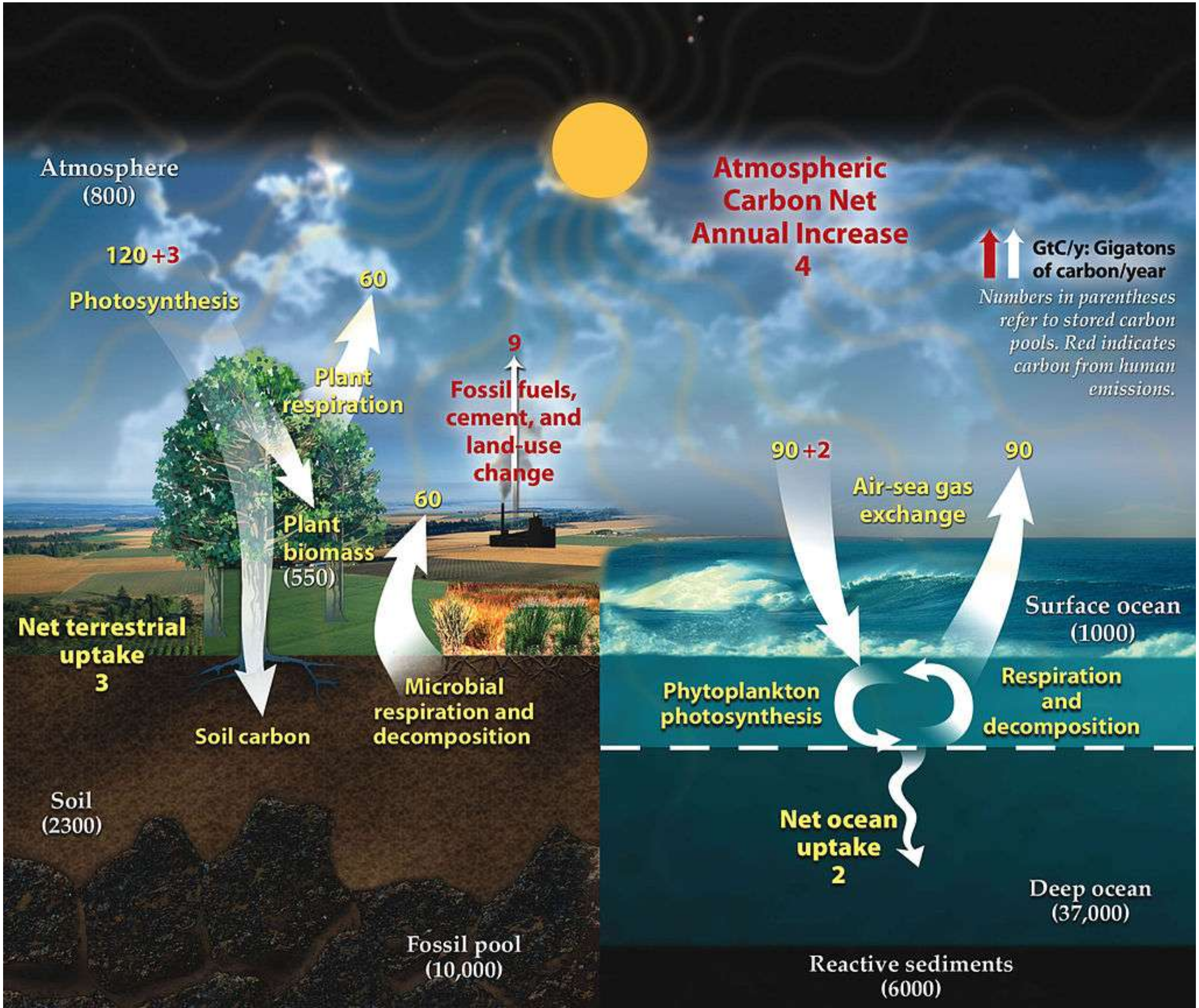


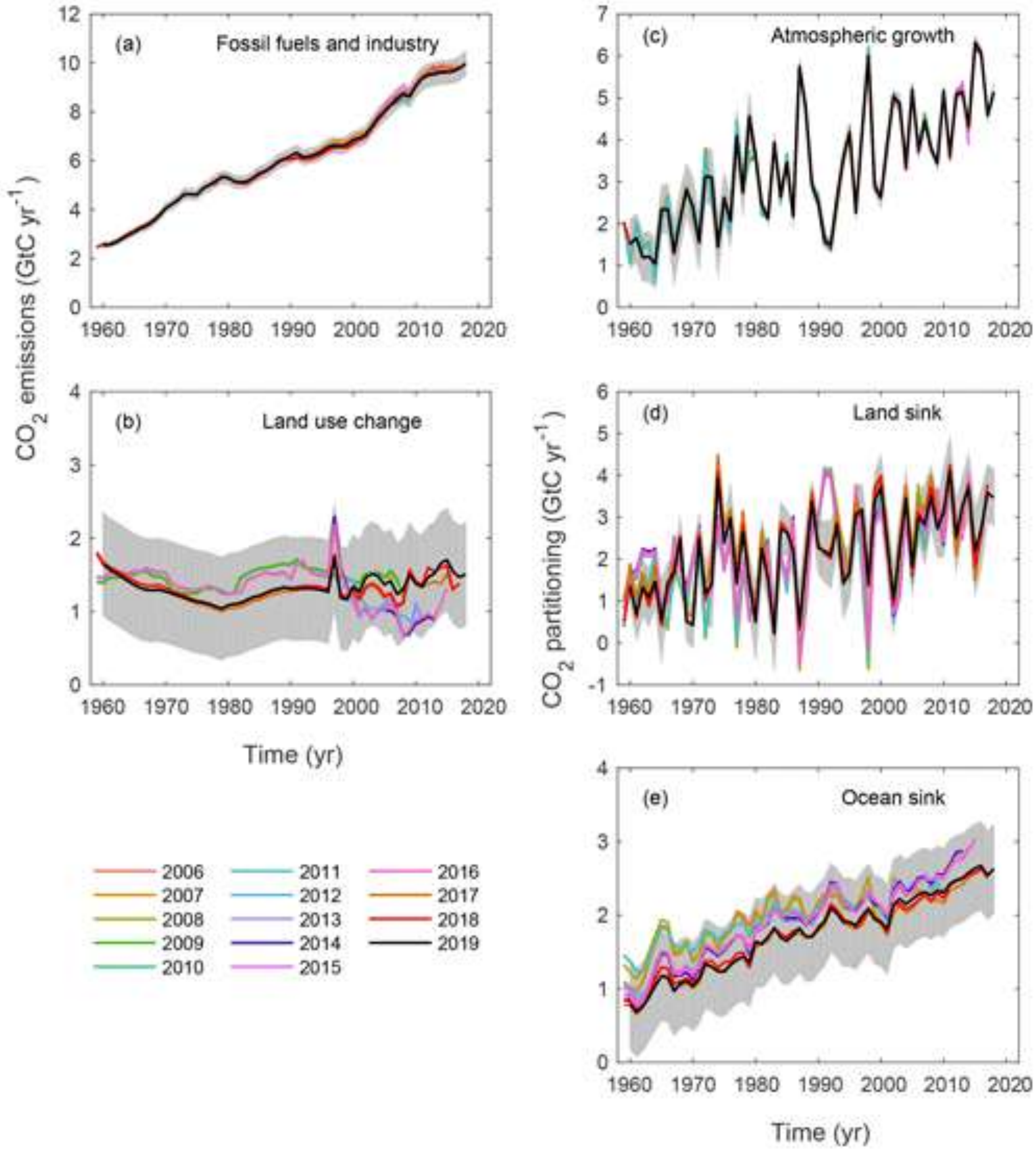
Human civilization is roughly 12,000 years old, as defined by the start of permanent settlements and agriculture.

Agriculture became established as the glaciers retreated from the last ice age.

Modern society has developed entirely in our current geological epoch, the Holocene. **Global temperatures haven't varied by more than ±1 °C since**.

Human related emission cause 4 gigatonnes of Carbon increase in the air annually

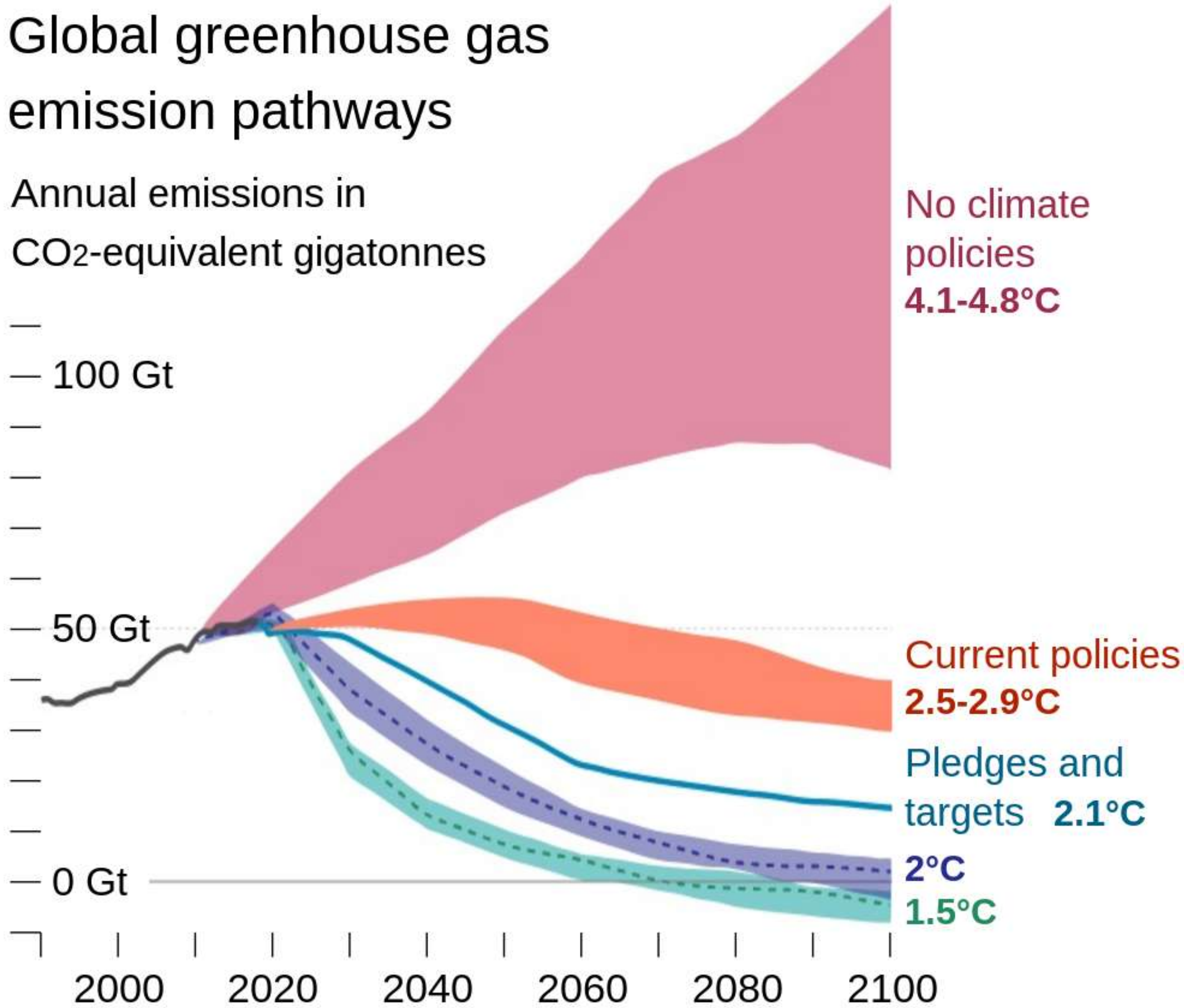


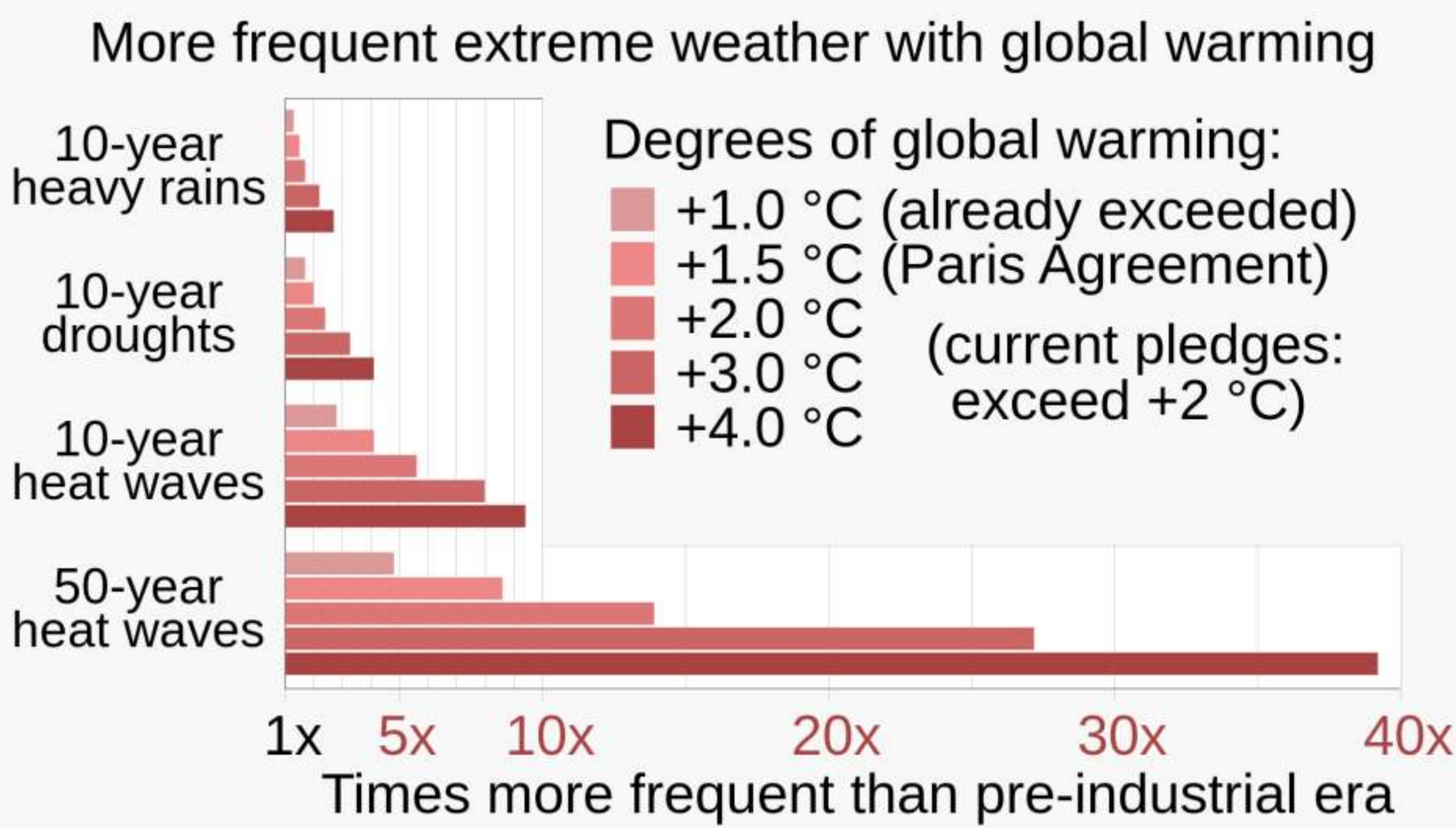


(a) Fossil fuels and industry
(b) Land use change
(c) Atmospheric growth
(d) Land sink
(e) Ocean sink
CO_2 emissions (GtC yr^{-1})
CO_2 partitioning (GtC yr^{-1})
Time (yr)
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019

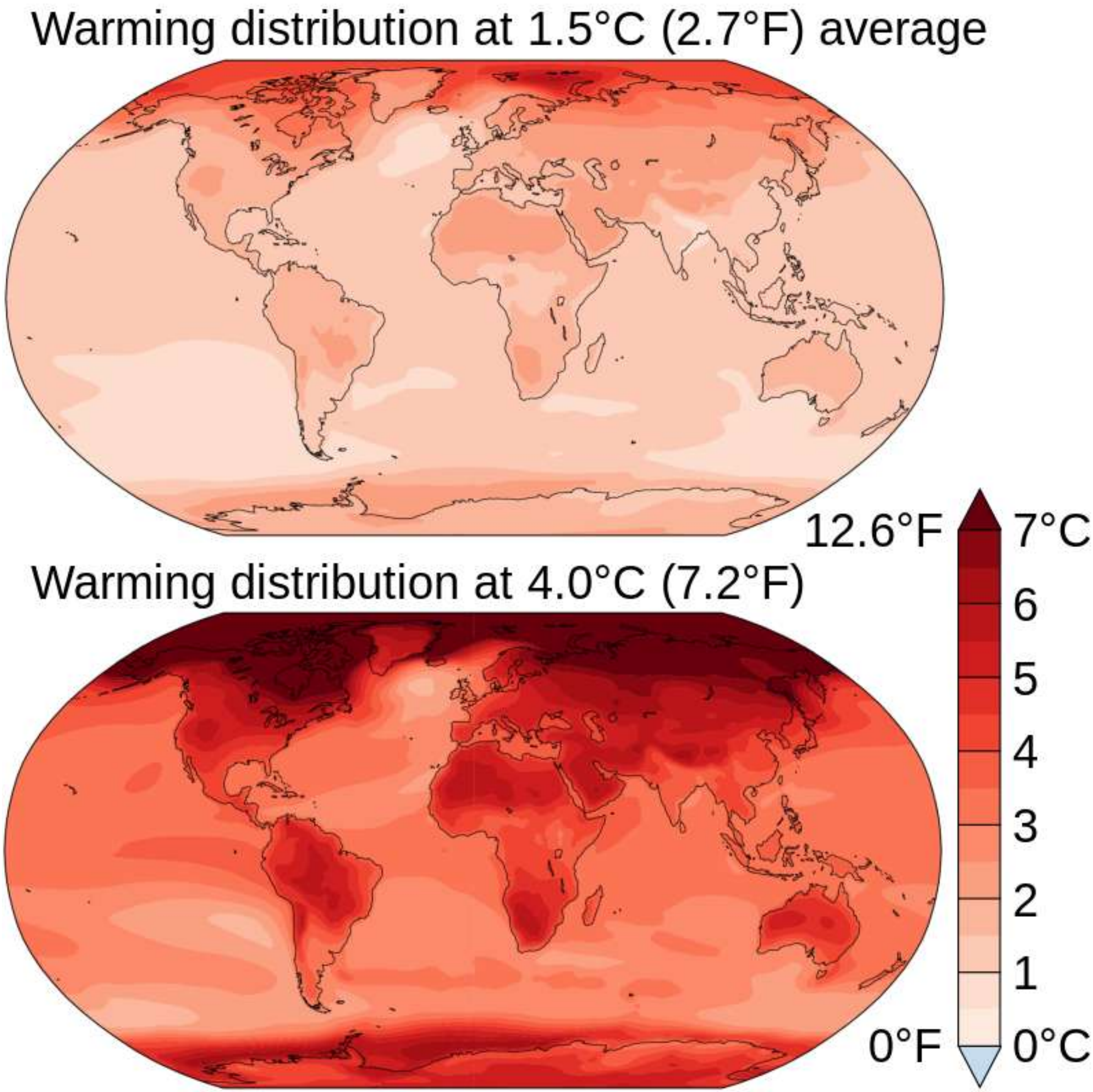
IPCC The Intergovernmental Panel on Climate Change (IPCC) is an intergovernmental body of the United Nations. Its job is to advance scientific knowledge about climate change caused by human activities

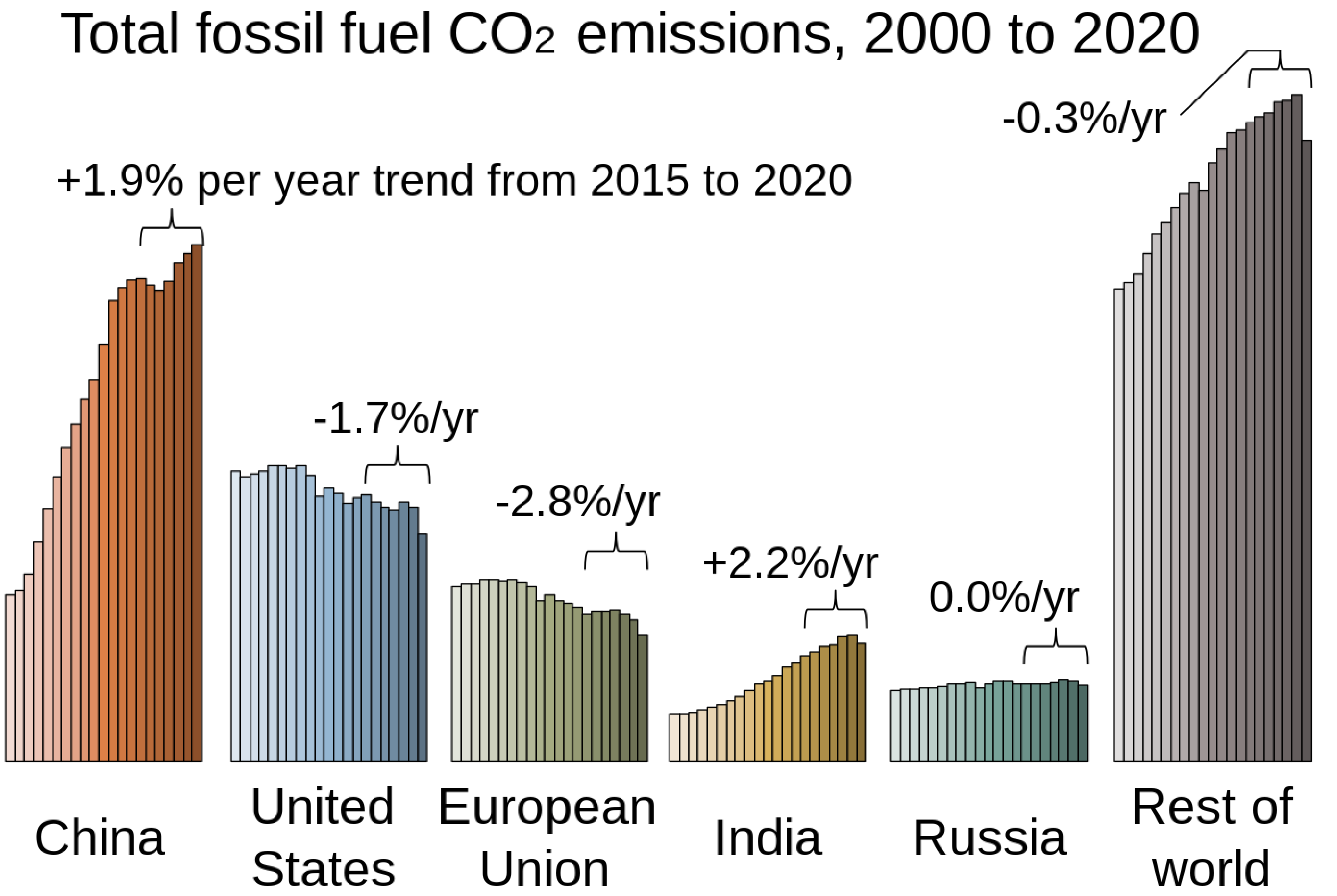
scenarios





More frequent extreme weather with global warming
10-year heavy rains
10-year droughts
10-year heat waves
50-year heat waves
Degrees of global warming:
+1.0 °C (already exceeded)
+1.5 °C (Paris Agreement)
+2.0 °C
+3.0 °C
+4.0 °C
(current pledges: exceed +2 °C)
1x
5x
10x
20x
30x
40x
Times more frequent than pre-industrial era


Warming distribution at 1.5°C (2.7°F) average
Warming distribution at 4.0°C (7.2°F)
12.6°F
7°C
6
5
4
3
2
1
0°F
0°C


Total fossil fuel CO2 emissions, 2000 to 2020
+1.9% per year trend from 2015 to 2020
-1.7%/yr
-2.8%/yr
+2.2%/yr
0.0%/yr
-0.3%/yr
China
United States
European Union
India
Russia
Rest of world

Forecast of future conditions

Uncertain (larger increase is possible):

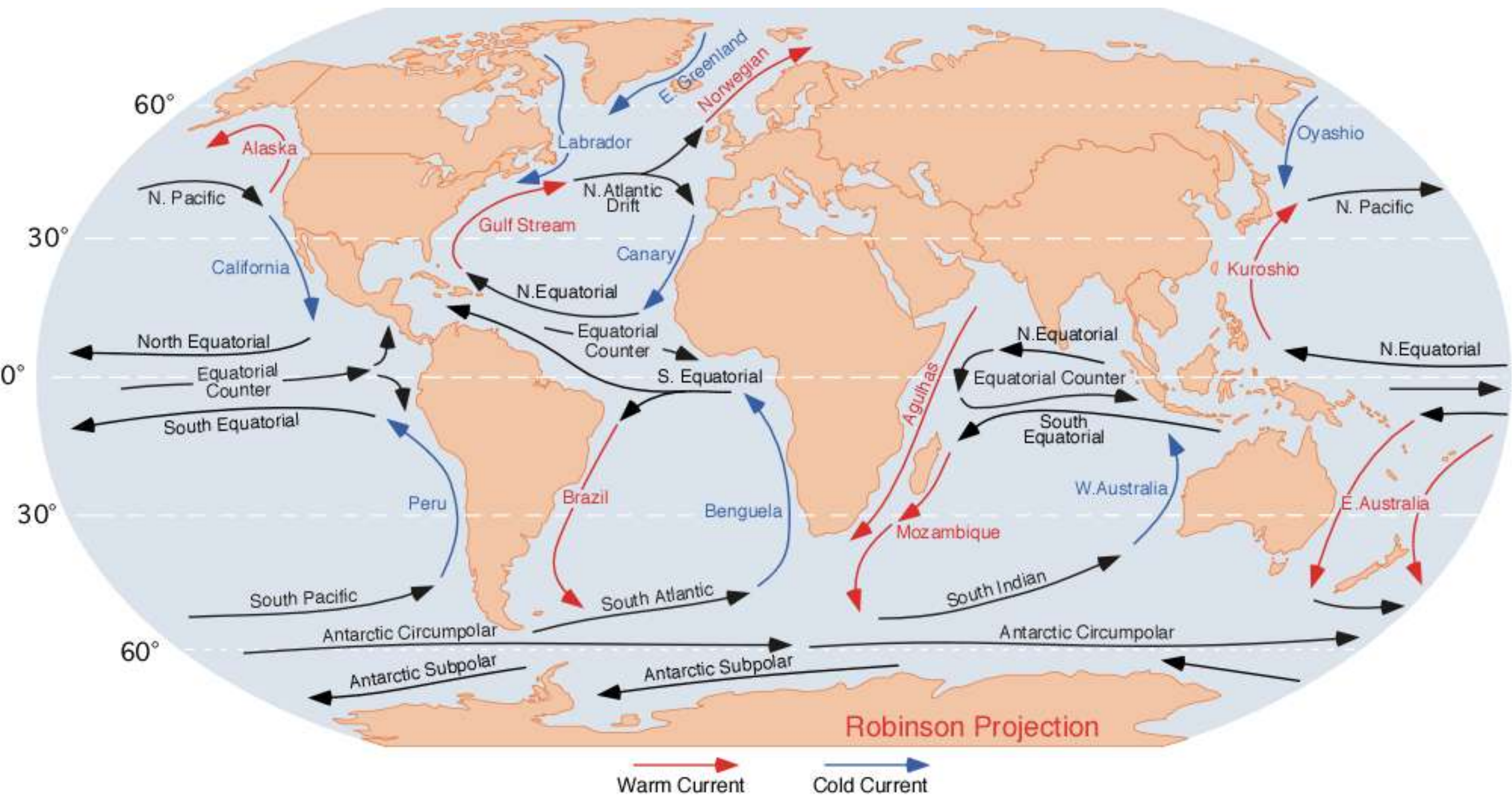
- Methane in Arctic soil
- Methanehydrat in ocean floor

Certain:

- Global increase of temperature and rainfall
- Larger frequency of extreme weather (droughts, floods, heat waves, hurricanes, tornados)

Local forecast with higher uncertainties:

- Higher increase at poles, the highest at north pole
- More rainfall at subtropical deserts in Africa and Asia
- More rainfall in subtropical areas
- Shutdown or reduction of certain ocean currents > e.g. Golf current weakness > extreme cold winters in Europe



60°
30°
0°
30°
60°
Alaska
N. Pacific
California
North Equatorial
Equatorial Counter
South Equatorial
Peru
South Pacific
Antarctic Circumpolar
Antarctic Subpolar
Labrador
E. Greenland
Norwegian
N. Atlantic Drift
Gulf Stream
Canary
N.Equatorial
Equatorial Counter
S. Equatorial
Brazil
Benguela
South Atlantic
Antarctic Subpolar
Agulhas
Mozambique
N.Equatorial
Equatorial Counter
South Equatorial
W.Australia
South Indian
Antarctic Circumpolar
Oyashio
N. Pacific
Kuroshio
N.Equatorial
E.Australia
Robinson Projection
Warm Current
Cold Current

Climate change – Ecological consequences

Global ecological effects

- More intense primary production – higher level of CO_2, more rainfall, longer vegetation period
- The CO_2 regulation mechanisms could work in short term:
  - Nitrogen and Phosphor limitation
  - Water limitation – more rainfall but higher turnover of the water
  - Forests as one of the most productive ecosystems has low coverage by forest cutting
  - CO_2 assimilation capacity of oceans/seas decreased by intense fishing, pollutions, higher temperature and acidity

Climate change – Ecological consequences

Local ecological effects

- Living organisms
  - Adaptation to the new conditions
  - Increase of emigration-immigration
  - R strategist with higher adaptation
  - K strategist with lower adaptation

- Areas of terrestrial species move an average 6 km/year toward the poles in temperate region, 6 m/year upper in mountains

- Change of Climax communities

- Large loss of coral reefs by increasing temperature, water level, acidity

Climate change – Ecological consequences

Local ecological effects

- Mass extinction of species (18-35% of species)
  - Coral reefs
  - Large role of refugee areas in mitigation negative effects

- Spread of disease (e.g. Malaria, West Nile Virus, Dengue fever…)

- Increasing tension in human societies – increase of migration

Increasing tension in human societies – increase of migration

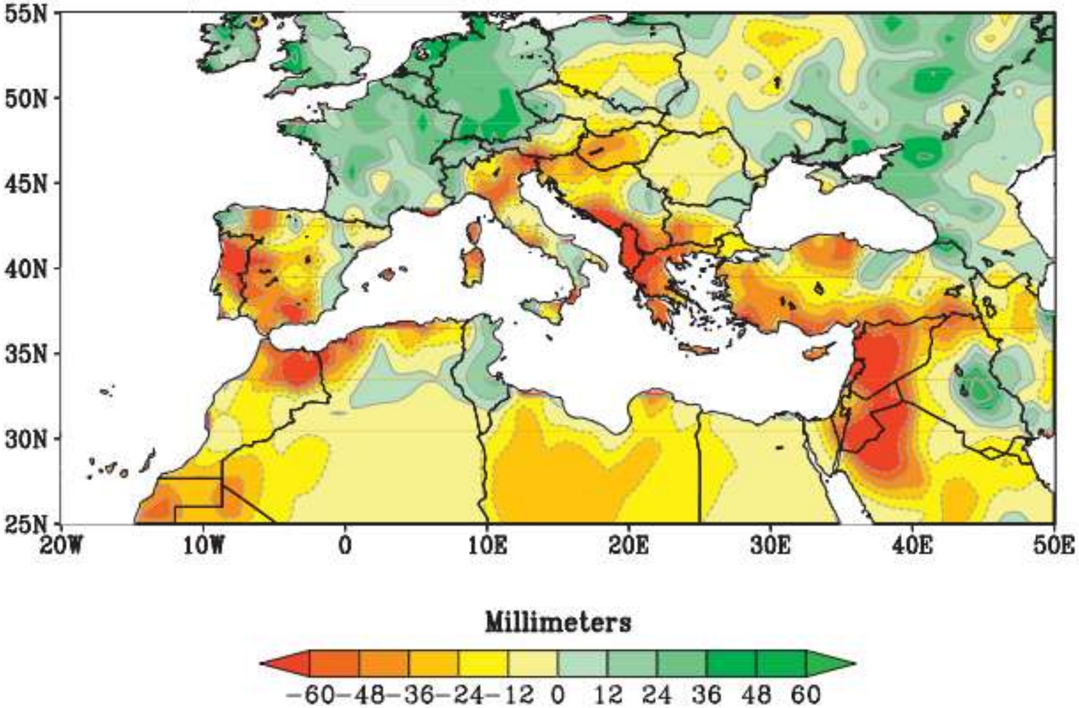


FIG. 1. (top) Observed time series of Mediterranean (30°–45°N; 10°W–40°E) cold season (November–April) precipitation for the period 1902–2010 and (bottom) the observed change in cold season precipitation for the period 1971–2010 minus 1902–70. Anomalies (mm) are relative to the 1902–2010 period. Solid curve is the smoothed precipitation time series using a nine-point Gaussian filter. Data are from the GPCC.