Biodiversity Monitoring (BBI1603)

- Books:
  - Primack R. B. 2010. Essentials of Conservation Biology. Macmillan Science
  - Hill D., Fasham M., Tucker G., Shewry M., Shaw P. 2005. Handbook of Biodiversity Methods_ Survey, Evaluation and Monitoring-Cambridge University Press
  - Vorisek P, Klvanova A, Wotton S, Gregory RD (2008) A Best Practice Guide for Wild Bird Monitoring Schemes.

Information in relation to the course:

http://zeus.nye.hu/~szept/kurzusok.htm

What is Biological Diversity?

– Conception

– **Measurable entity**

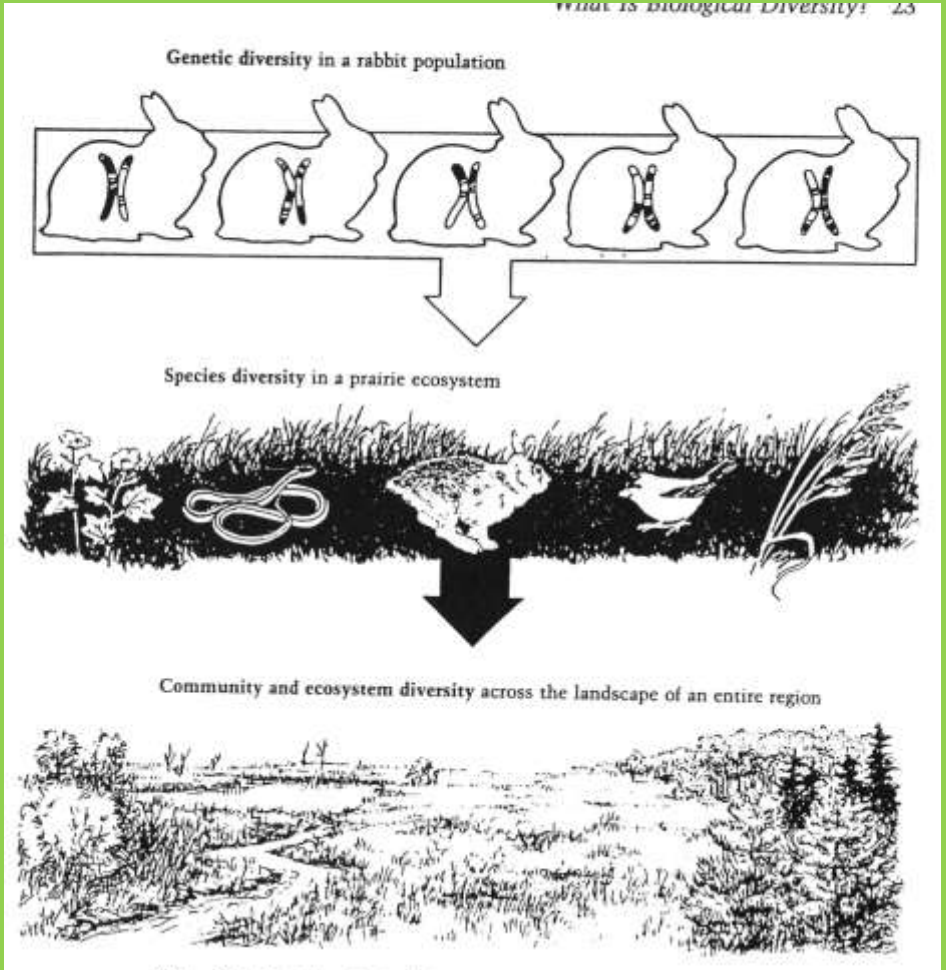
– Scientific field

Level of Biological Diversity

- Genetic diversity

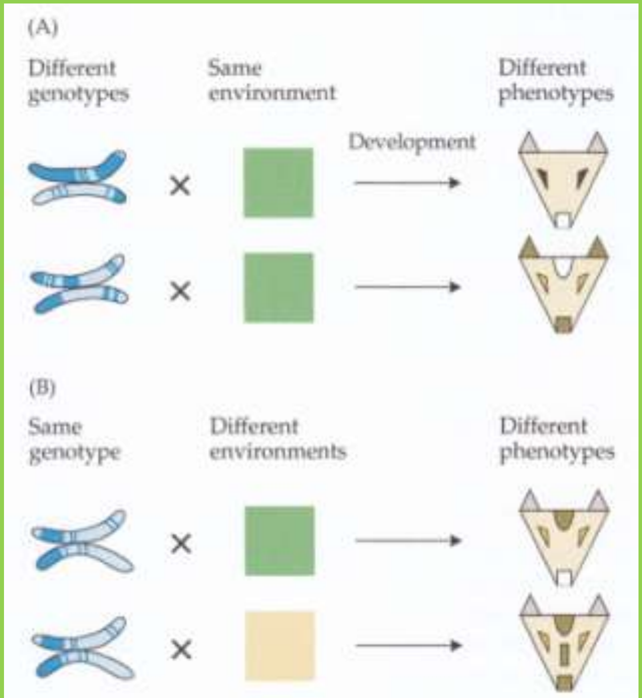
- Taxonomic diversity

- Community diversity

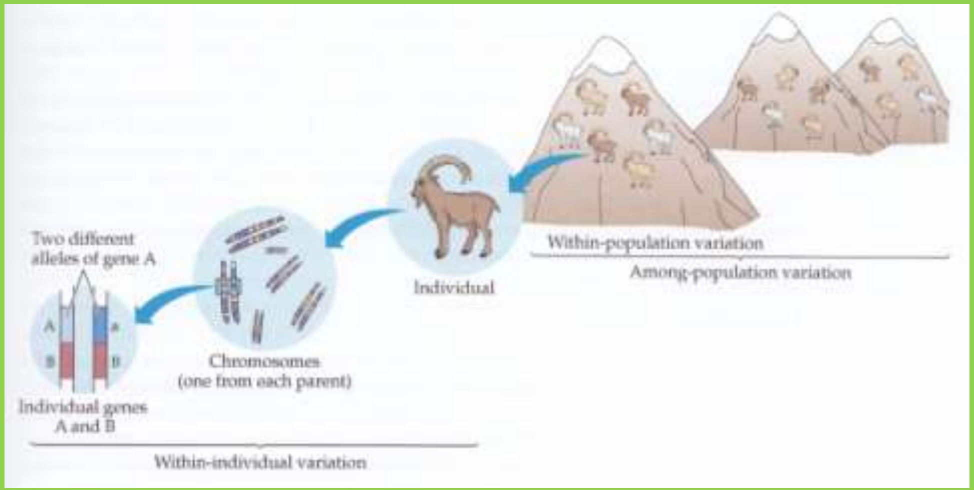


2.1 Biological diversity includes genetic diversity (the genetic variation found within each species), species diversity (the range of species in a given ecosystem), and community/ecosystem diversity (the variety of habitat types and ecosystem processes extending over a given region. (From Temple 1991; drawing by T. Sayre.)

Genetic diversity



- Among species (sibling species – Drosophila)
- Within species, among populations (e.g. dogs,)



Genetic diversity

Measurement

- Phenotypical diversity – isoensims
- Sequence of DNA

Polymorphism (P)

- Ratio of genes in the population with polymorphic allele

Heterozygousness (H)

The ratio of genes per individual that are polymorphic

Genetic diversity

Species genetic diversity(H_t)

$H_t=H_s+D_{st}$

H_s: Diversity within population

D_{st}: Diversity between populations

Polymorphism and heterozygousness has positive correlation

Diversity of taxonomic groups

Diversity of species, genus, family, order, class, phylum,,….

Number of species

Diversity index

Shannon-Wiener $$H = -\sum_{i-1}^{S} pi * \ln pi$$

ahol S: number of species, pi: frequency of the i-th species

Evenness

E= H/Hmax, H/lnS

There are several types of diversity index – Diversity ordering used nowadays

A

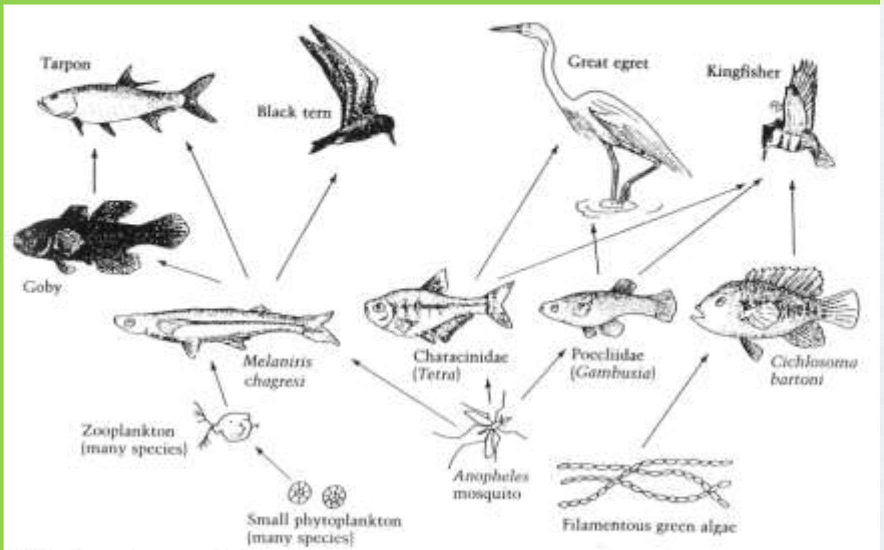
Species	Ni	pi (frequency)	ln pi	pi * ln pi	1/S	ln (1/S)	(1/S) * ln (1/S)
Great tit	13	0.406	-0.901	-0.366	0.143	-1.946	-0.278
Blue tit	8	0.250	-1.386	-0.347	0.143	-1.946	-0.278
Blackbird	4	0.125	-2.079	-0.260	0.143	-1.946	-0.278
Nuthatch	3	0.094	-2.367	-0.222	0.143	-1.946	-0.278
Great spotted woodpecker	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

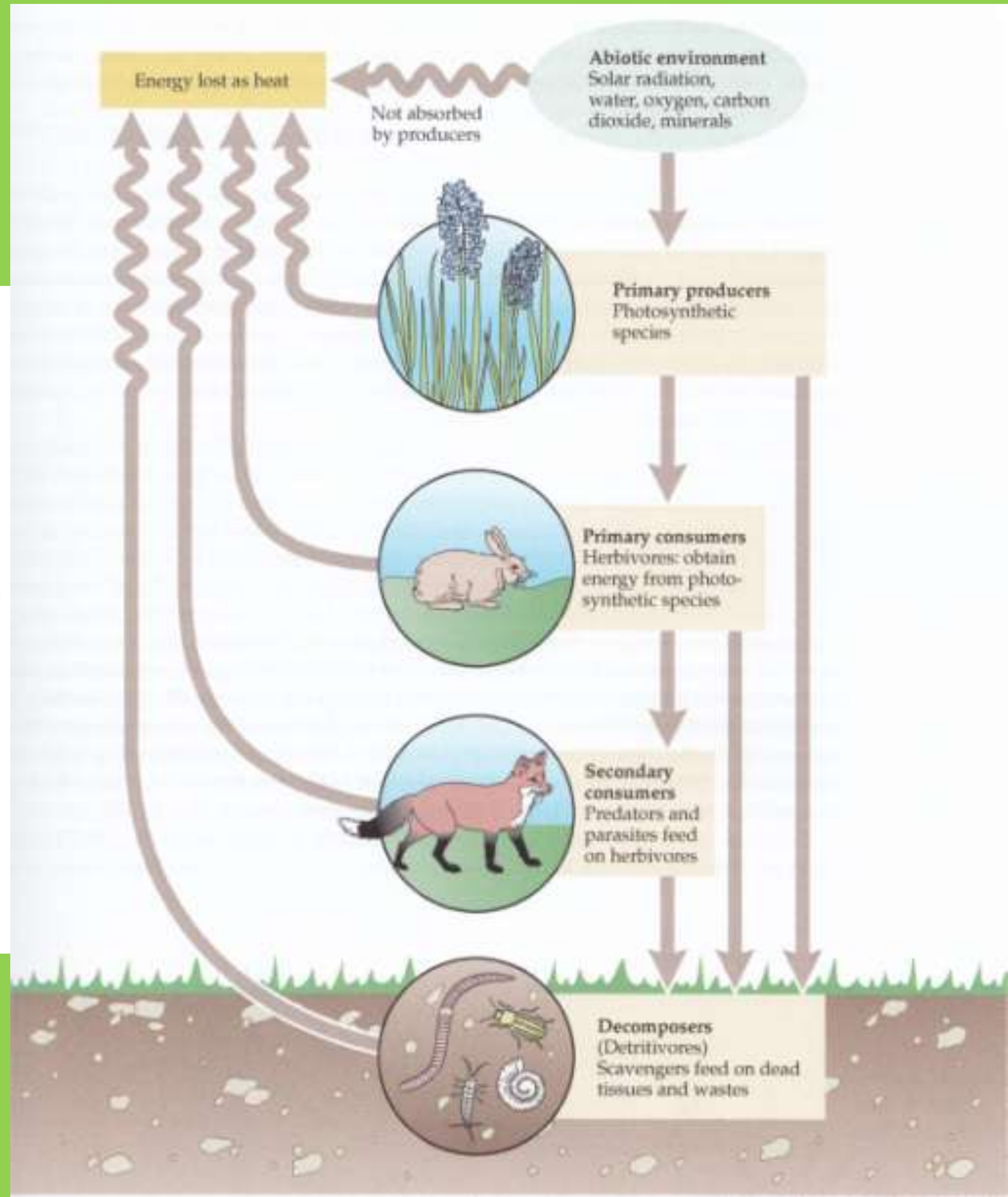
Species	Ni	pi (frequency)	ln pi	pi * ln pi	1/S	ln (1/S)	(1/S) * ln (1/S)
Great tit	20	0.625	-0.470	-0.294	0.143	-1.946	-0.278
Blue tit	5	0.156	-1.856	-0.290	0.143	-1.946	-0.278
Blackbird	3	0.094	-2.367	-0.222	0.143	-1.946	-0.278
Nuthatch	1	0.031	-3.466	-0.108	0.143	-1.946	-0.278
Great spotted woodpecker	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**

Community ecosystem diversity

- Diversity of functional groups



2.9 Diagram of an actual food web studied in Gatun Lake, Panama. Phytoplankton ("floating plants") such as green algae are the primary producers at the base of the web. Zooplankton are tiny, often microscopic, floating animals; they are primary consumers, not photosynthesizers, but they, along with insects and algae, are crucial food sources for fish in aquatic ecosystems. (Courtesy of G. H. Orians.)



Community ecosystem diversity

- Diversity of habitats
- Diversity of habitat patches

Biodiversity

The importance of species varies in the nature

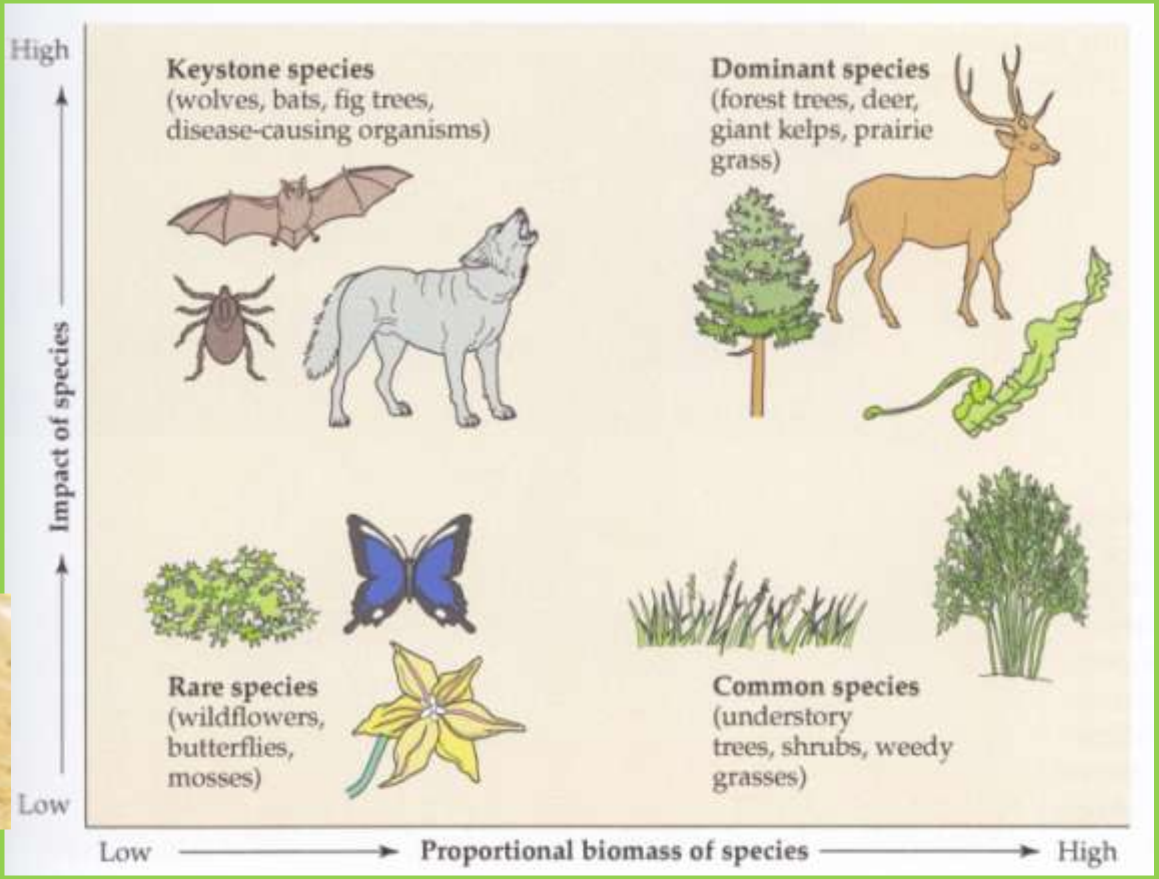
Naturalness – rarity - threateness

Keystone species

- Top predators– e.g. wolf

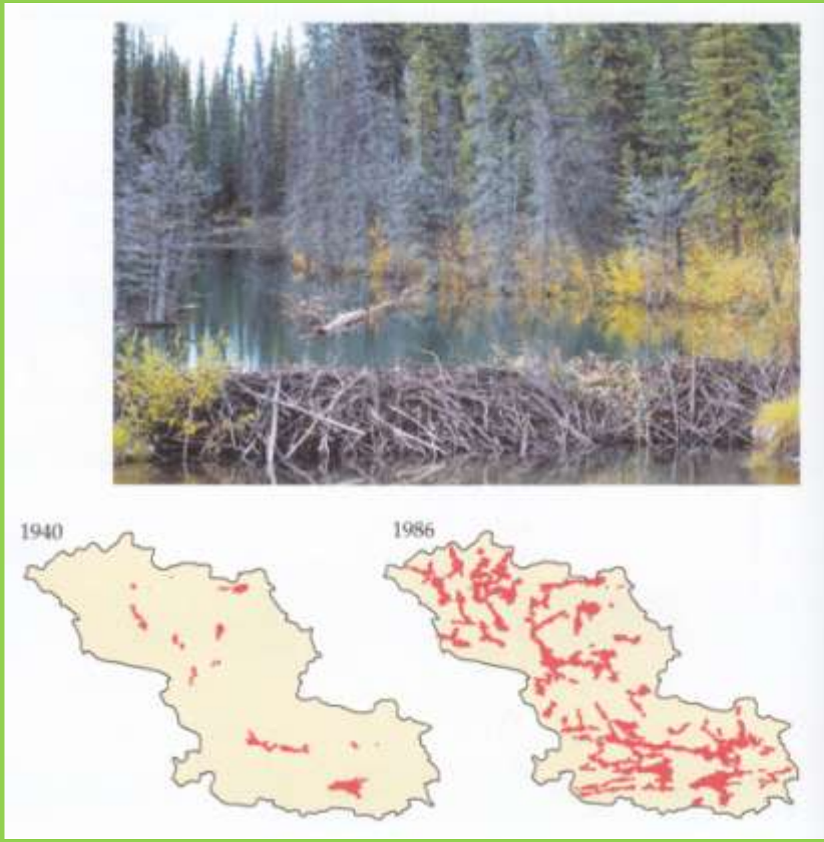
- Flying foxes

- Ecosystem engineers – beaver, elephant, dung beetles



Ecosystem engineers

- Beavers



Ecosystem engineers

- Elephant





Keystone Resources

- Salt-licks and mineral pools
- Deep pools
- Elevational gradients
- Mangroves

Indicators

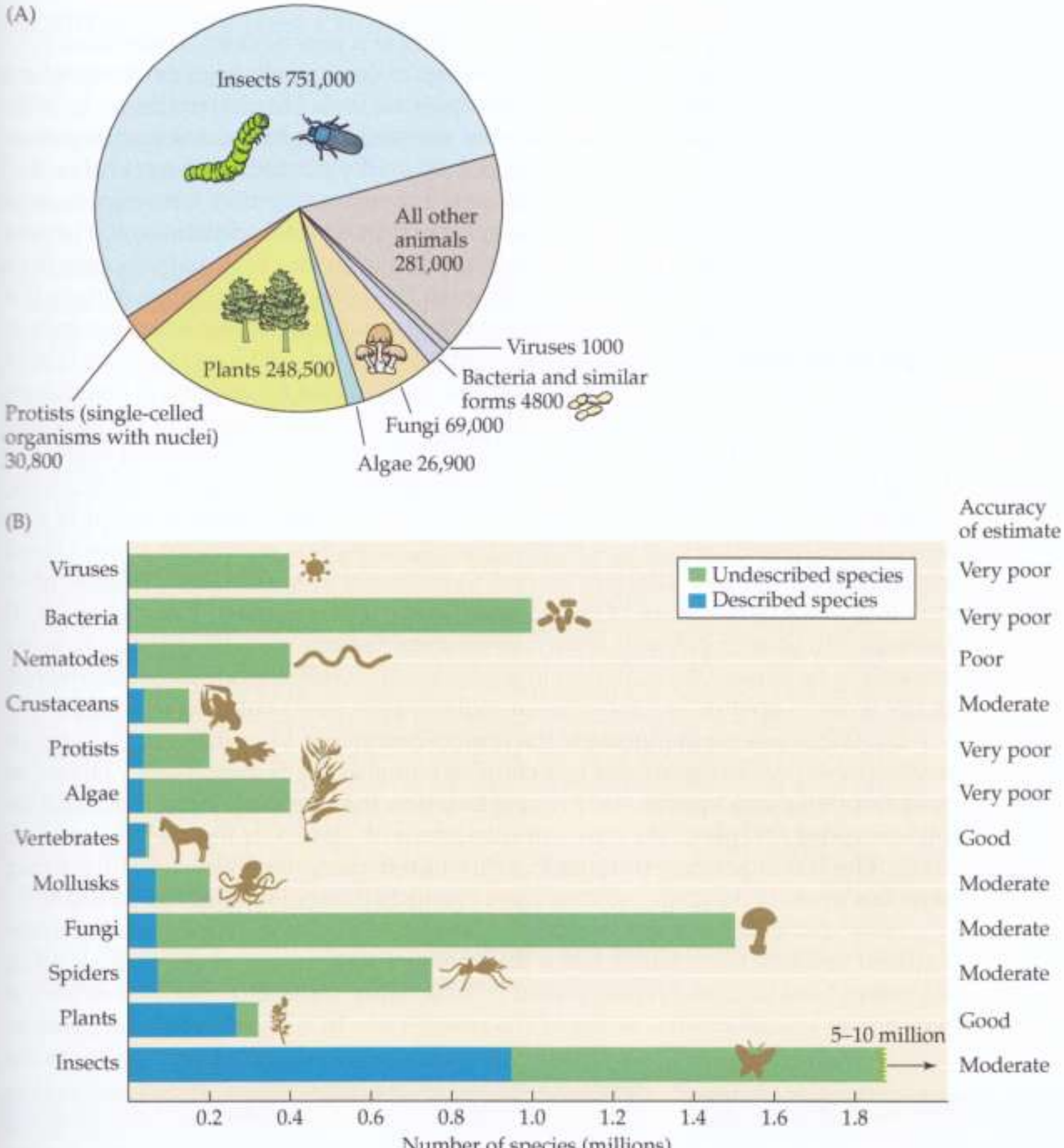
- Flagship species (Panda, Californian Condor)

http://wwf.panda.org/what_we_do/endangered_species/

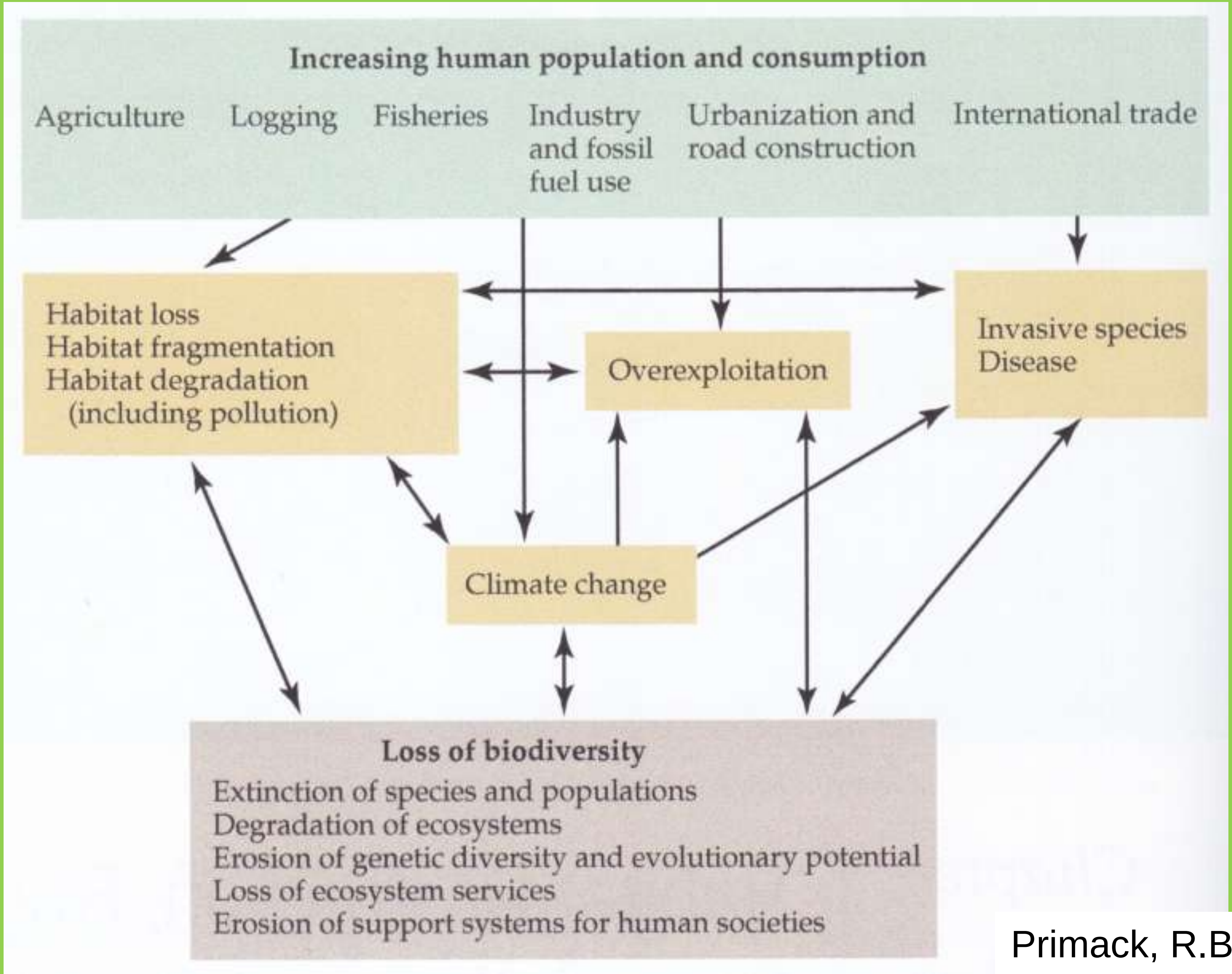
- Umbrella species (e.g. Grizzly Bears)

Biological Diversity

- The science described ~2.000.000 species,
- however the estimated number of species on the Earth are over 10 millions



The planet has lost 58% of its biodiversity since 1970 according to a 2016 study by the World Wildlife Fund



Primack, R.B. 2014

Biodiversity Monitoring

is essential:

- To collection information about status of the biodiversity for researchers, decision makers and public
- To detect adverse trends of populations, species, communities, habitats, ecosystems
- To measure efficiency of actions against adverse trends

Importance of indicators in the biodiversity monitoring

Not feasible to monitor regularly and in details all species !

Biodiversity indicators (species, groups of species) tools to indirectly get information about status of several other species, communities, habitats

Requirements of biodiversity indicators:

- Easy to survey even by not specialist –> for large spatial coverage
- Low cost of survey –> cost effective way of getting proper data
- Ecological meaningful and properly explanatory data –> investigation
- Known by the public and/or has economic values -> interpretation
- …

Birds – exclusive role in the biodiversity monitoring

- Proper indicators in regional and country level

- Intensively studied animals – large amount of research to interpret the data

- National (e.g. In Hungary: MME/BirdLife Hungary) and International professional organisations (e.g. In Europe: EBCC, EURING, BirdLife Europe) with standard of methods, data handlings and cooperations

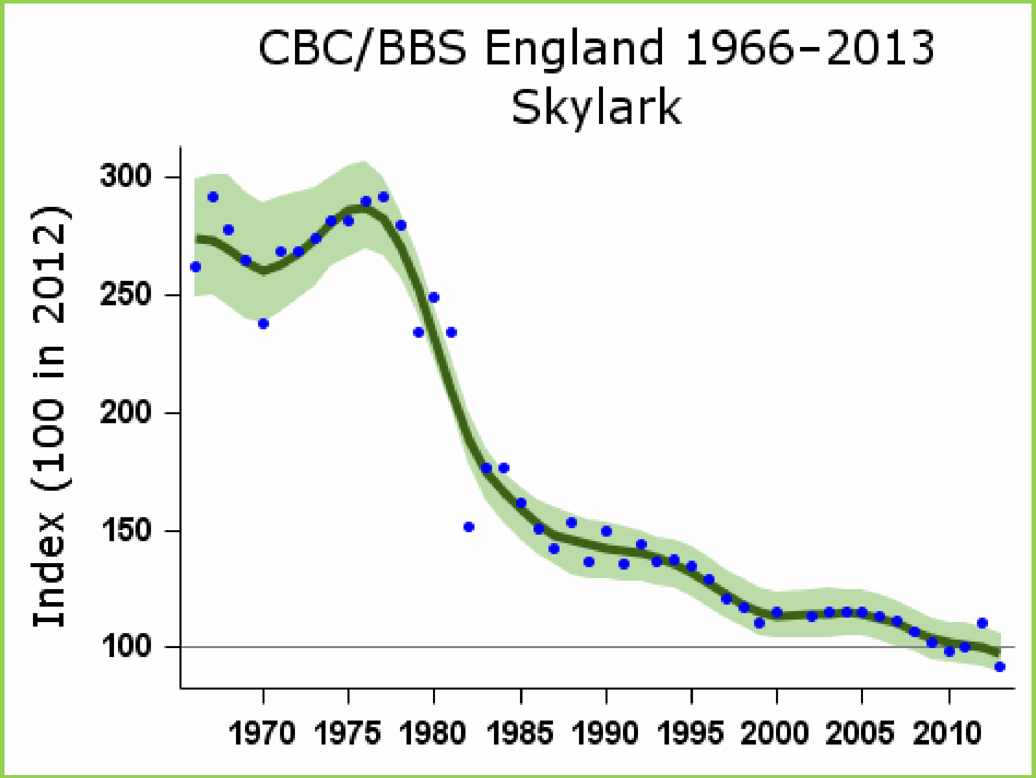
- Large database in space and time

- Opportunity to collect data with much lower cost comparing to other animals– **largest network of voluntary people for surveying**

- One of the best now animal group for the general public – large interest by the public

Biodiversity monitoring with birds in Europe

-In Europe, ~2/3 of the areas transformed to agricultural land during centuries
-Large loss of the biodiversity in this dominant habitats from 1980 indicated by breeding bird species in Western Europe

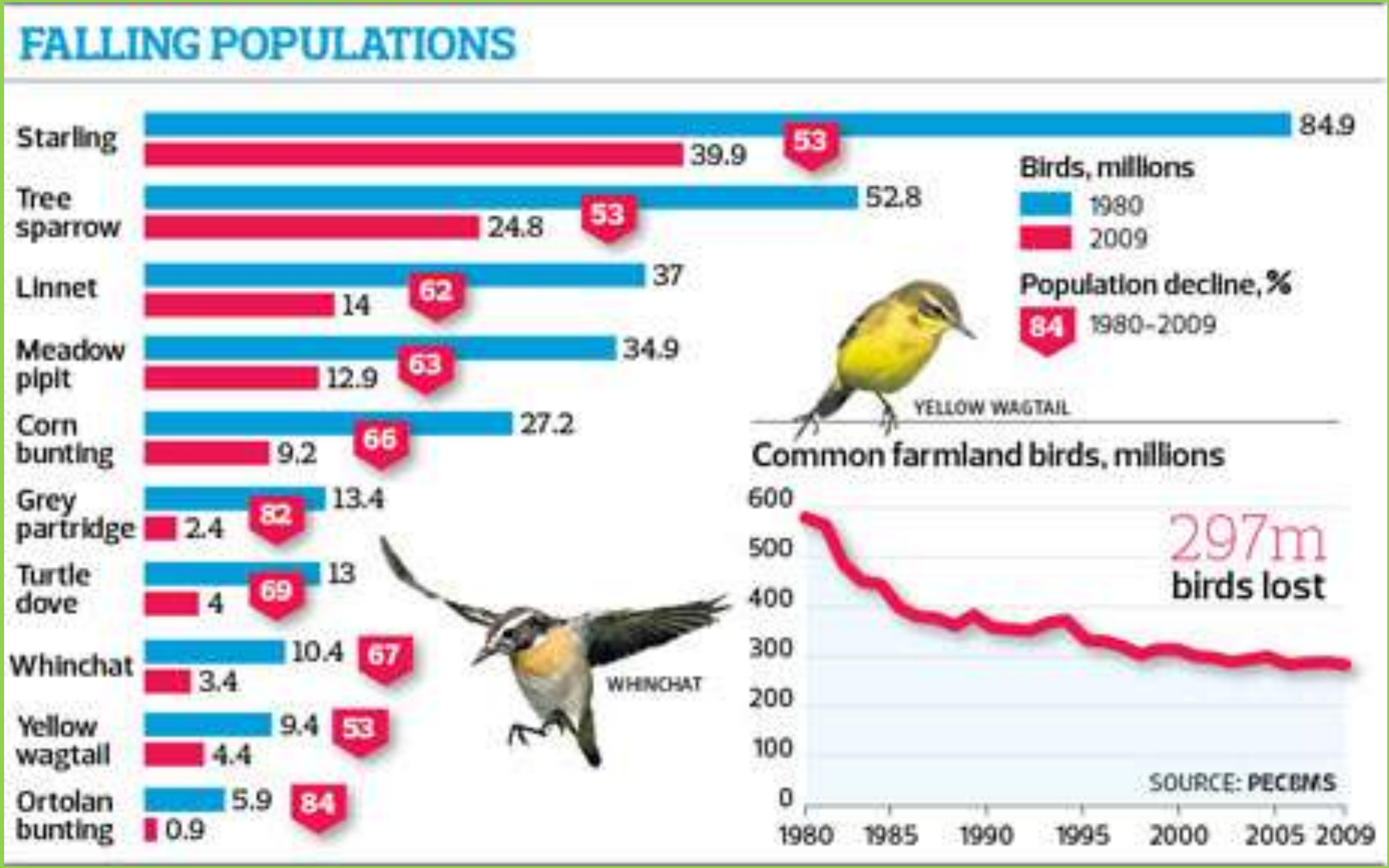


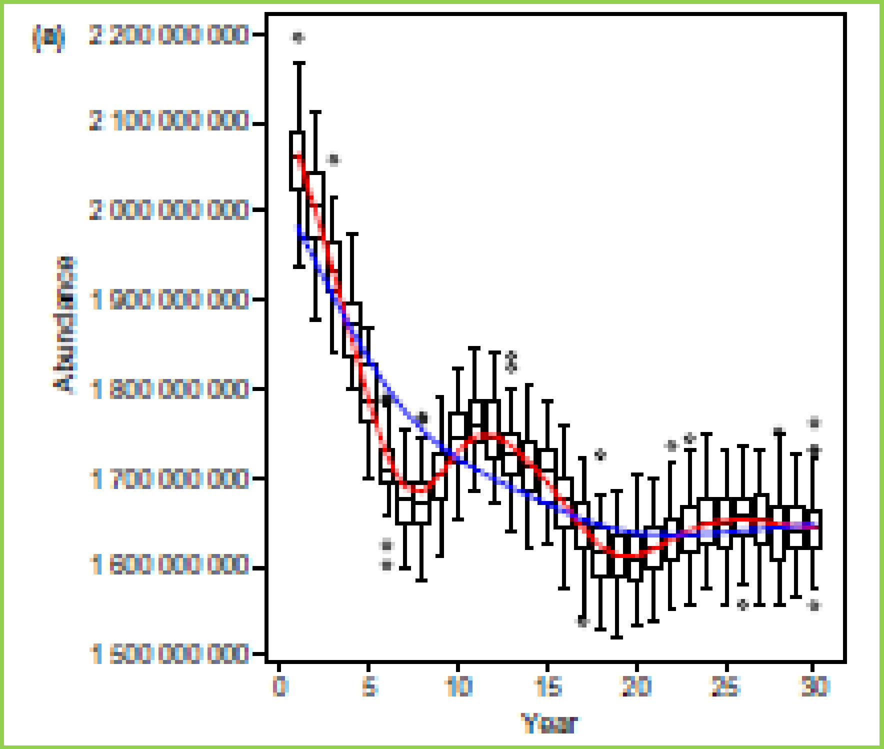
Trend of population size of skylark (Alauda arvensis) in England

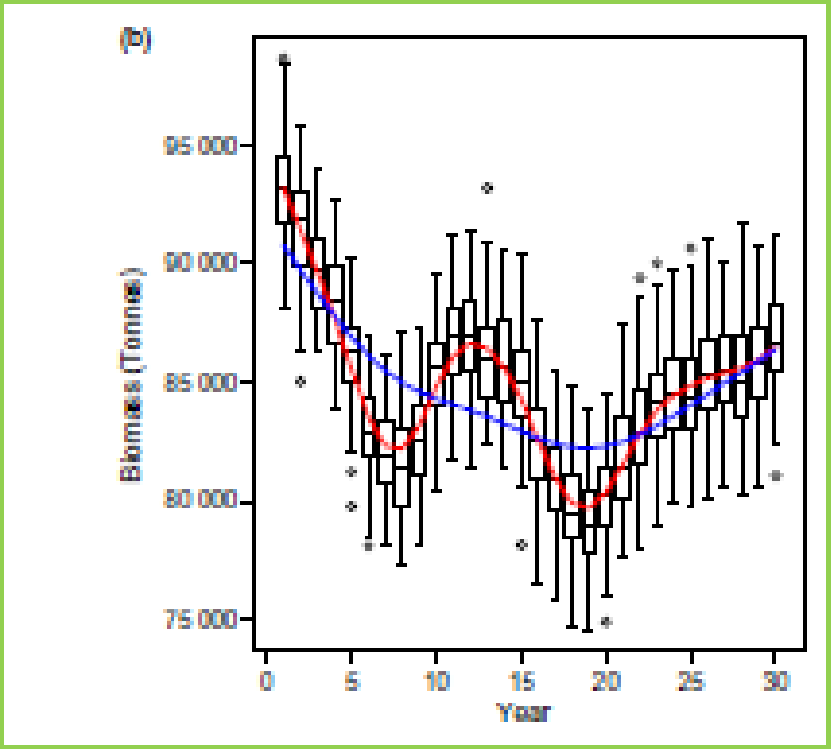
Large decline of the population size of breeding bird farmland species in Western Europe from 1980

-

Common Agricultural Policy (CAP) started in the European Union in 1980



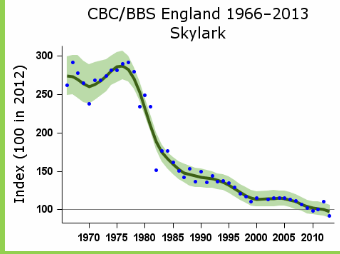




(a) Number of individuals and (b) estimated biomass

In Europe, 421 million bird individuals missing, (7 000 tons of bird biomass) between 1980-1994 *(Inger et al. Ecology Letters, 2014)*.

Main causes



Common Agricultural Policy (CAP) of EU

- Large increase of the agricultural intensification -> large negative influence on farmland species *(Butler et al. 2007. Science)*

  -Spring to autumn sowing

  -Loss on non-cropped habitat

  -Increased agrochemical inputs

  -Land drainage

  -Switch from hay to silage and earlier harvesting

  -Intensified grassland management

Direct effects on Birds:

– ***Decline of foraging site during the breeding and wintering seasons***
– ***Decline of food during the breeding and wintering seasons***
– ***Decline of breeding sites***

Pan-European Common Bird Monitoring Scheme (PECBMS) by the EBCC

Main goal is to use common birds as indicators of the general state of nature using large-scale and long-term monitoring data on changes in breeding populations across Europe

Common birds are good indicators as they are widespread, relatively easy to identify and count, sensitive to land use and climate change, and are popular with the public.

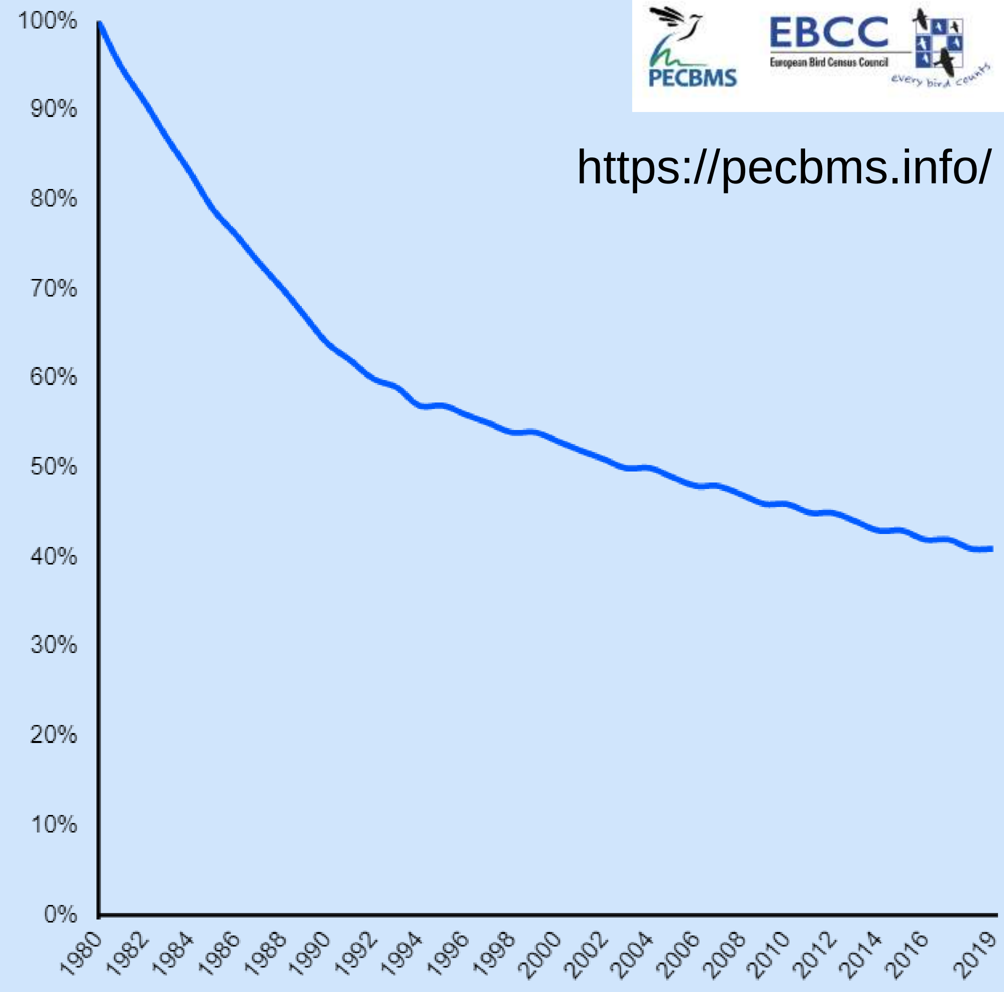
https://pecbms.info/

Pan-European Common Bird Monitoring Scheme (PECBMS) by the EBCC

Common bird indicators (multi-species composite indices)

Geometric mean of annual indices of species use similar habitat

Farmland Bird Indicator (**FBI**) in Europe between 1980 and 2019



PECBMS

EBCC European Bird Census Council every bird counts

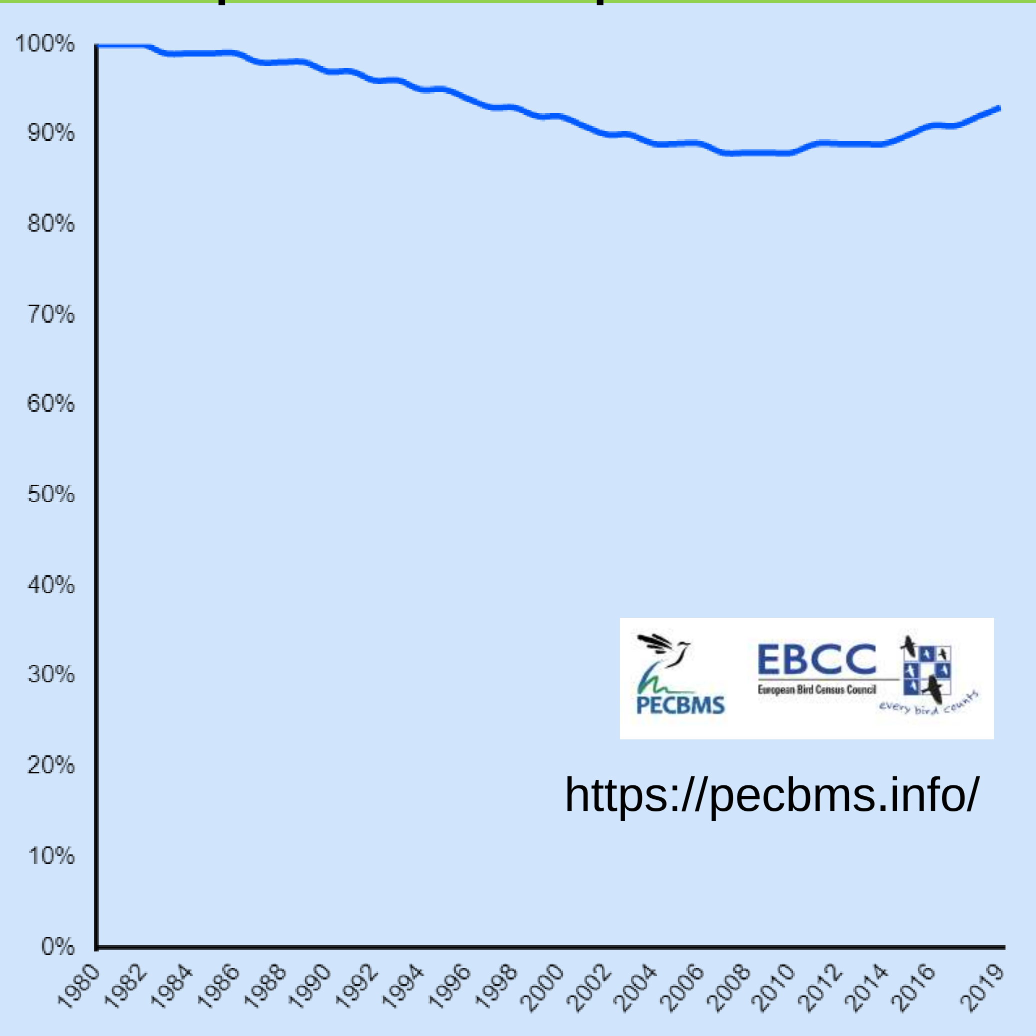
https://pecbms.info/

Pan-European Common Bird Monitoring Scheme (PECBMS) by the EBCC

Common bird indicators (multi-species composite indices)

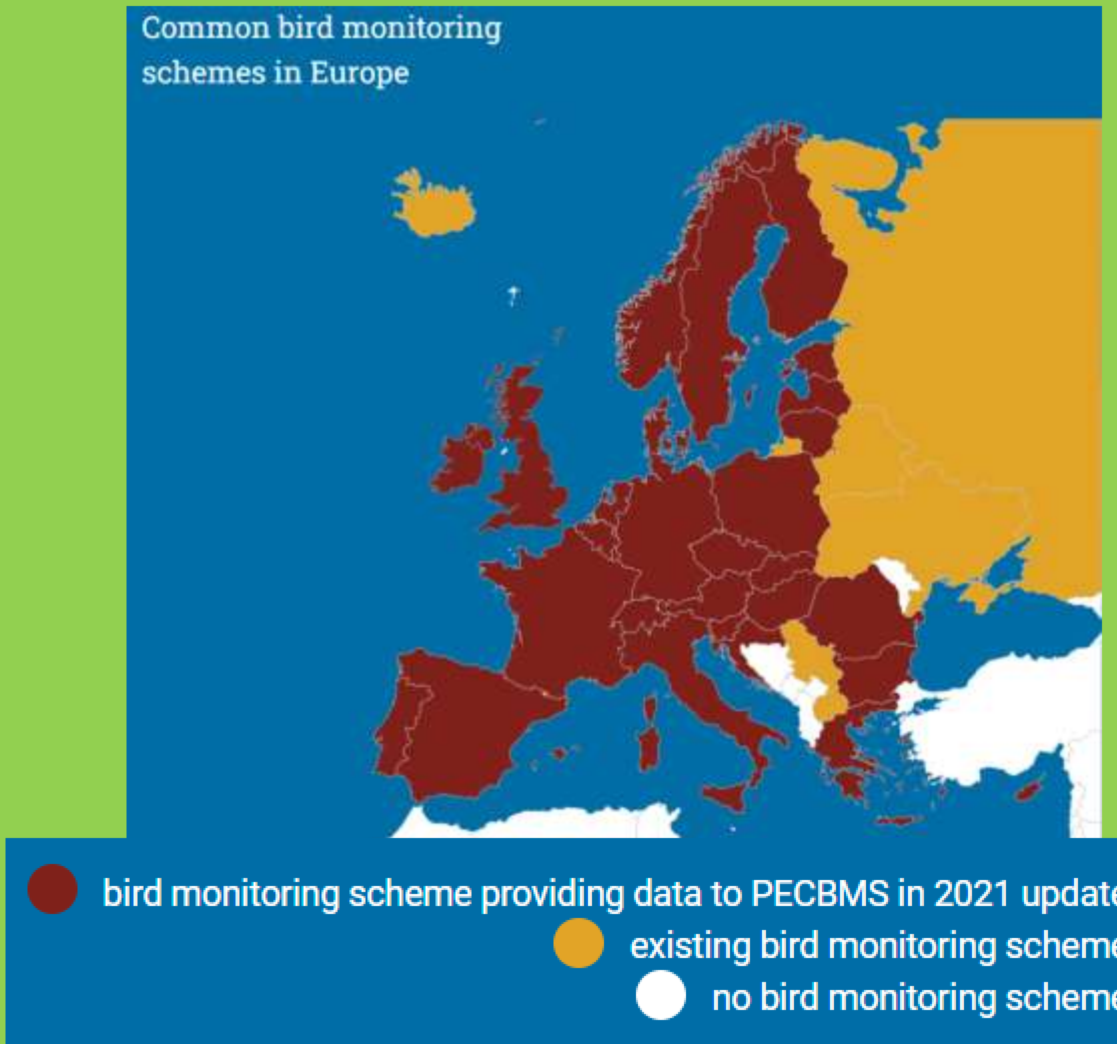
Geometric mean of annual indices of species use similar habitat

Indicator forest birds in Europe between 1980 and 2019



Pan-European Common Bird Monitoring Scheme (PECBMS) by the EBCC

Large coverage of Europe for 2021



https://pecbms.info/

Pan-European Common Bird Monitoring Scheme (PECBMS) by the EBCC

The PECBMS indicators have been accepted as

- Indicators for the EU´s Structural Indicator
- Indicators of Sustainable Development of the EU
- National versions of the Farmland bird indicators have also been approved as the Regulation indicators in the EU´s Rural Development Plans

Other international institutions, e. g, have used the indicators. Organization for Economic Co-operation and Development (OECD), or European Environment Agency (EEA), and have also been included in Living Planet Index (LPI).

https://pecbms.info/

Can we monitor biodiversity in Hungary properly with birds ? (plenty of discussion from 1997)

Hungary became member of the EU in 2004:

- What is the influence of the Common Agricultural Policy (CAP) on the farmland biodiversity in Hungary ?

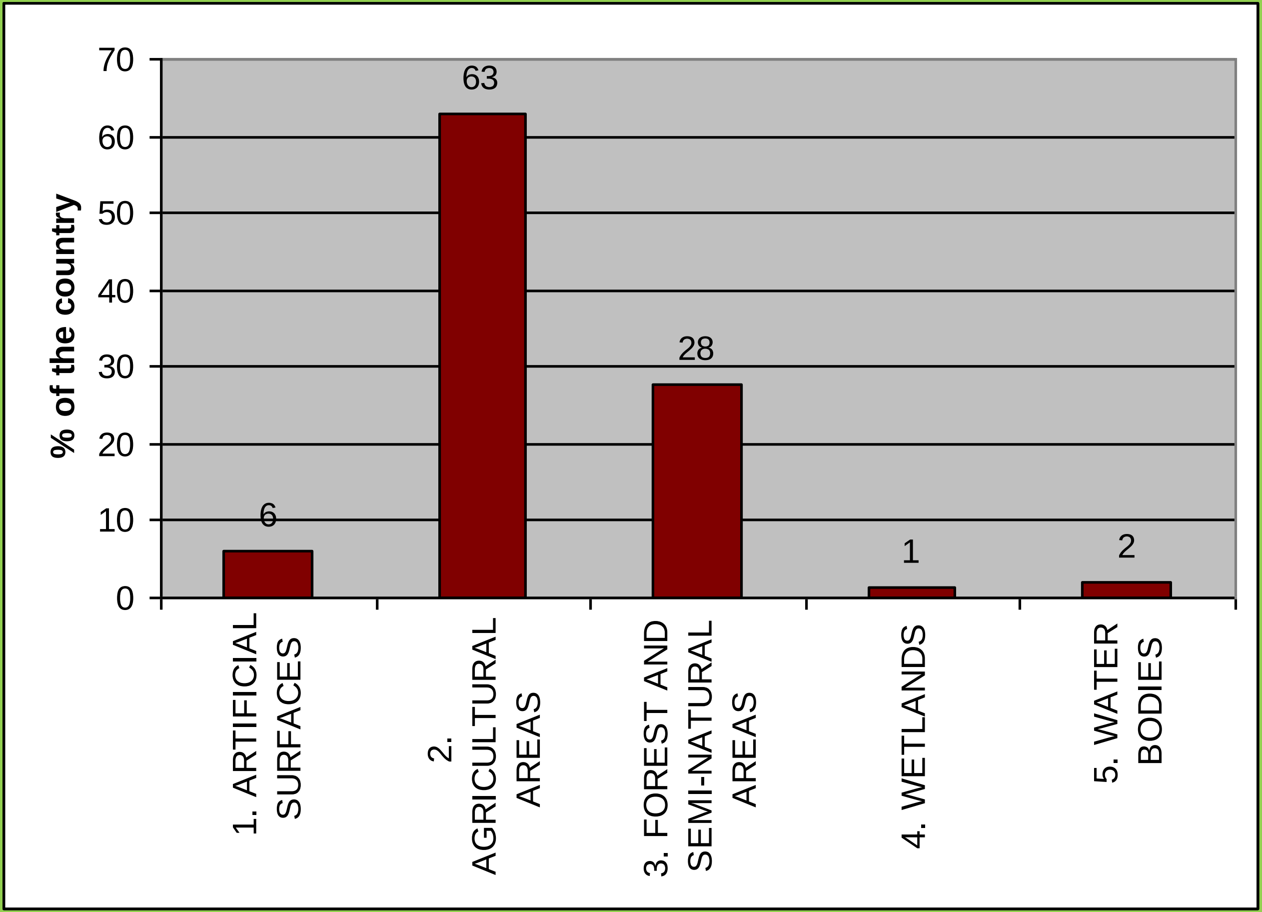
- How the agri-environmental schemes able to handle the known potential negative impacts of the CAP on the farmland biodiversity in Hungary?

Which kind of other factors (climate change, development,…etc) influence the Biodiversity ?

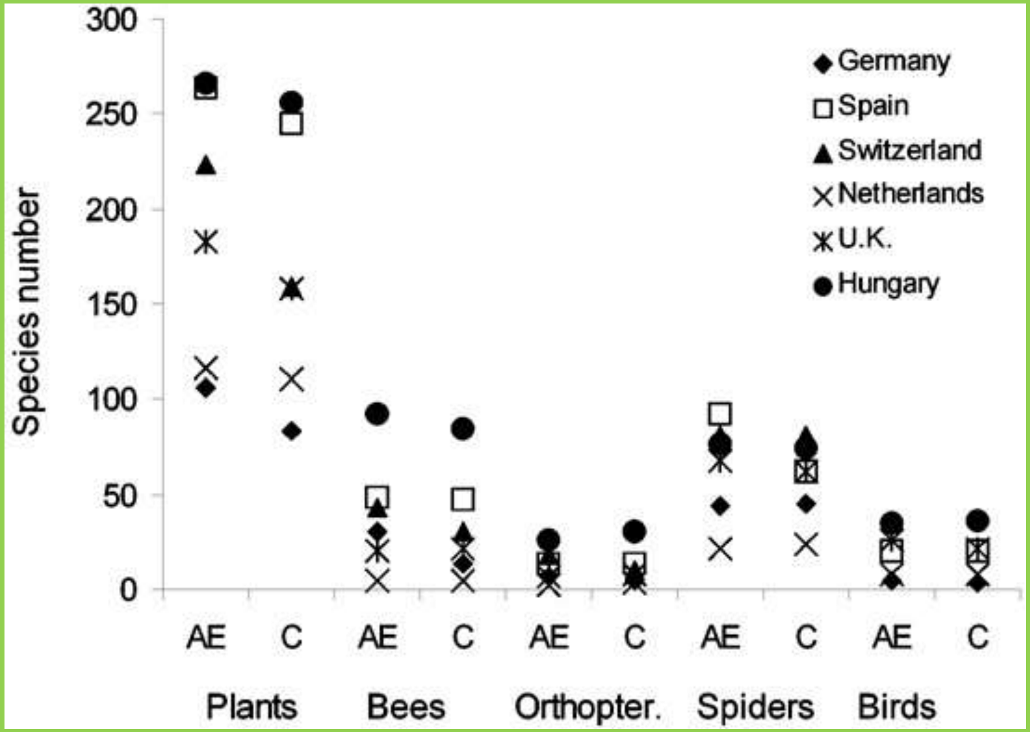
Distribution of habitats in Hungary (Corine)

94 000 sq km

~10 million people



Biodiversity of Hungarian farmland is among the highest in Europe



Detailed field investigations carried out in 2003, species richness and abundance of 10 different species groups . (AE:extensively grazed, C: intensively grazed semi-natural pastures)

Báldi, A. Batáry, P. Klein, D. 2013. Effects of grazing and biogeographic regions on grassland biodiversity in Hungary – analysing assemblages of 1200 species. *Agriculture, Ecosystems and Environment*

Monitoring of birds before 1997

- No relevant bird data from the main habitats
  - There wasn’t proper nationwide general monitoring scheme of common birds
- Bird monitoring focused on rare birds and mainly in natural habitats (Monitoring of Rare and Colonial birds, RTM)
  - Free choice selection of the studied areas
  - Not representative for the main habitats of the country
  - Limited sources for the start and running schemes

Important condition for an effective biodiversity monitoring

Need to know the answers for:

- Why ?
- What ?
- How ?

Focusing only collection of all kind of data of wild plant/animals without considering these questions during the planning could let to difficult to analyse and interpret the collected information about status of biodiversity

Biodiversity monitoring on large scale

Big challenge

- Regular data collection in large areas
- Sites of observations need to be representative for the main habitats and regions of the studied area
- **„Instrument" – the observers who can identify the species**
- Need to control factors influence the observation (date, time, weather, distance,…etc.)
- Importance of usage objective, standard methods
- Limited sources for start and long-term running

- **Only feasible by considering large number of voluntary people with proper identification skill with proper protocol for data collection, analysis and with coordination of their work!**

Challenge of biodiversity monitoring with voluntary people

- Different skill

- Enthusiastic start with often too large intensity – threat of fast „burnout”

- Continuously changing participants

- **However, committed and ready for even hard work**

- **Voluntary people can carry out field work when there is „gaps” in the sources of monitoring**

Challenge of biodiversity monitoring with voluntary people

Indispensable:

- Adequate sampling and surveying methods to the questions one want to answer with the scheme
- Easy to learn and use methods
- Monitoring center with proper staff and sources for long-term activity (in frame of NGO or GO): **tranning, coordination, information, motivation, data handling, control, analysis and feedback to the voluntary people**

- Application of proper, even less accurate sampling and survey methods ->> small bias and high accuracy because of large number of representative samples
- Less costly, but not free!, than monitoring with full time employees

https://pecbms.info/best-practice-guide/

Hungarian Common Bird Monitoring scheme since 1999

Mindennapi Madaraink Monitoringja (MMM)

Started with the help of RSPB and EBCC

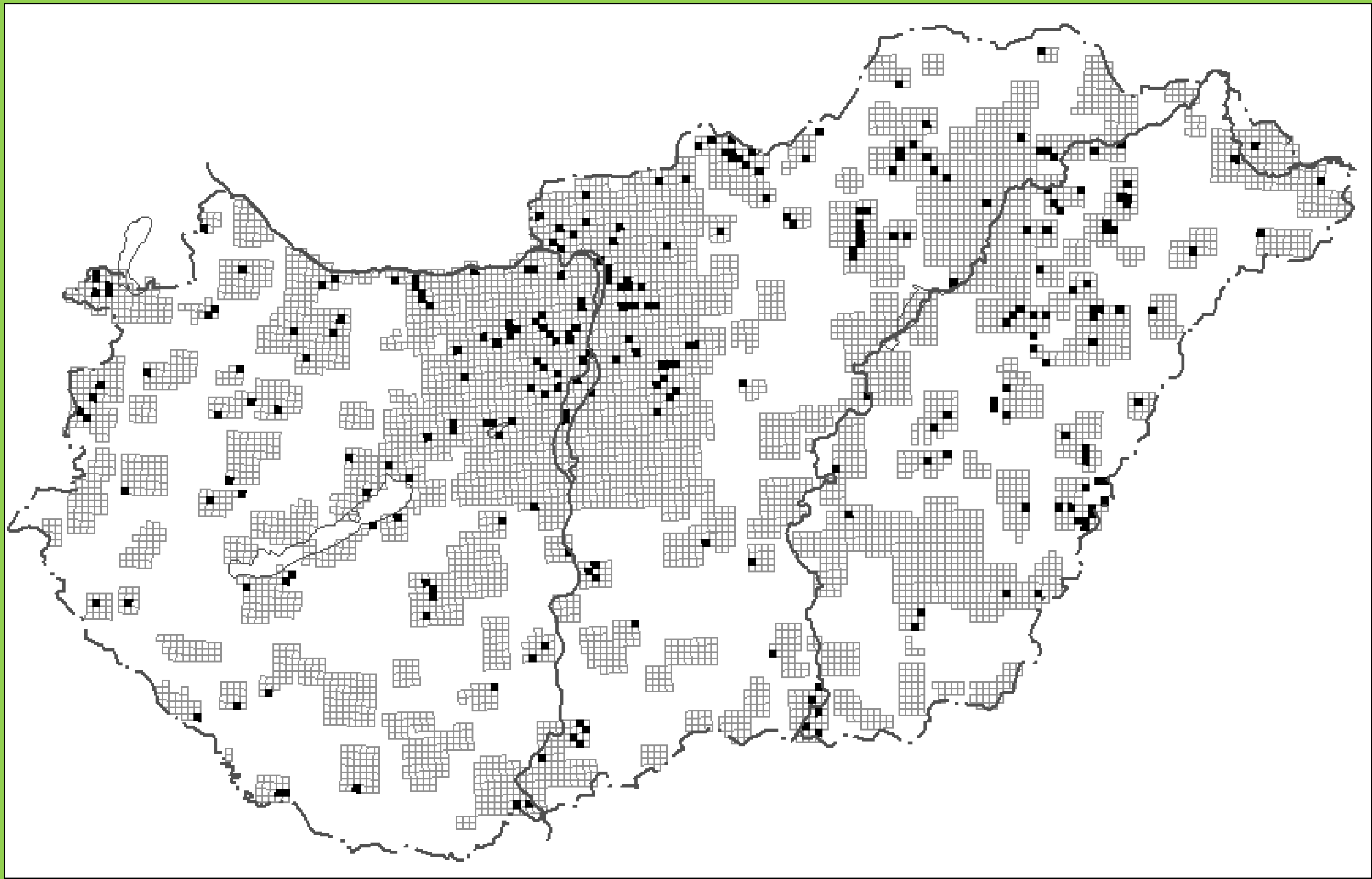
- Szép, T. and Gibbons, D. 2000. Monitoring of common breeding birds in Hungary using a randomised sampling design. The Ring 22: 45-55.

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

Sampling design

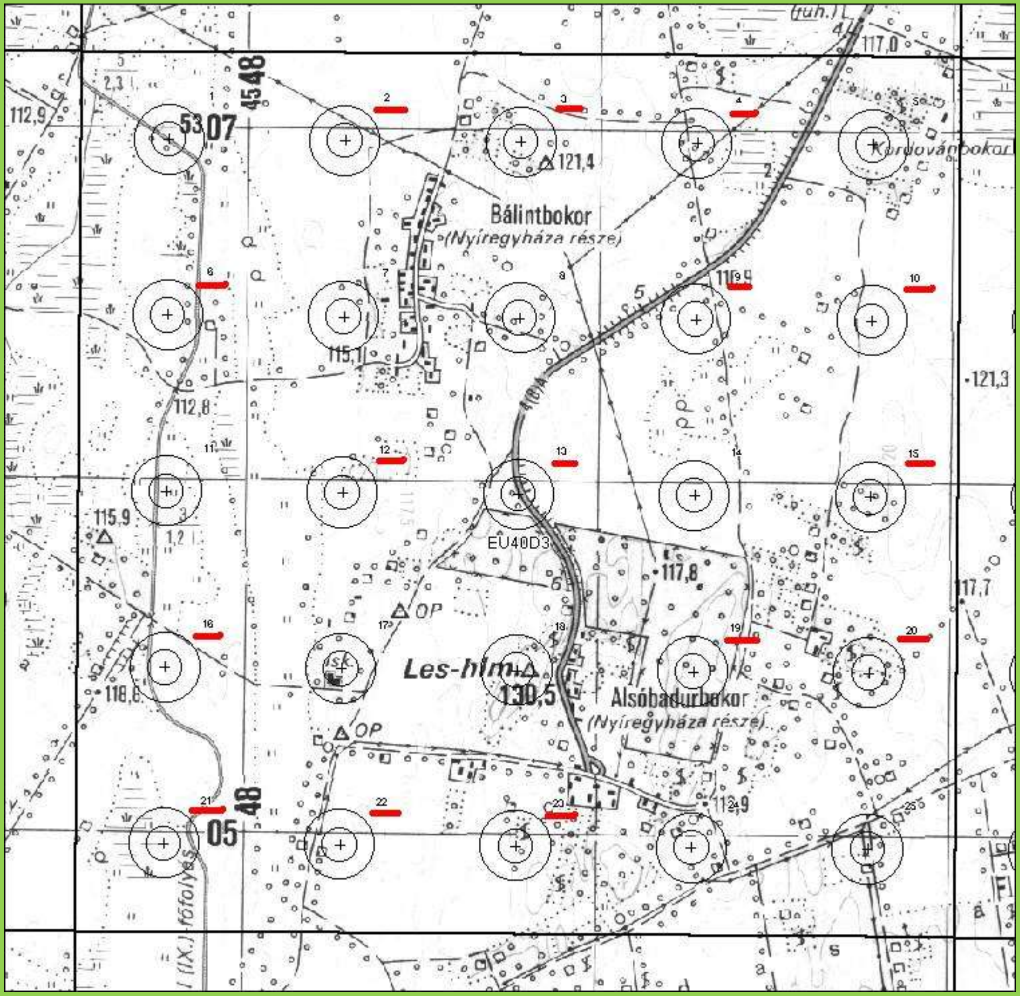
Semi-random selection of the surveyed 2.5*2.5km UTM squares

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



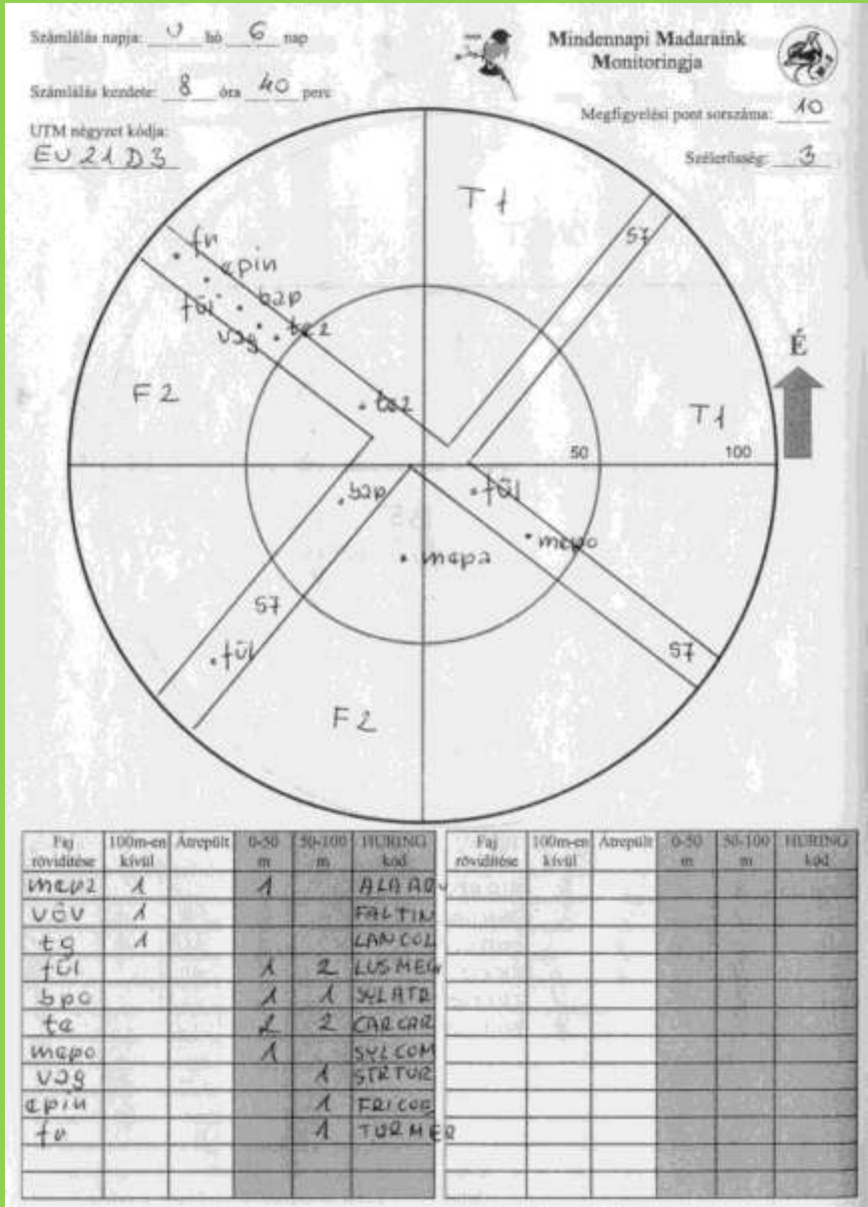
Sampling design

- 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

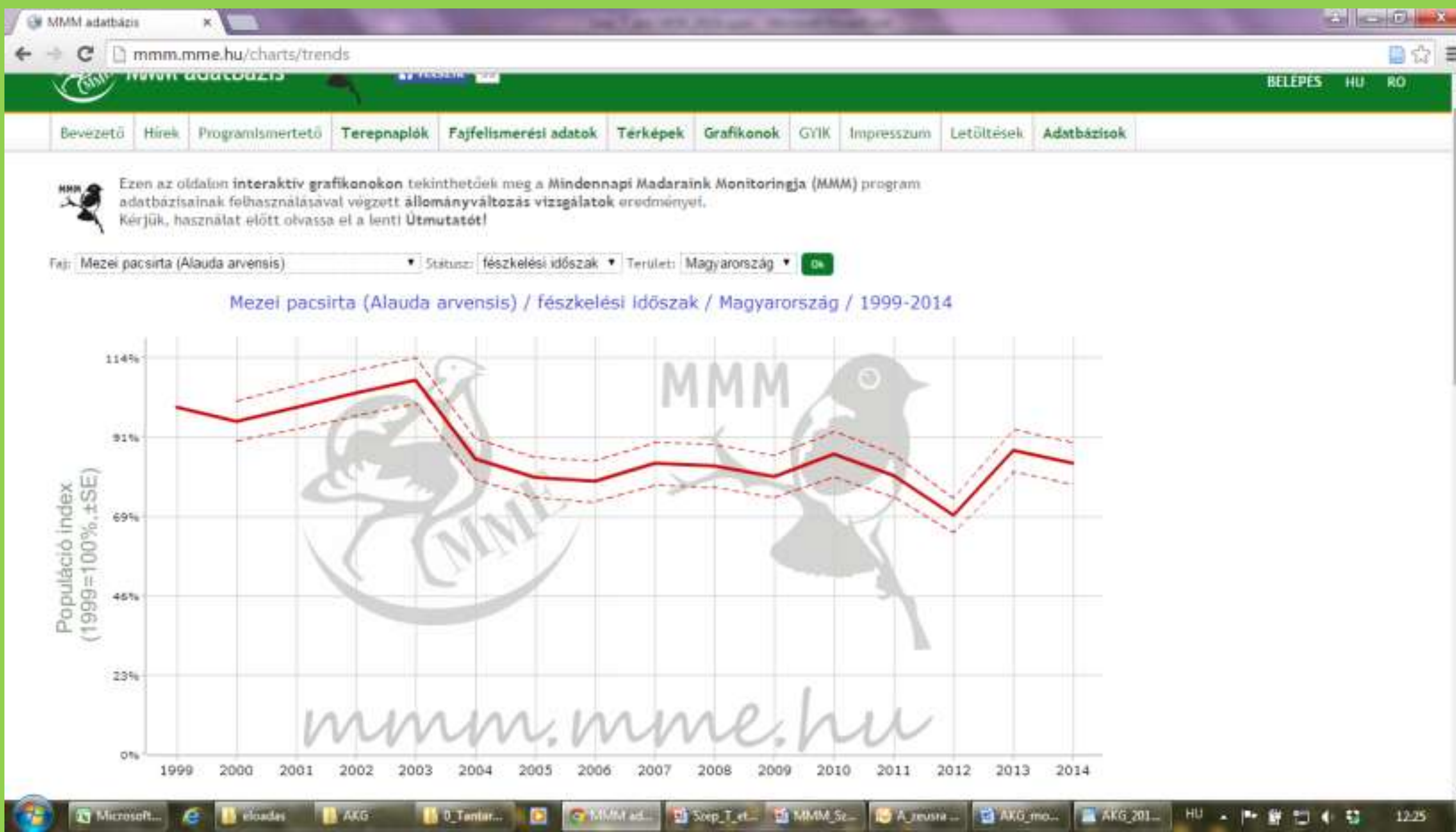
- Annual survey of the species identification skill of the observers for each species occurring in Hungary
  - „How can you identify the given species?”
    - only by view
    - only by sound
    - by view and sound
    - I’m uncertain to identify

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

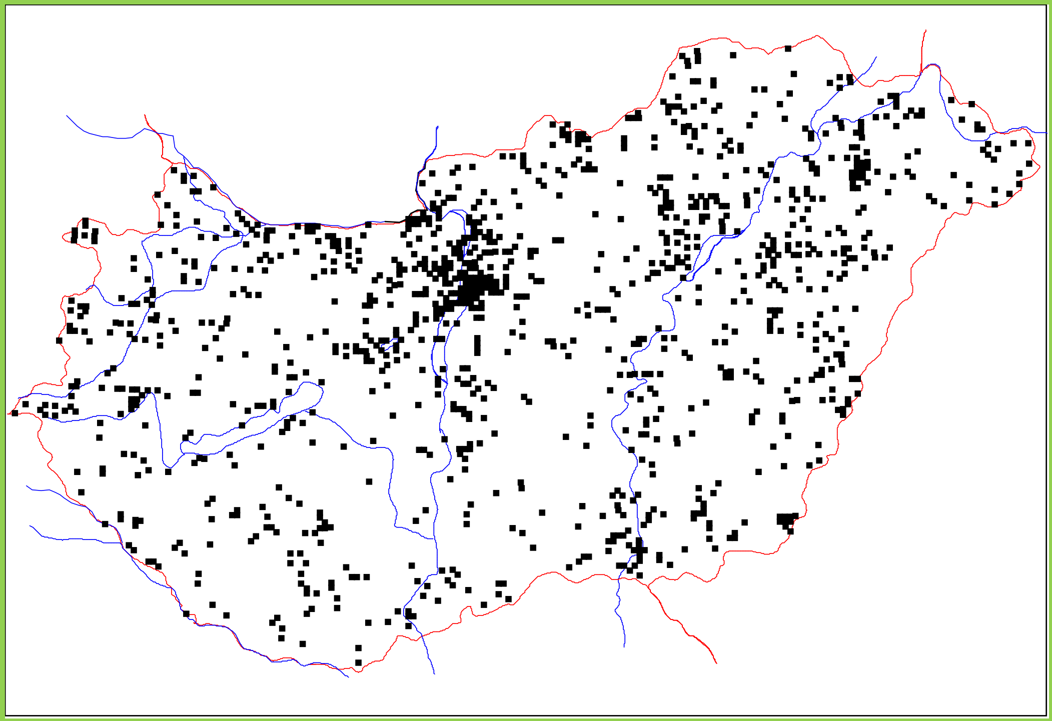
On-line database

http://mmm.mme.hu

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



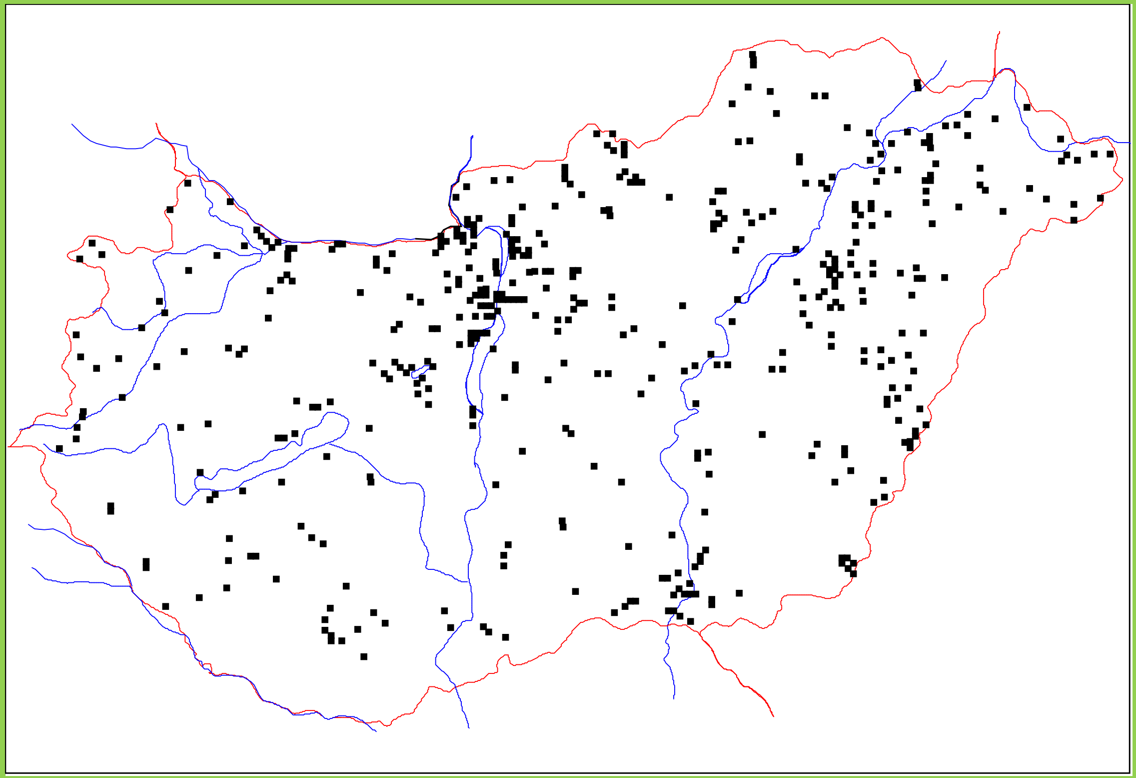
Surveyed UTM squares between 1999-2024 during the breeding season



Surveyed UTM squares

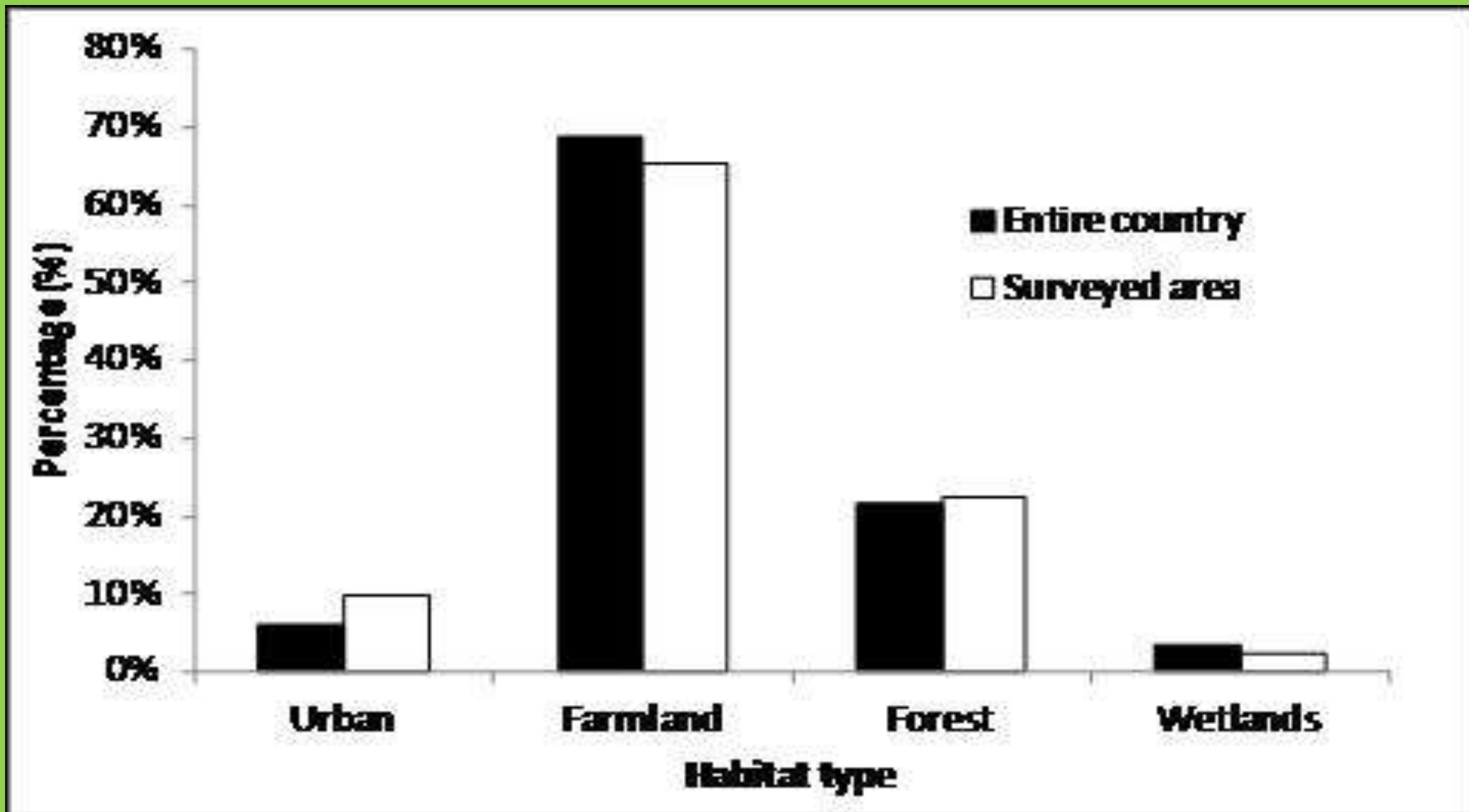
- More than 1300 squares surveyed minimum in two years
- More than 1000 participating observers
- One of the largest database on common birds in Central-Eastern Europe, based on random sampling design, ~60 million records (UTM, point, species, date, number)
- 200-300 UTM surveyed annually (~2% of the country territory)

Surveyed UTM squares between 2000-2024 during the wintering season (January)

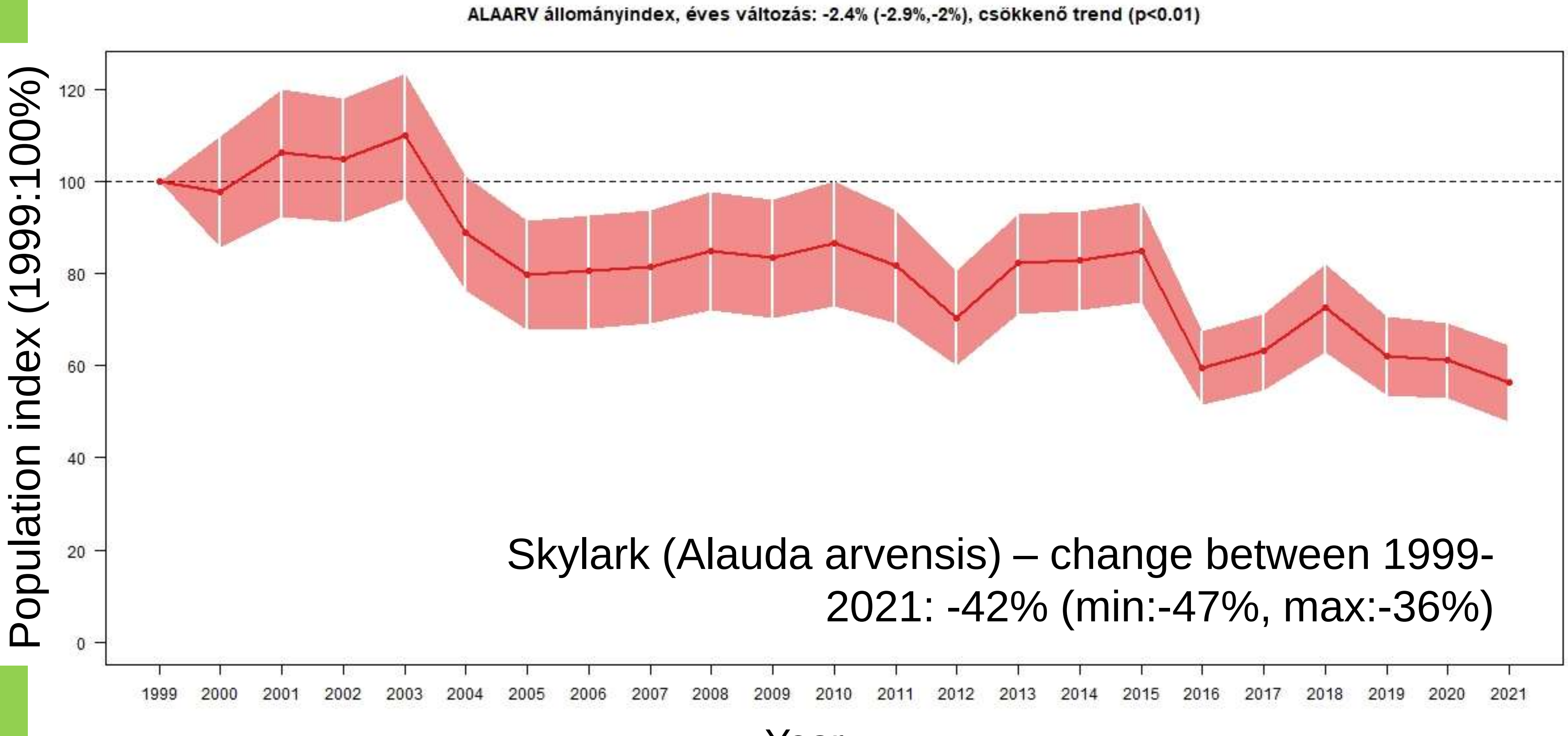


- Standard survey during the wintering season for monitoring occurence and abundance of species
- Use of similar field protocol as during the breeding season (but: only one visit in January, during daylight period)

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

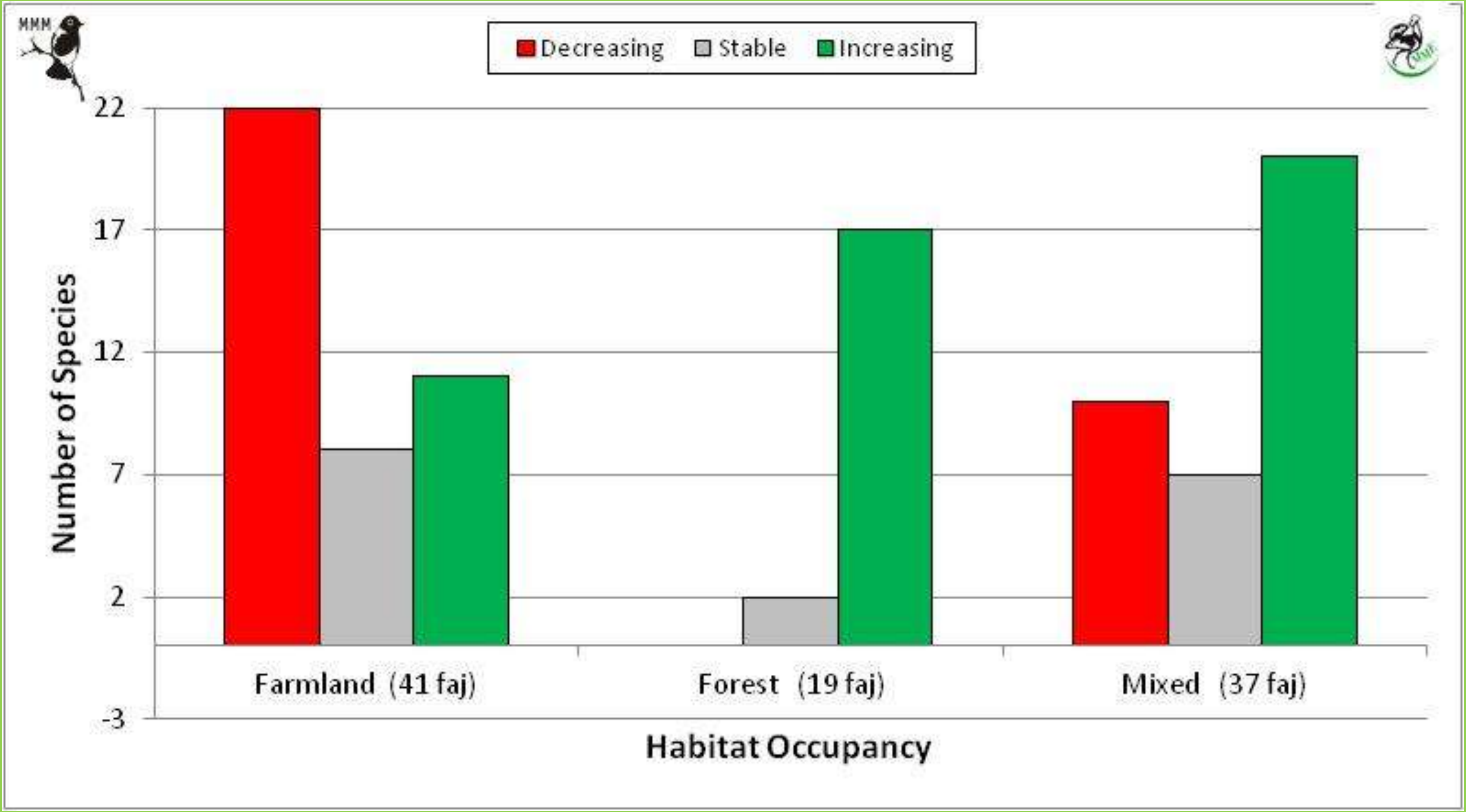


Size of the country: 93 000 km^2



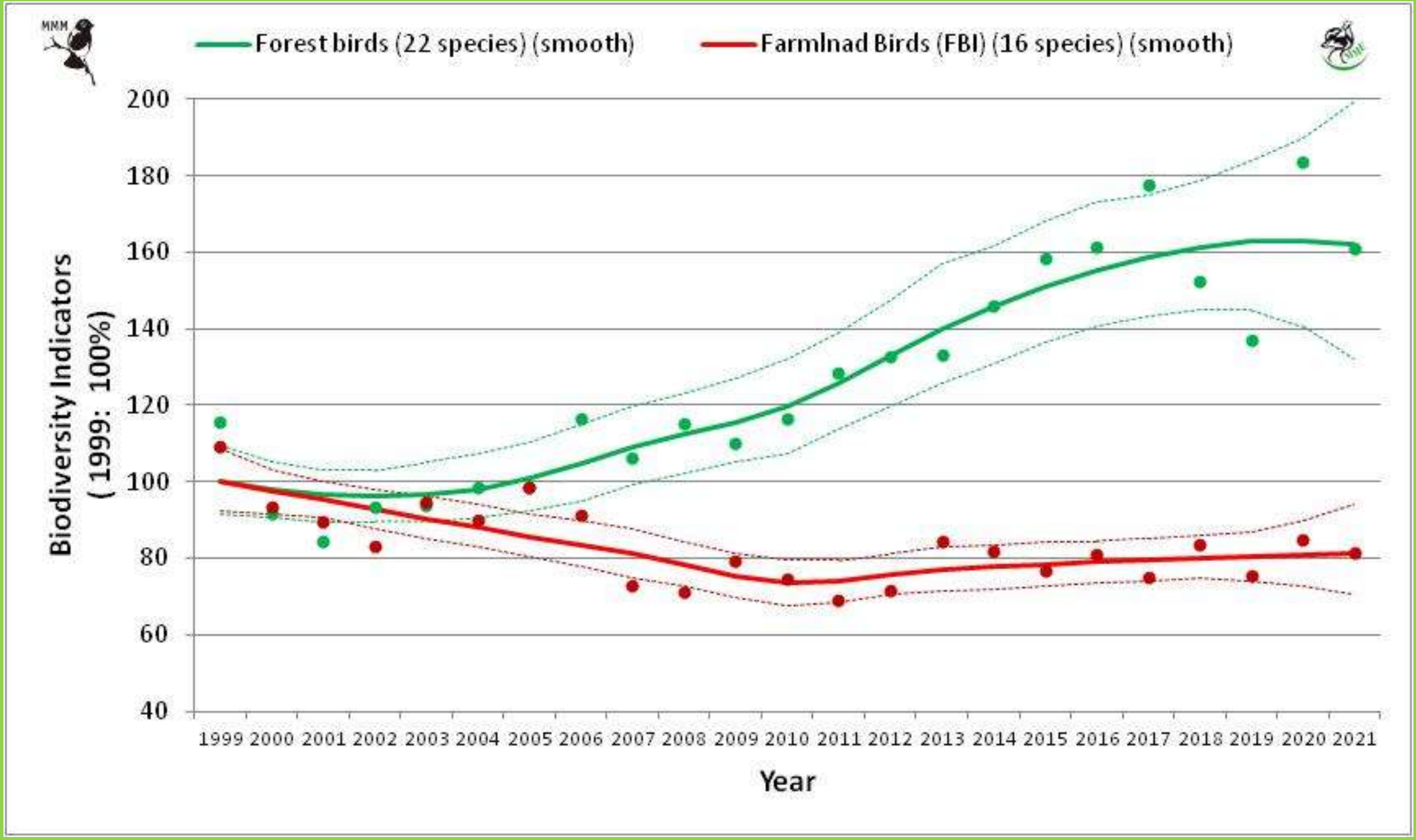
Skylark (Alauda arvensis) – change between 1999-2021: -42% (min:-47%, max:-36%)

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)

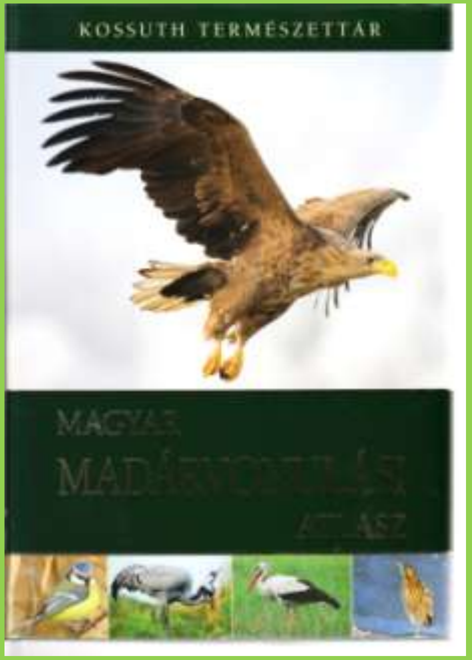
Classification species on migration strategy

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

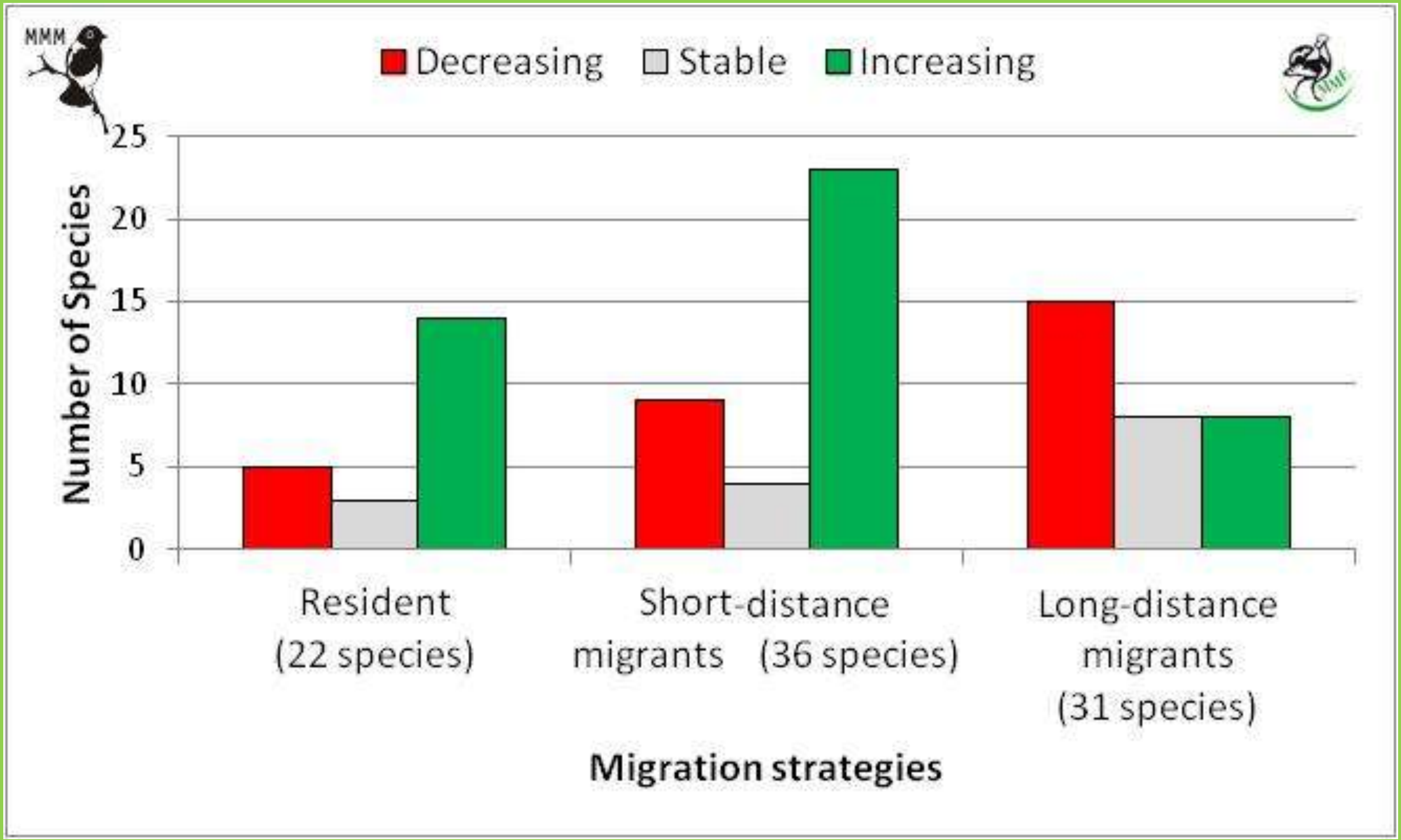
– Resident – spend entire year in the breeding area

– Partial and/or short-distance migrants – migrate only until the Mediterranean region

– Long-distance migrants – migrate over the Sahara

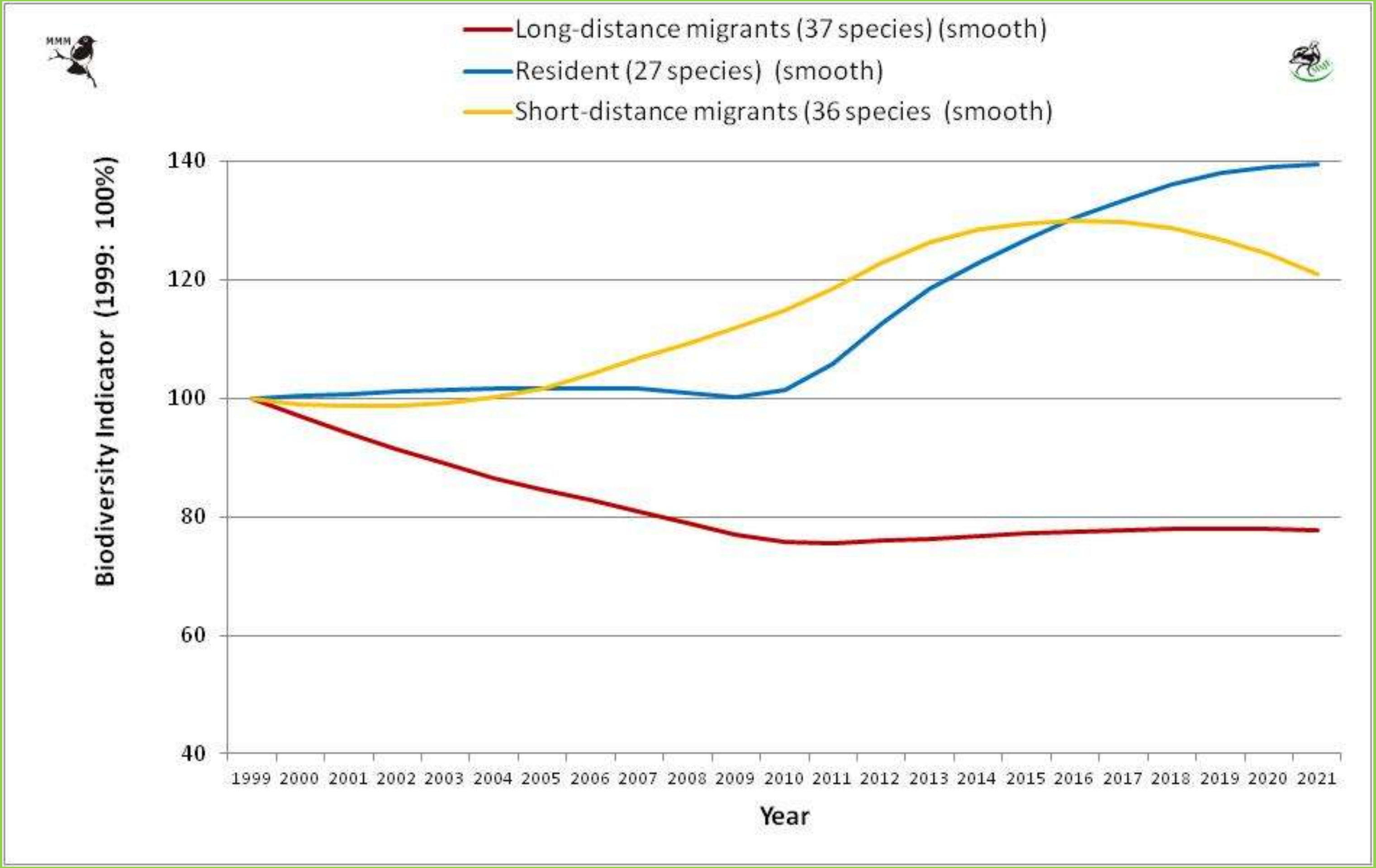


Trends of 100 breeding species were identified by TRIM between 1999-2021



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

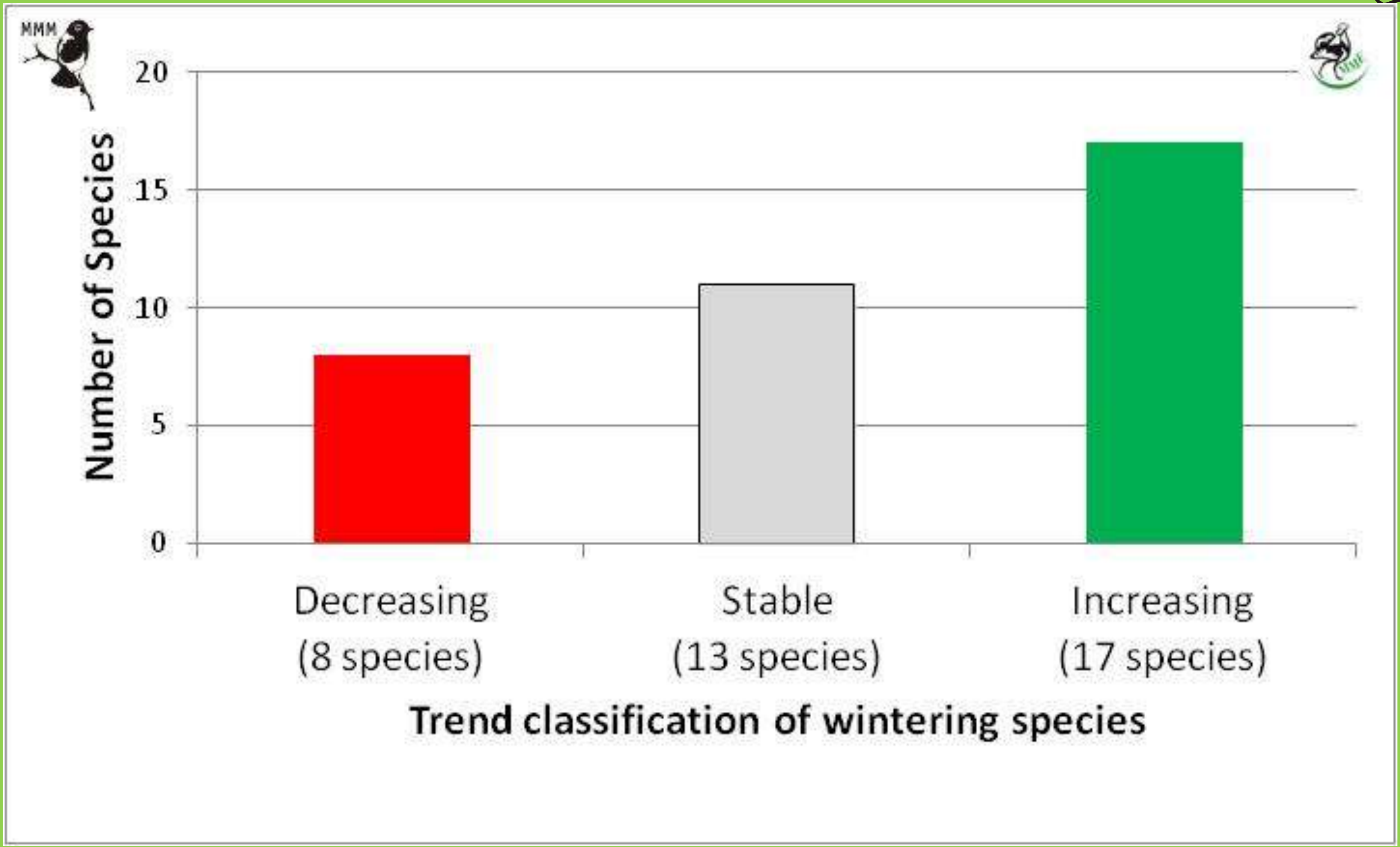
Recent trends of Bird Indicators in Hungary, migration strategy



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

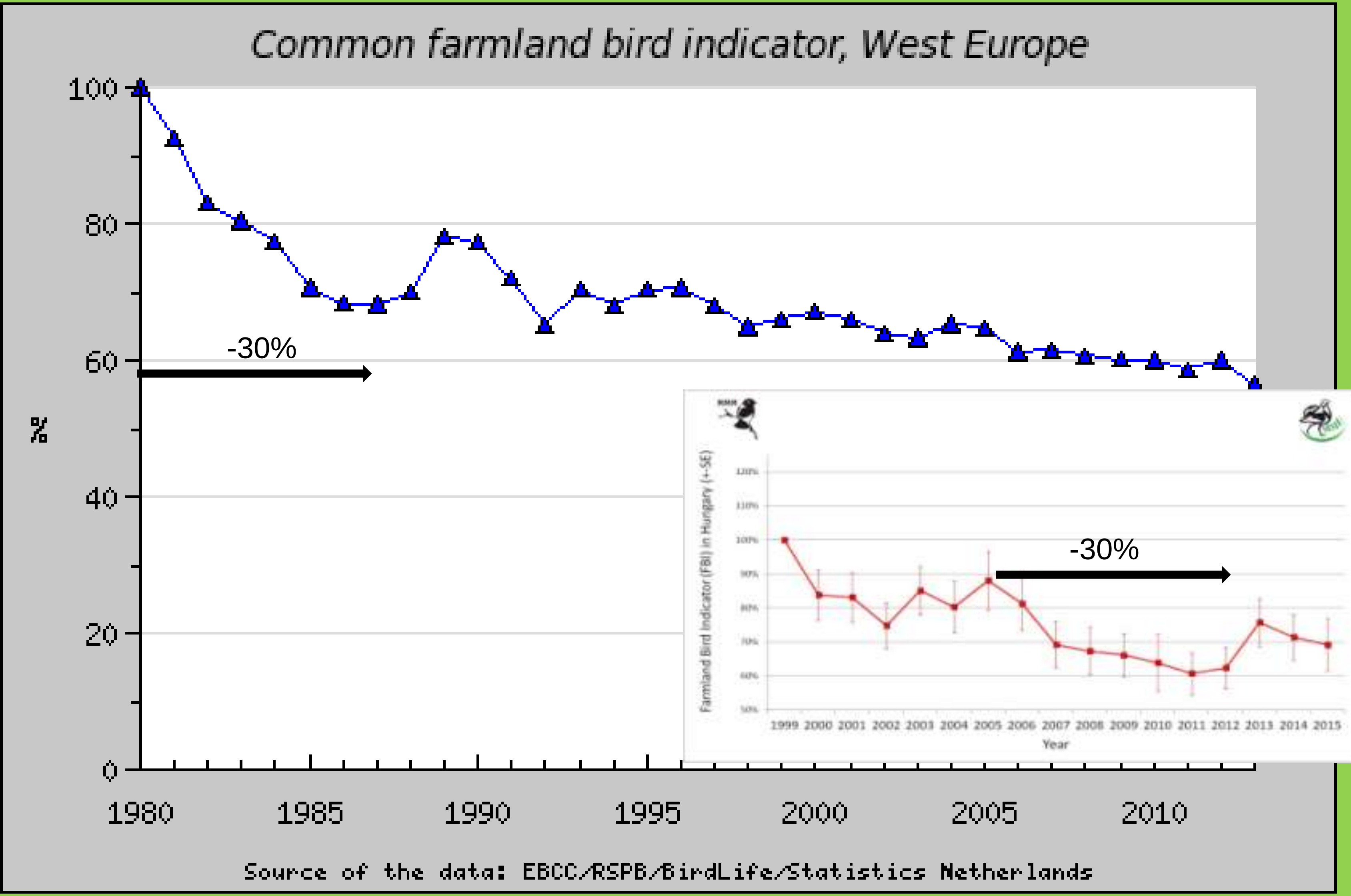
• Farmland biodiversity show marked decline since EU CAP has implemented in Hungary!

• 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

FBI in Western Europe and in Hungary



Decline of FBI in Hungary during 7 years (2005-2012) since join to EU is similar to the level of decline in Western Europe during 7 years following start of CAP (1980-1987)!

Option to detect the effects of the agri-environmental schemes (AES) using farmland bird indicator (FBI) on the scale of the country

- Proper population data from the surveyed 1009 pieces UTM squares before and after the start the CAP (2004) in Hungary

- Opportunity to identify the surveyed farmland UTM squares on the base of CORINE landcover database

- Opportunity to measure coverage of AES in each surveyed farmland UTM squares

- Opportunity to estimate population trends of farmland species and FBI for groups of farmland UTM squares with similar AES coverage

    - Opportunity to compare large scale trends of FBI in farmland areas with different AES coverage

Agri-environmental schemes (AES) in Hungary

Existing 19 AES grouped in four types on the base of the main type of farmland habitats it run:

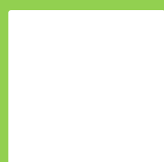
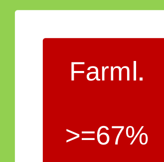
- Arable related AES
- Grassland related AES
- Fruit and grape related AES
- Reedbeds related

How the coverage of AES influence the FBI in farmland areas Hungary during 1999-2014?

We considered the **591** pieces of 2.5*2.5 km UTM squares (UTM)

• monitored with standard protocol of MMM during 1999-2014 at least in two years (Σ 1003 pieces)

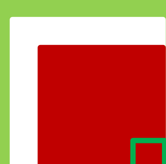
• dominant part of the UTM area (>66.6%) covered with farmland habitats,on the base CORINE CLC50

1003 pc. UTM  ====>>> 

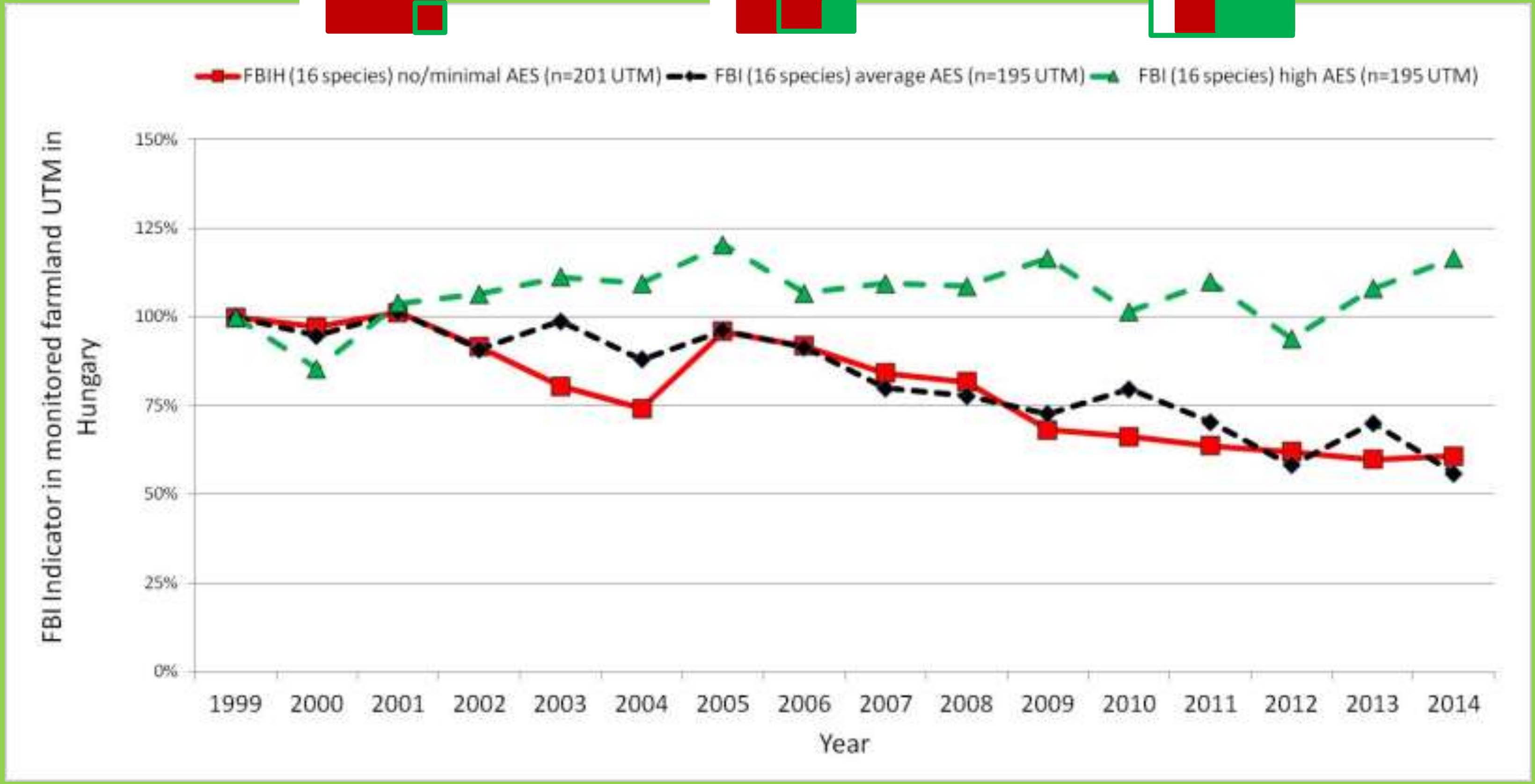
591 pc. farmland UTM

The 591 pieces of farmland UTM grouped to three similar size groups (percentiles) on the base of covarege of four types of AES in the area of the given UTM

	n=201	n=195	n=195
AES intensity	**no/minimal**	**average**	**high**
<u>Σ AES area</u> UTM area	<4.31	>=4.310% and <=28.219%	>=28.219%

FBI of farmland areas with different coverage of Agri-Environmental Schemes in Hungary, 1999-2014



•The FBI did not show trend in farmland areas where the coverage of AES in the UTM was higher than 28.2% (P=0.227)

•Areas with no/minimal/average AES coverage (<28.2%) showed significant decline (slope: -0.028, SE=0.003, P<0.001)

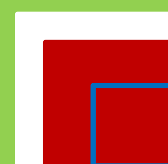
How the coverage of AES influence the FBI in farmland areas with low level of protection coverage Hungary during 1999-2014?

We considered the **445** pieces of 2.5*2.5 km UTM squares (UTM)

- Monitored with standard protocol of MMM during 1999-2014 at least in two years (Σ 1003 pieces)
- Dominant part of the UTM area (>66.6%) covered with **farmland** habitats,on the base CORINE CLC50
- Coverage of **NATURA 2000 areas** of the UTM was less then 33.3%

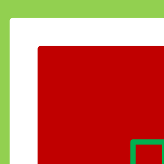
591 pc. farmland UTM

====>>>

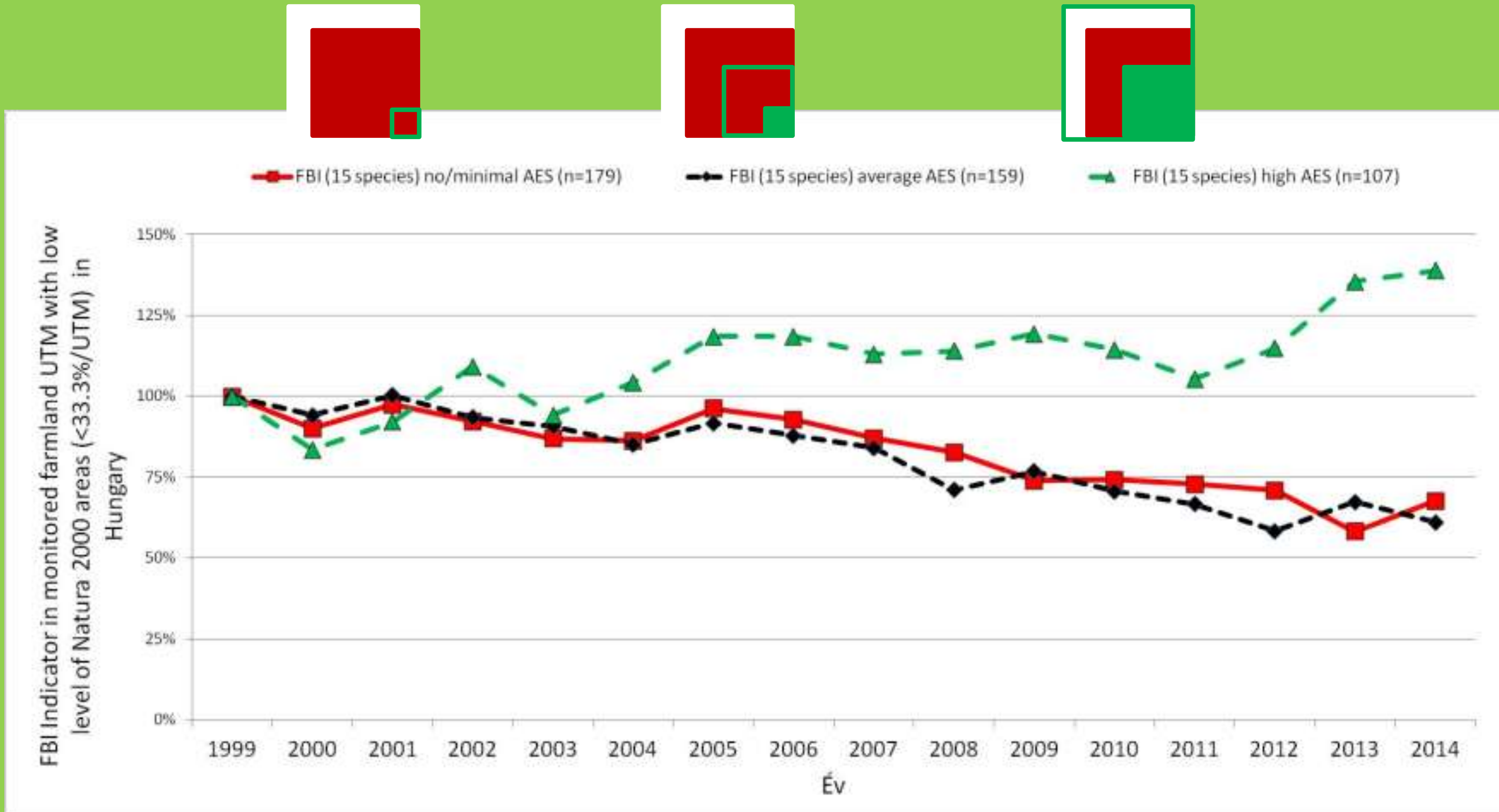


445 pc. farmland with low protection UTM

The 445 pieces of farmland UTM low level of nature protection formed three groups with similar size on the base of covarege of all kind of AES in the area of the given UTM

	n=179	n=159	n=107
AES intensity	**no/minimal**	**average**	**high**
Σ AES area	<4.31	>=4.310% and <=28.219%	>=28.219%
UTM area			

FBI of farmland areas with low level of protected areas with different coverage of Agri-Environmental Schemes in Hungary



•The FBI showed increasing trend in areas where the coverage of AES in the UTM was higher than 28.2% even the level of NATURA 2000 areas is low (slope=0.025, SE=0.005, P<0.001)

• Other areas had decreasing trends (slope =< -0.023, SE<=0.003, P<0.001