The quest for appropriate indicators for biodiversity change

Arco van Strien

Wildlife Statistics
Statistics Netherlands
(the national statistical agency)

Headline indicator: **summary statistic to provide simplified information about progress towards targets at global, national or regional level**

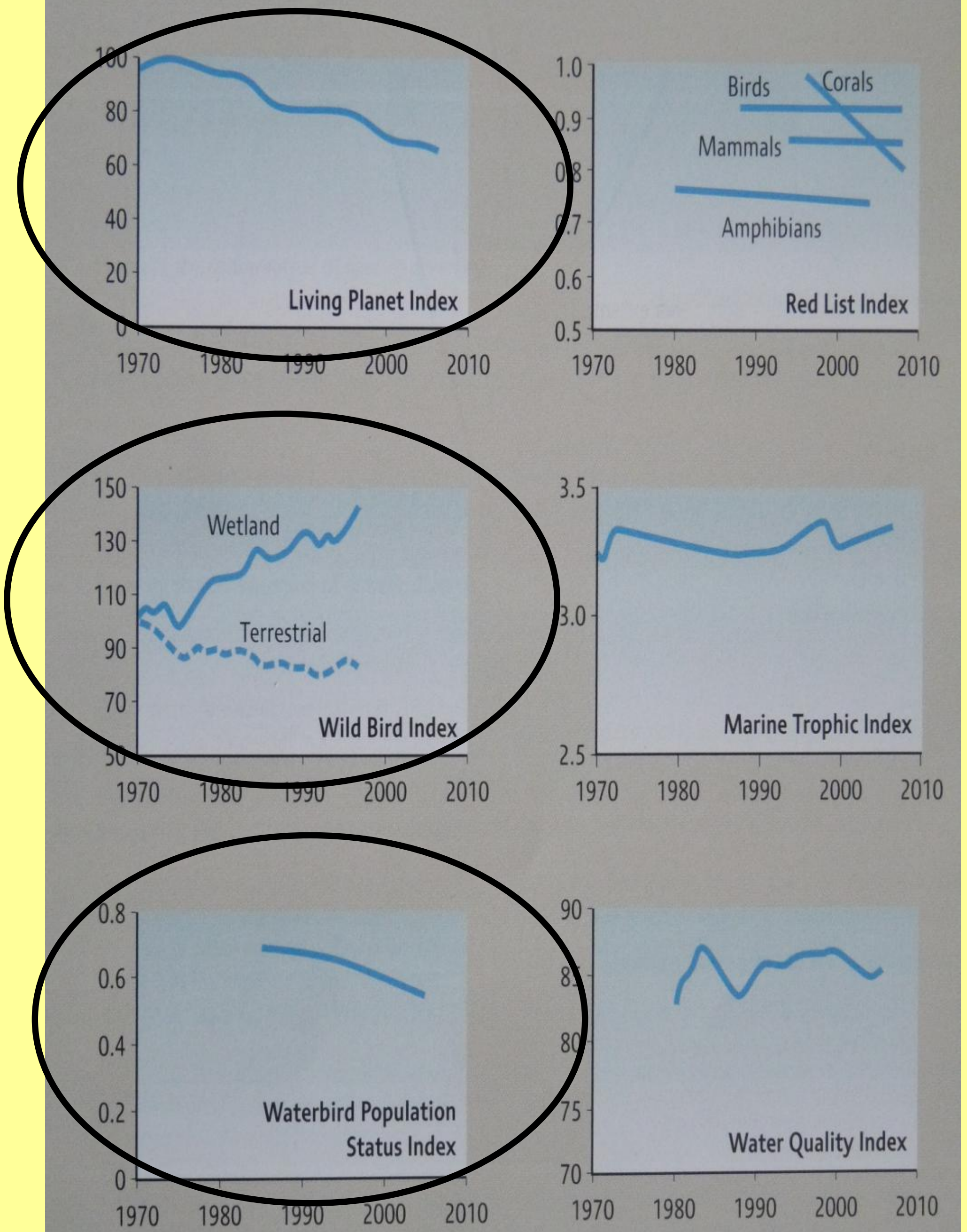
target e.g. reduce rate of biodiversity loss

Some headline indicators under the Convention of Biodiversity:

- ***Trends in extent of selected biomes, ecosystems, habitats***
- ***Coverage of protected areas***
- ***Trends in abundance of selected species***
- ***Climate Impact Indicator***
- ***Changes in status of threatened species***
- ***Trends in genetic diversity***
- ***Marine Trophic Index***

Examples of indicators on trends in abundance of selected species [1)]

Conclusion: rate of biodiversity loss is NOT reducing at global level



Flaws:

* Available indicators biased to birds and other vertebrates
* Tropical species poorly represented
* Incomplete indicators at national and regional level

>> much to do

1) Butchart, S., Walpole,M., Collen, B, van Strien, A., Scharlemann, J. et al. 2010. Global Biodiversity: Indicators of Recent Declines. Science

How to create indicators for biodiversity change?

There are guidelines [1,2] - no cookbook

This talk is about guidelines:

- Requirements to indicators
- A few examples of well-developed indicators

1) 2010 Biodiversity Indicators Partnership 2010. Guidance for national biodiversity indicator development and use. UNEP World Conservation Monitoring Centre, Cambridge.

2) van Strien, A., L. van Duuren, R.P.B. Foppen & L.L. Soldaat 2009. A typology of indicators of biodiversity change as a tool to make better indicators. Ecological Indicators.

Many requirements to headline indicators found in the literature…

Summary statistic tells a story

with wider applications

linkable to societal dimension

policy relevant

data realistic to collect

easily understood

simplifies information

user driven

international compatible

susceptible to human influence

indicative about more than itself

headline indicator

have

linkable to pressures

ow costs o easurements

is scientifically credible

and is feasible in practice

unbiased

responsive to changes

operationally simple

representative

sufficient power

mathematically sound

allows regular update

Summary statistic tells a story

- ecologically relevant
- policy relevant
- user driven
- easily understood
- simplifies information
- susceptible to human influence

with wider applications

- indicative about more than itself
- linkable to causes
- linkable to societal dimension
- linkable to pressures
- international compatible

headline indicator

- quantitative
- unbiased
- responsive to changes
- representative
- sufficient power
- have known precision
- mathematically sound

- low costs of measurements
- data realistic to collect
- operationally simple
- allows regular update

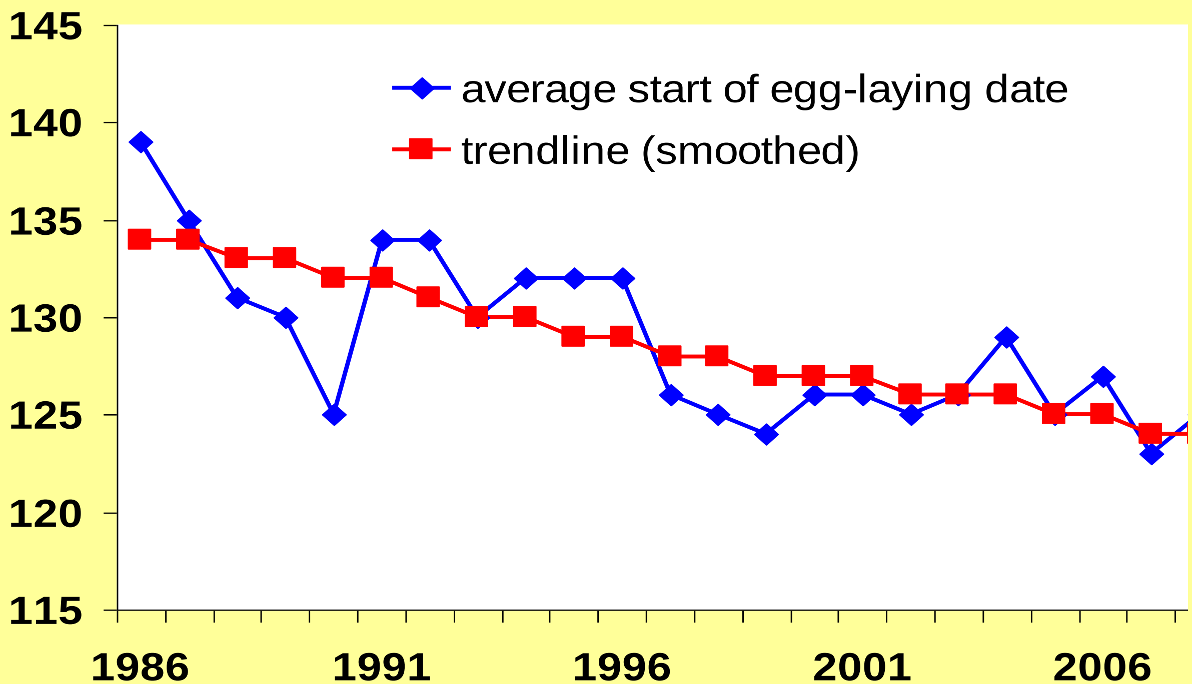
Summary statistic tells a story, with wider applications

e.g. about effects of climate change on biodiversity in a country

Expectation: climate change >> warmer springs >> advancement of start of egg-laying

Indicator summarizes all species trends and confirms: songbirds advanced start of breeding

Mean start date of egg-laying of songbirds in the Netherlands



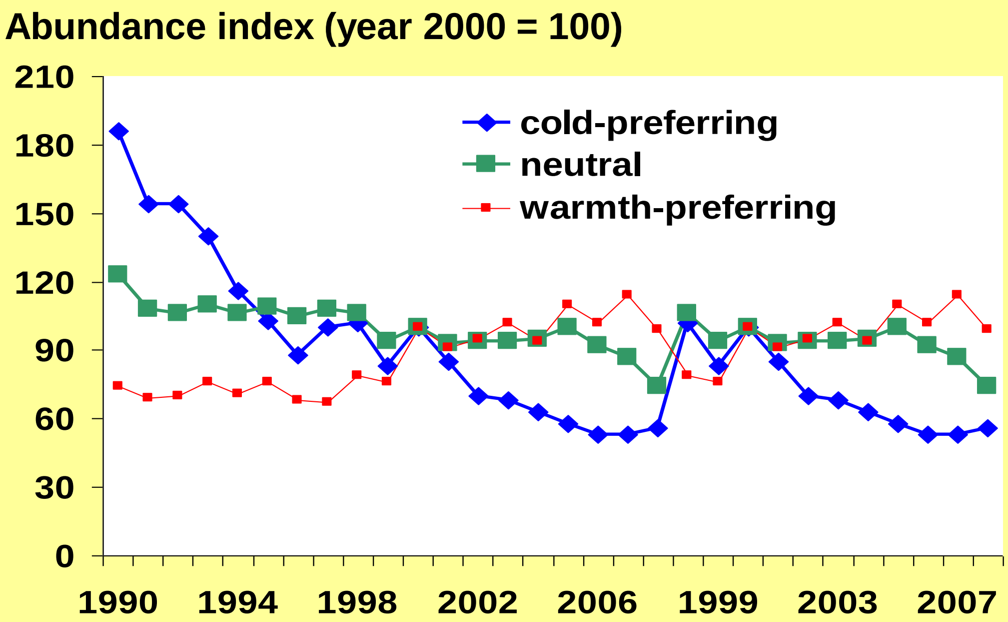
Easily understood & links to pressure

Relevancy? Relation with population trends in songbirds?
>> incomplete story for a headline indicator

Another example: changes in abundance related to climate change in Netherlands

Expectation: climate change >> range shifts of species
>> warmth-preferring species increase, cold-preferring species decline and neutral species are stable (preferences based on mean temperature within range)

Indicator confirms: warmth-preferring species increase & cold-preferring species decline



Easily understood & links to pressure

Relevancy: changes at population level
>> better headline indicator for climate change than “start of egg-laying indicator”

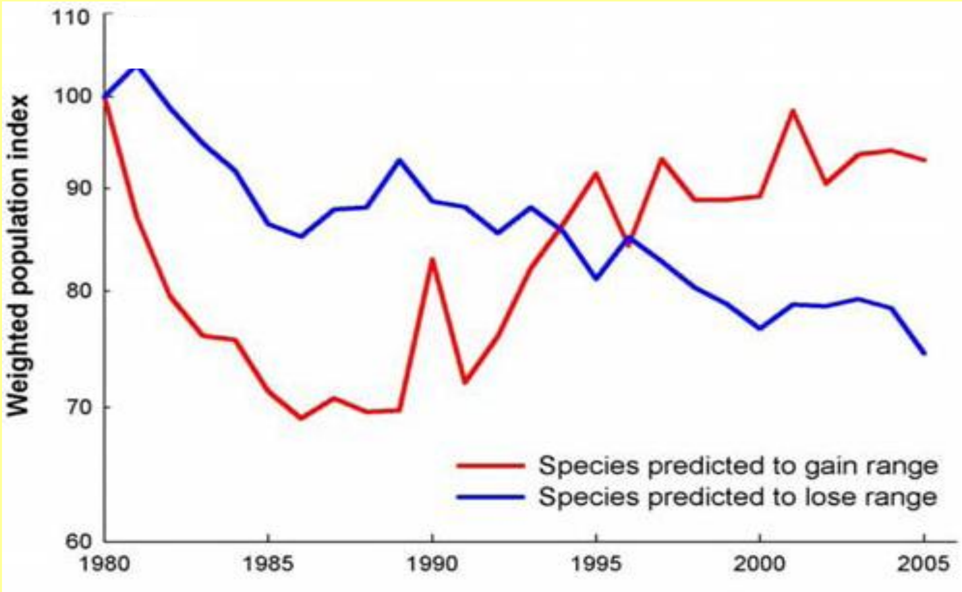
Refinement

Expectation: climate change >> range shifts >> climatic scenarios + climate envelope models predict some species to gain range and others to lose range

Indicator confirms this for birds in Europe [1)v]

1) Gregory et al., 2009. An Indicator of the Impact of Climatic Change on European Bird Populations. PLOS

Abundance index (year 1980 = 100)



Relevancy: changes at population level

Easily understood, but better link to pressure (climate scenarios) than temperature preference only, because climatic envelopes cover more subtle climate variables >> adopted by EU as climate change indicator

Summary statistic tells a story

- ecologically relevant
- policy relevant
- user driven
- easily understood
- simplifies information
- susceptible to human influence

with wider applications

- indicative
- linkable to causes
- linkable to societal dimension
- linkable to pressures
- international compatible

is scientifically credible

- quantitative
- unbiased
- responsive to changes
- representative
- sufficient power
- have known precision
- mathematically sound

- low costs of measurements
- data realistic to collect
- operationally simple
- allows regular update

The indicator should be statistically robust = quantitative, precise and unbiased

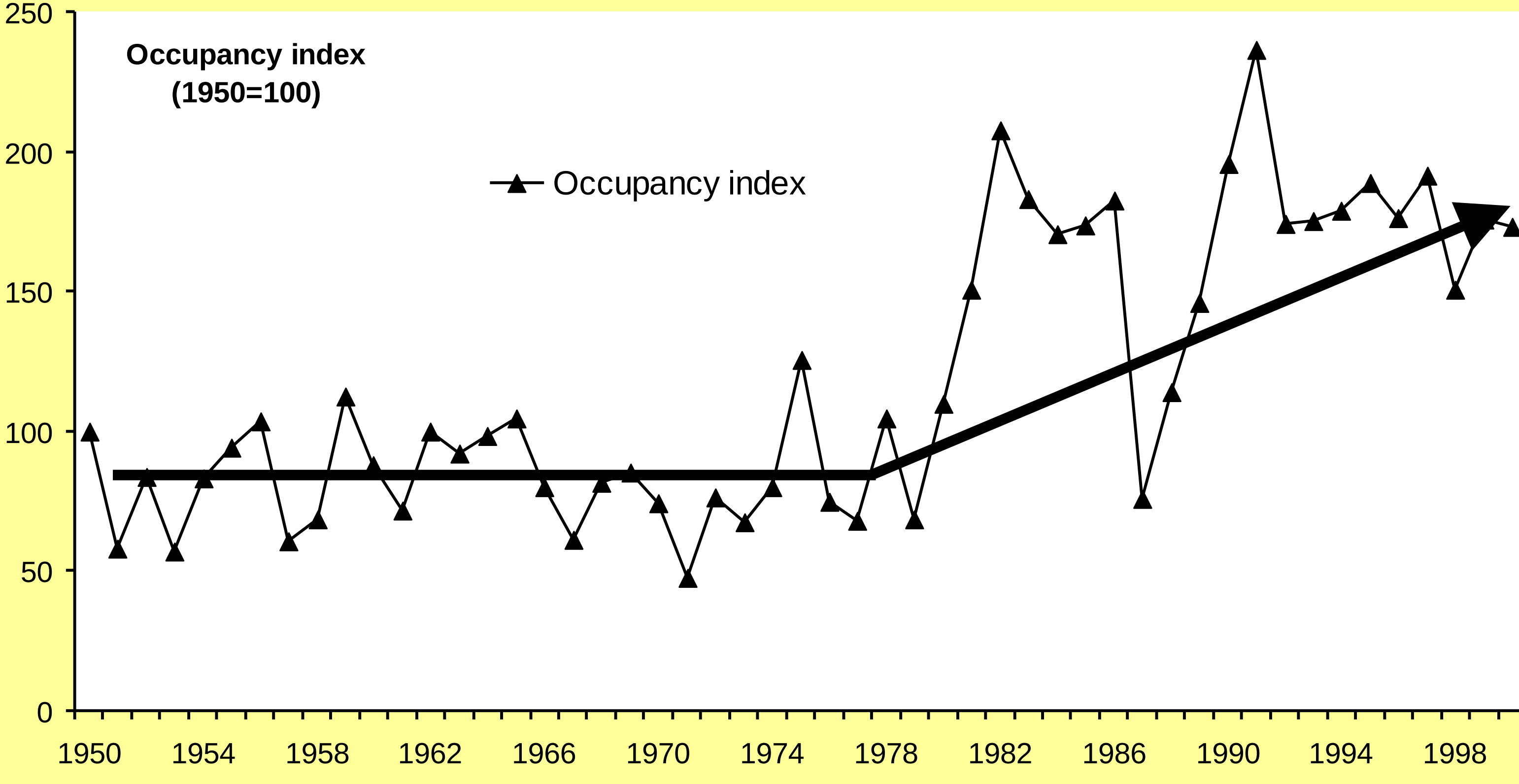
- Field data required to assess *trend* in abundance or distribution of species (expert judgments alone too soft)

- Collecting field data per species without controlling for observation effort >> risk of biased trend

Example of bias

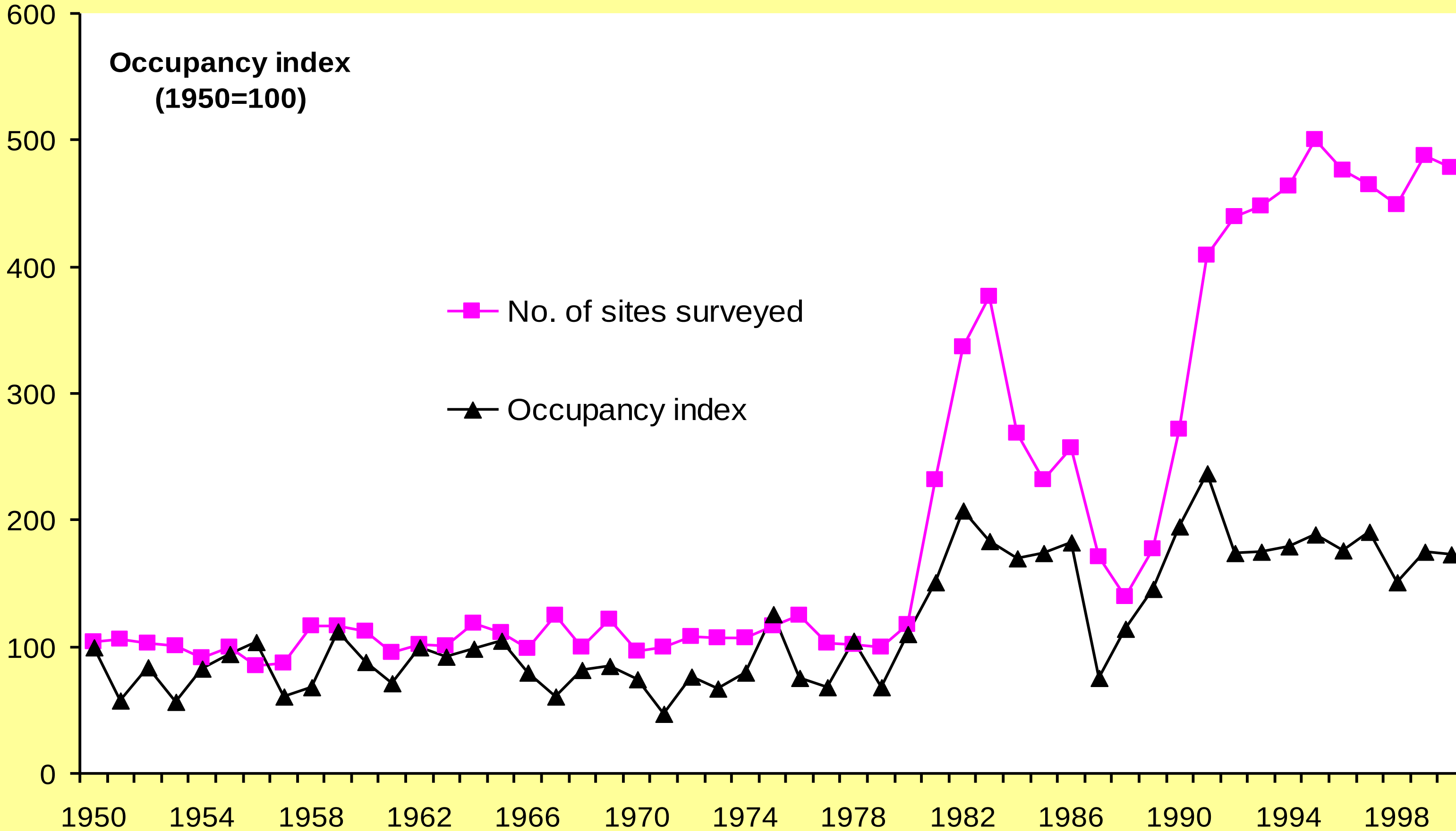
Number of sites where butterfly species *Grayling is* present (occupancy) increased after 1980

But is there really a trend?



Example of bias
Trend in butterfly species *Grayling*?

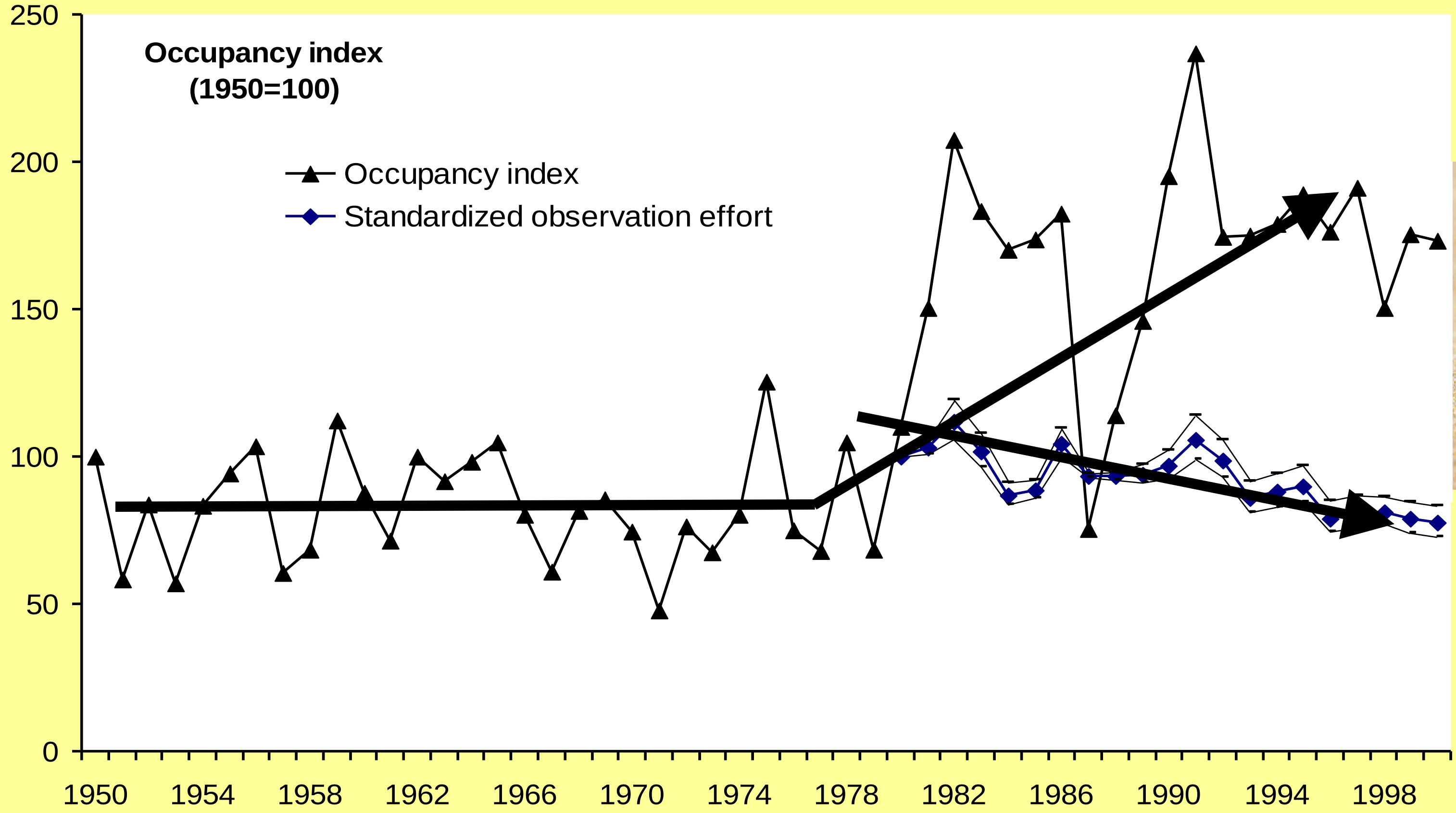
Also number of *surveyed* sites increased after 1980……..



Example of bias: trend in butterfly species *Grayling?*

Standardized observation effort: decline

>> observation effort need to be standardized to avoid bias in species trends before combination into indicator



Indicator should have logical mathematical behaviour

Similar requirements as in consumer price indices
(if prices of all commodities increase, inflation rate increase)

Some desirable mathematical properties (there are more):

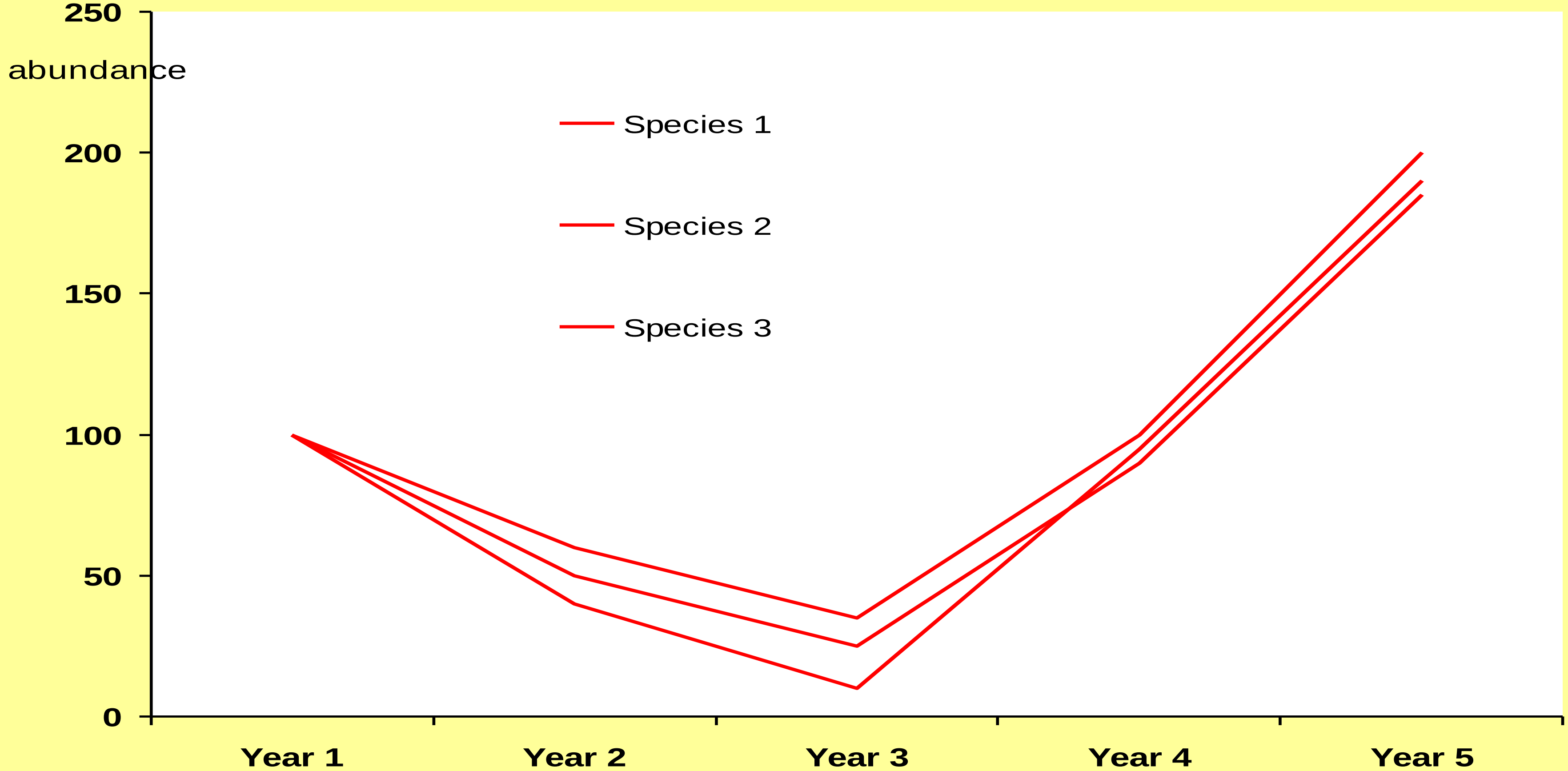
monotonicity test: all species decline >> indicator declines

proportionality test: all species decline by say 50% >> indicator declines by 50%

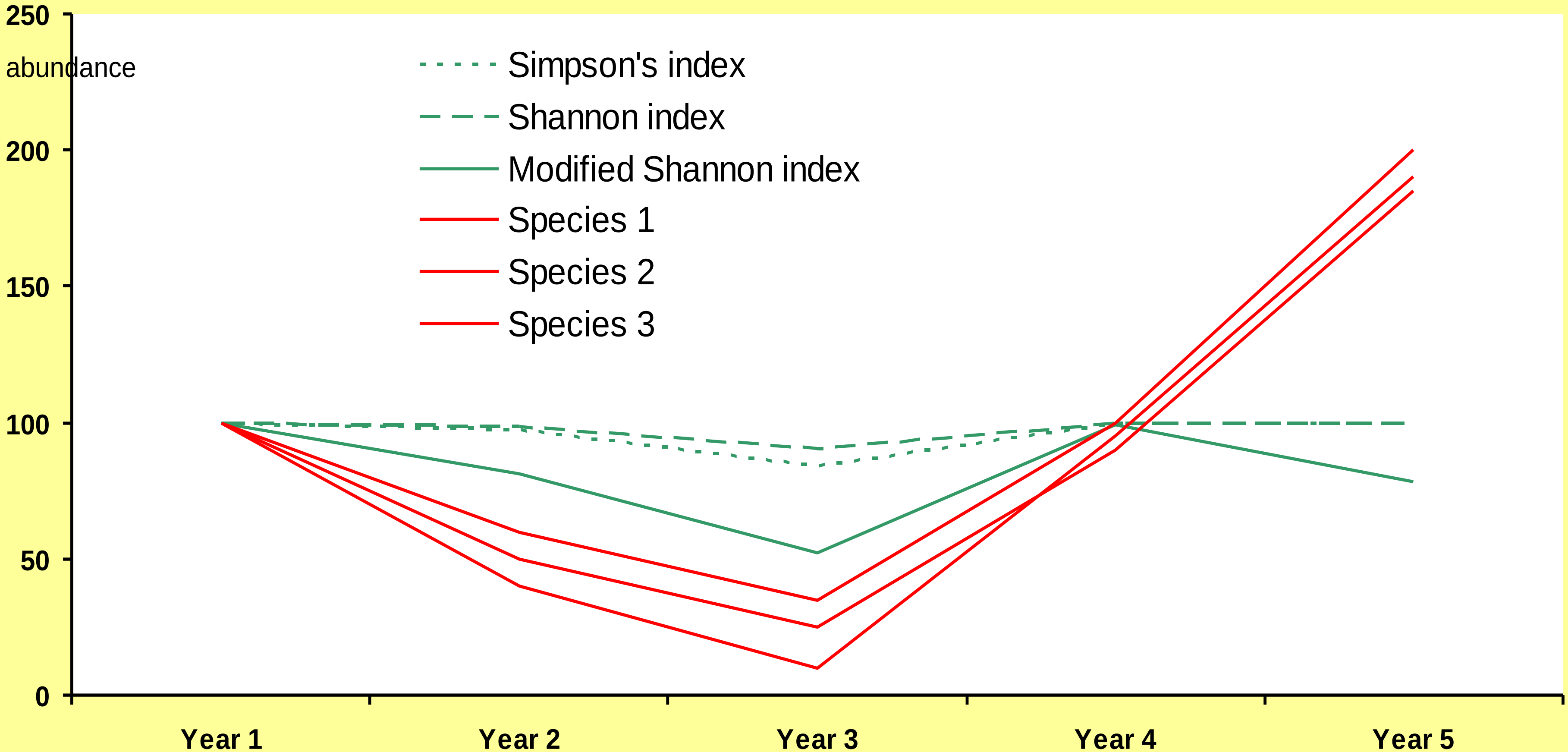
Example: three equally valued species with similar behaviour over time (species indices with abundance in first year set at 100)

How would different indicator approaches perform?

We expect first a decline and then a increase…

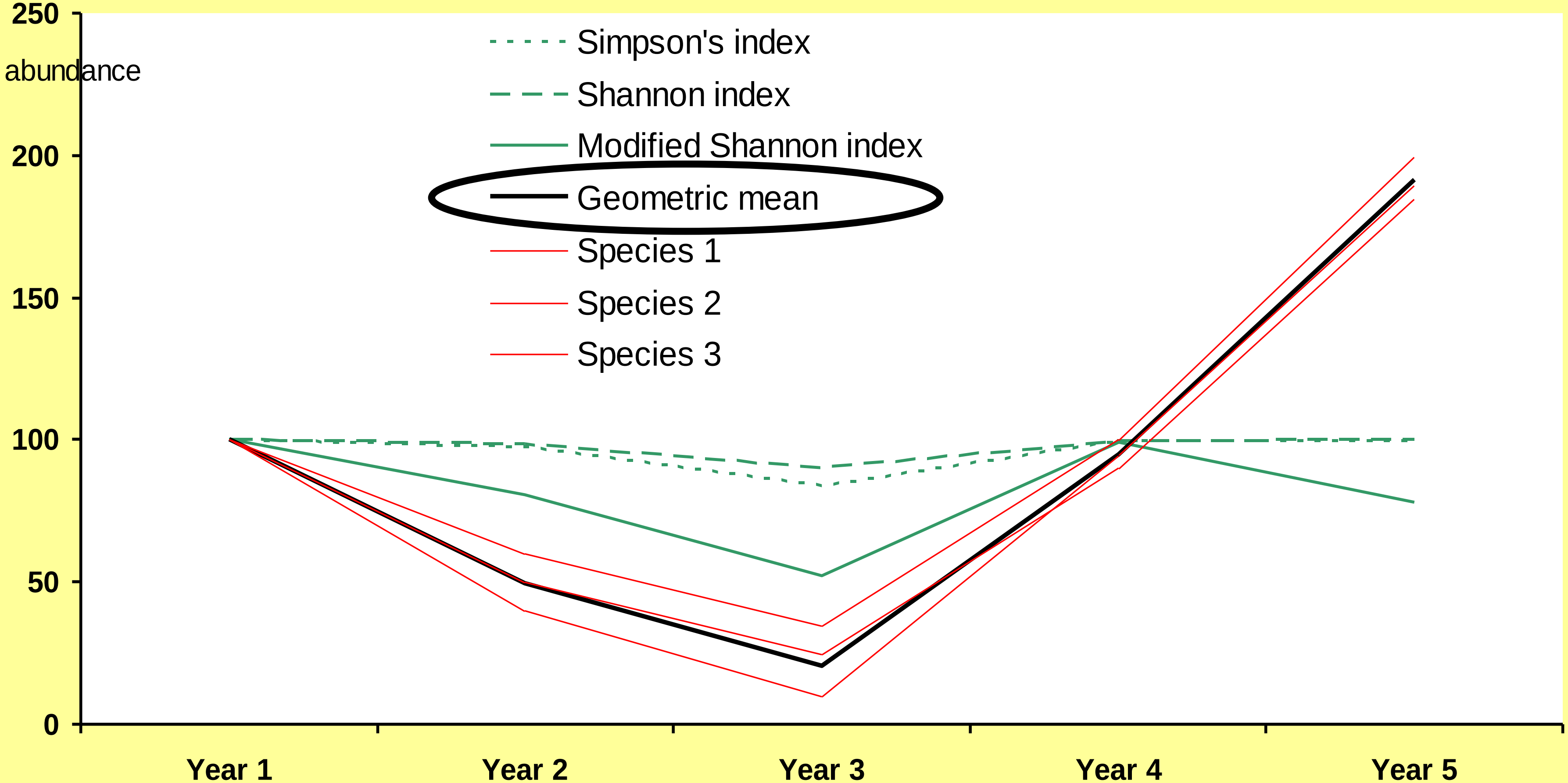


Traditional diversity indices (green) do not mirror behaviour of the species
>> violate monotonicity and proportionality test



Geometric mean of indices (black) (= mean of log of species indices) mirrors changes in species appropriately
>> satisfies monotonicity and proportionality test.

Geometric mean used in European Wild Bird Index and Living Plant Index



Summary statistic tells a story

- ecologically relevant
- policy relevant
- user driven
- easily understood
- simplifies information
- susceptible to human influence

with wider applications

- indicative
- linkable to causes
- linkable to societal dimension
- linkable to pressures
- international compatible

headline indicator

is scientifically credible

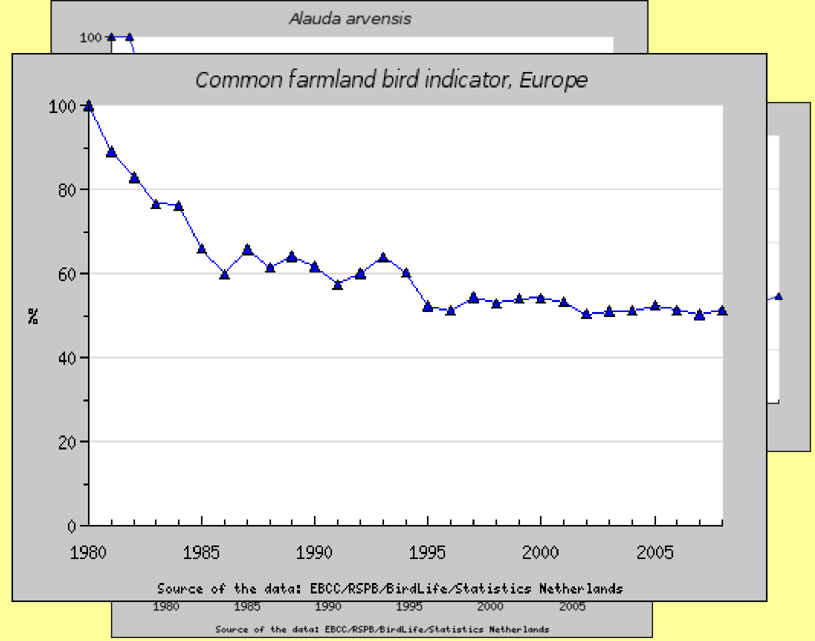
- quantitative
- unbiased
- responsive to changes
- representative
- sufficient power
- have known precision
- mathematically sound

and is feasible in practice

- low costs of measurements
- data realistic to collect
- operationally simple
- allows regular update

How to make it cost-effective?

Example: Farmland bird indicator [1]



- Volunteer-based field work, organized via NGO's
- Data-entry by volunteers via portals on the internet
- Automatic checks during data-entry to detect improbable records
- Automation to facilitate data-processing of species trends and multiple species indicators: European farmland bird and forest bird indicator

[1] Gregory, R.D., van Strien, A.J., Vorisek, P., Gmelig Meyling, A.W., Noble, D., Foppen et al. 2005. Developing indicators for European birds. Philos. Trans. R. Soc.

Summary statistic tells a story

- common farmland birds decline
- birds great public resonance
- political relevant

with wider applications

- trend linked to intensive farming
- indicative to other species groups
- international cooperation ensures compatibility

European Farmland Bird Indicator used by EU

is scientifically credible

- standardized monitoring
- representative species selection
- confidence intervals
- geometric mean to summarize species trends

and is feasible in practice

- field work by volunteers
- supra-national cooperation to automate data processing

But: standardized monitoring species abundance using volunteers does not work everywhere…..

Alternative:

- changes in distribution (occupancy) surrogate to changes in abundance
- daily species lists [1)] surrogate to standardized field work

How to avoid risk of biased trend if field work is not standardized?

Magic word: dynamic occupancy modeling

[1)] = **list of all species recorded by one observer on one day in one location, e.g. 1x1 km**

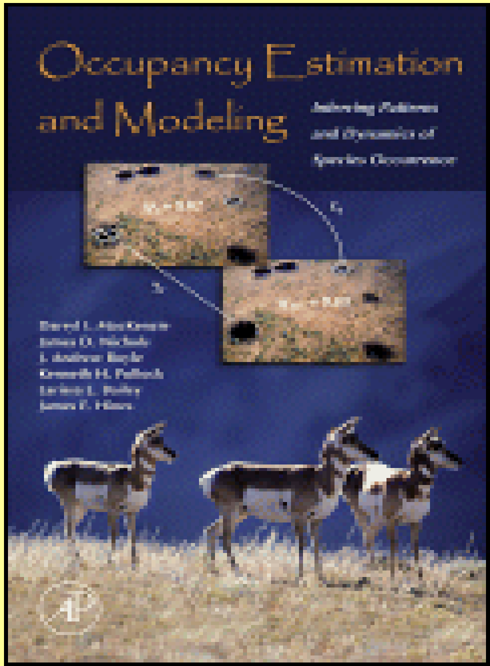
What is dynamic occupancy modeling [1)]

- Observers often do not detect a species when present >> presence/absence data are detection/non-detection data.
- Species not recorded on daily lists = non-detections. Including non-detection data improves quality of distribution maps and trends.
- Detection probability can be estimated >> “true” presence/absence
- Estimation requires replicated surveys in the season on > 50 locations
- Occupancy modeling estimates yearly no of occupied sites, taking into account detection probability >> trends in occupancy
- But: computer-intensive (Bayesian methods)

New insight:

- variation in observation effort over the years may be grasped by assessing yearly species detectability
- adjust for detectability and derive inferences on trends from data not collected with standardized field methods

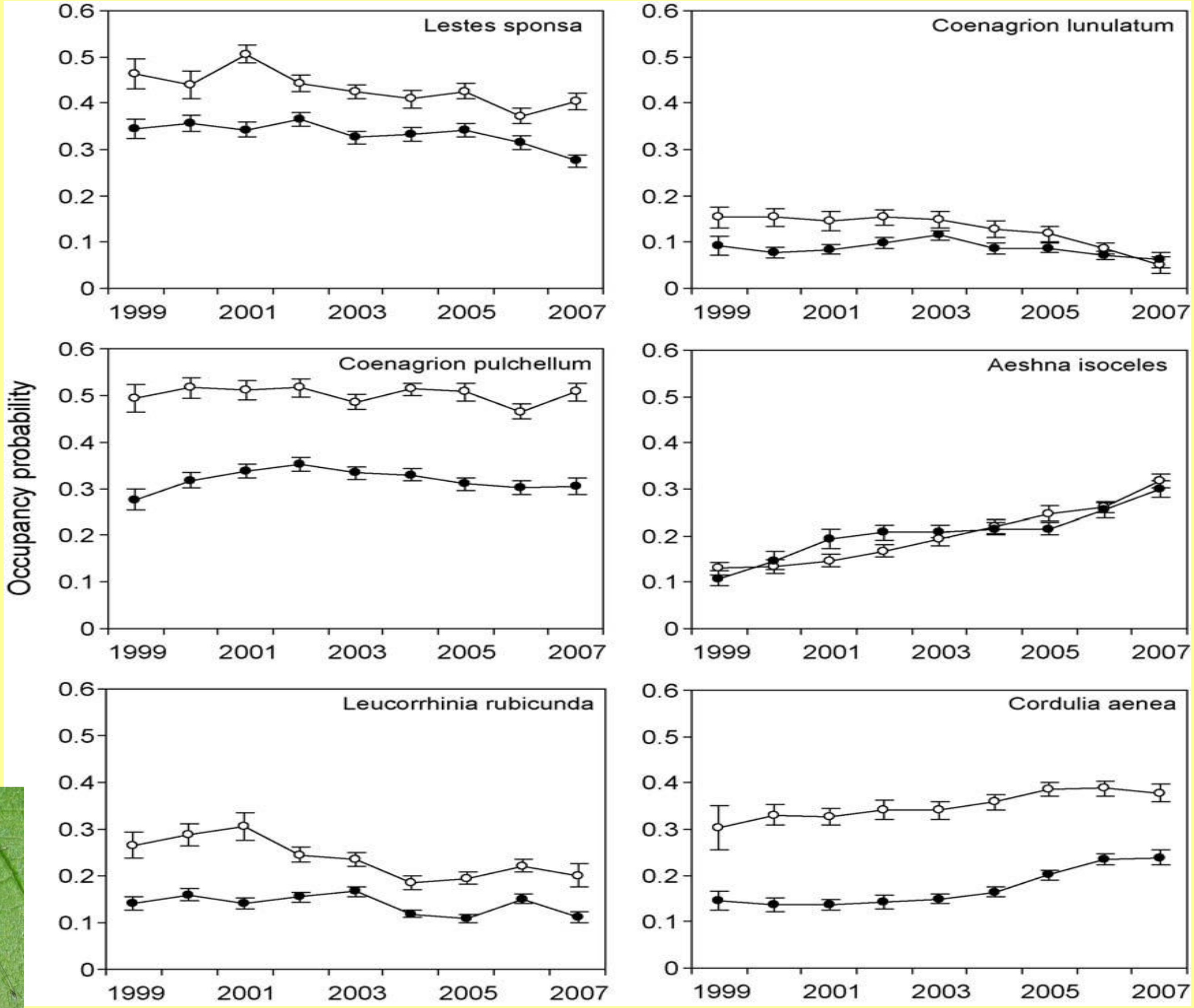
= standardization after field work



[1)] **MacKenzie et al. 2006. Occupancy estimation and modeling**

Test confirmed [1)]

dragonfly species



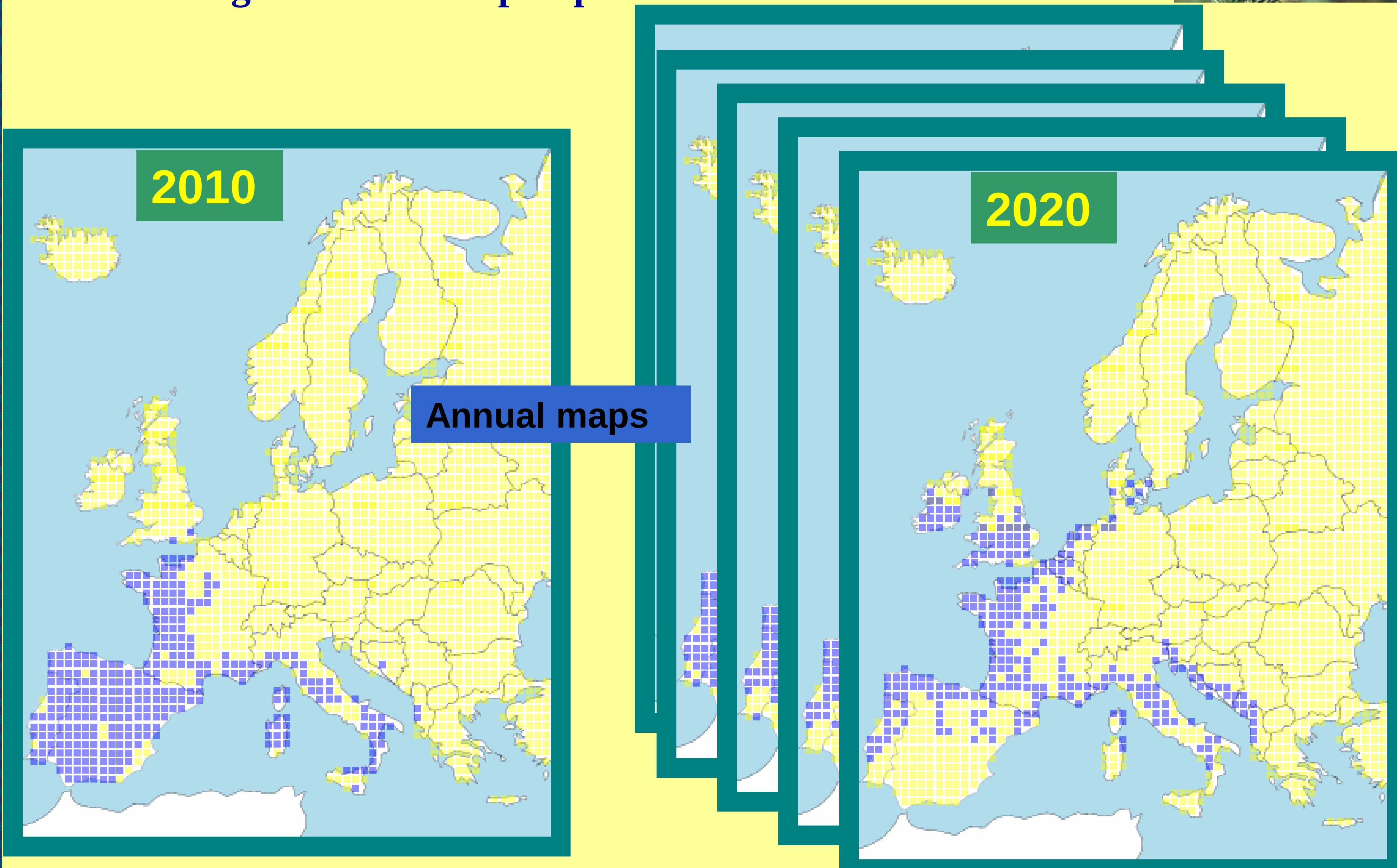
trends based on daily species lists analyzed with occupancy model

=

trends based on standardized monitoring

[1)] **Van Strien et al. 2010. Site-occupancy models may offer new opportunities for dragonfly monitoring based on daily species lists. Basic and Applied Ecology.**

Occupancy model delivers *annual* maps of distribution to relate to e.g. climate change, corrected for observation efforts >> future indicator based on occupancy modeling: geometric mean of trends in range sizes of multiple species



So, how to create indicators for biodiversity change?
Some recommendations:

Summary statistic tells a story

- identify an important conservation issue
- assemble a key message

with wider applications

- look for opportunities for causal links and to generalise findings

is scientifically credible

- collect field data
- adjust for observation efforts (standardization field work or via occupancy model)
- geometric mean to combine species trends

and is feasible in practice

- recruit cheap field workers
- keep field work very simple: daily species lists
- occupancy modeling to adjust for variation in observation effort