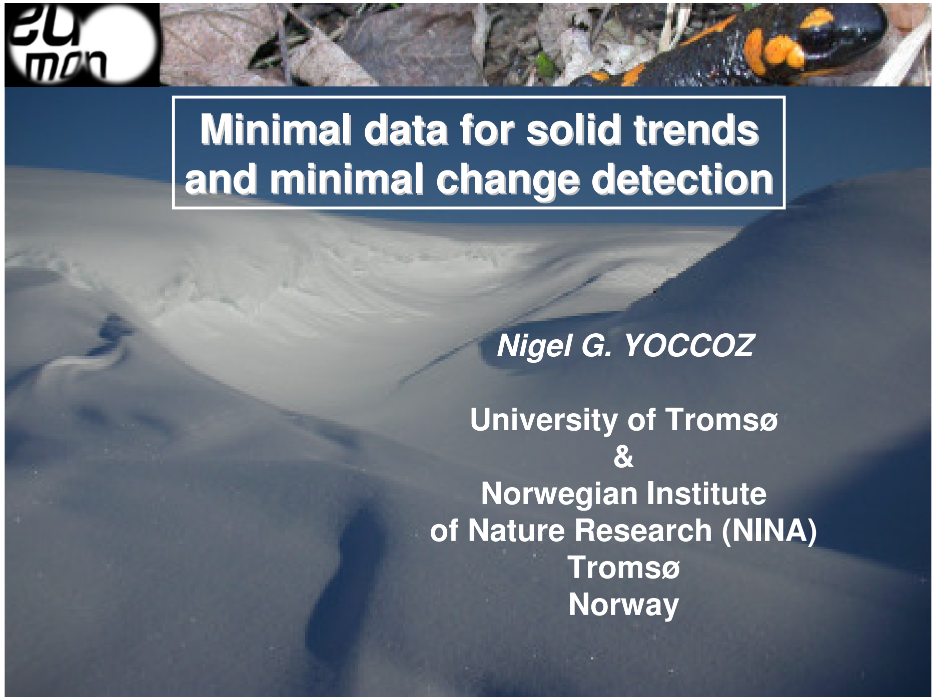

Minimal: depends on objectives, not costs

Costs of decennial census in US

1980	226,542,199	$1,078,488,000	$4.76
1990	248,718,301	$2,492,830,000	$10.02
2000	281,421,906	$4.5 Billion	$15.99

France (latest 1999): 3.1 euros/person

Minimal costs of habitat or species surveillance/monitoring…

EU-wide monitoring methods and systems of surveillance for species and habitats of Community interest

Surveillance: Estimating state variables (species richness, diversity, habitat areas) and temporal changes

Monitoring: Making inferences about these changes (Why are they changing ?)

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Monitoring of biological diversity in space and time

Nigel G. Yoccoz, James D. Nichols and Thierry Boulinier

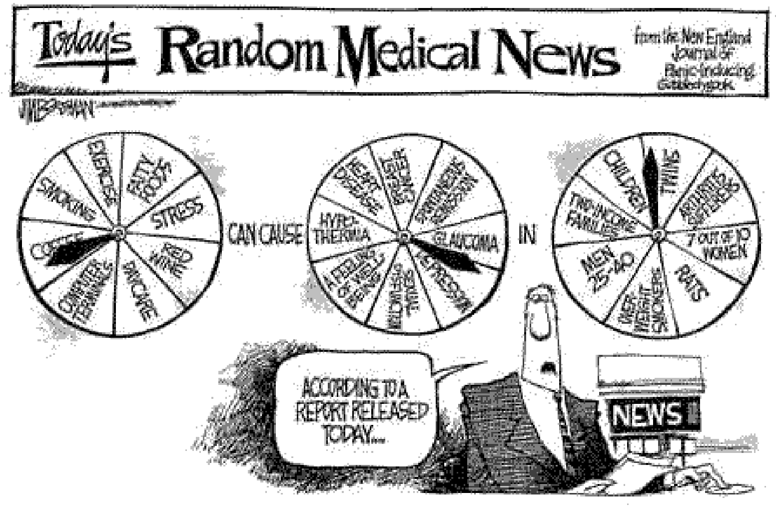
Minimal requirements; the three D's

Design, design and design

Estimation of state variables (mean, distribution):
Unbiasedness achieved by some variation around random sampling
+ precise definition of the ***target*** population

Estimation of causal effects
"Inference about changes"
Unbiasedness achieved by randomization

Absence of randomization (experiments in a restricted statistical sense)



Two components of uncertainty: Bias and Precision (systematic error + sampling variability)

Focus on precision rather than statistical power

- Power is hard to communicate (null hypothesis, alternative hypothesis, arbitrary values (0.05), confusion about P-values, etc.)

- Precision, given some precautions, is easier for most to understand
(even if of course there are some difficult issues)

Changes in species richness or habitat areas

We will achieve a precision of ± 1% at the 50% level of confidence and ± 3% at the 95% level of confidence

versus

The power is 0.5 for the alternative hypothesis : change = -2%, for α = 0.05

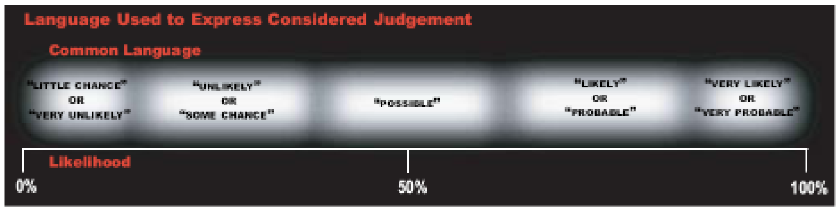


Figure 3-5. "Pillow diagram" used in the US National Assessment to denote fuzzy boundaries to the categories of certainty and uncertainty used. From National Assessment Synthesis Team (2001).

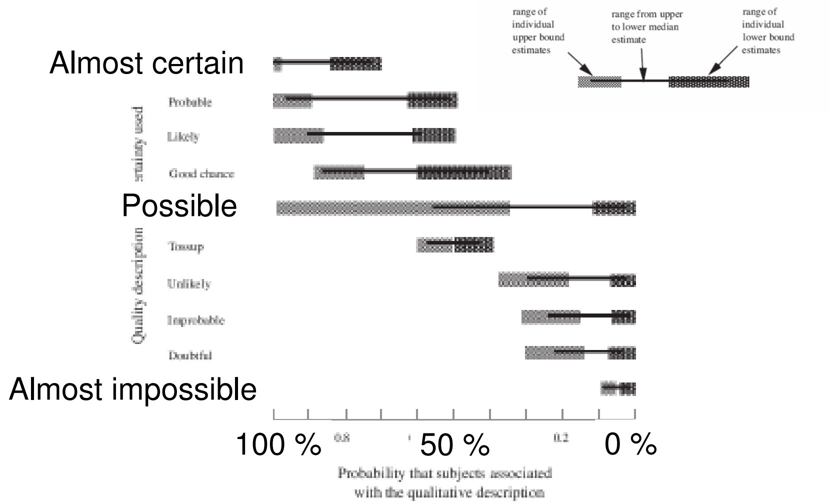


Figure 3-4. Interpretation of common words used to express degrees of certainty or uncertainty. From G. Morgan adapted from Wallsten *et al.* 1986.

IPCC Workshop on

Describing Scientific Uncertainties in Climate Change to Support Analysis of Risk and of Options

How do we assess precision ?

s.e. (mean) = σ / sqrt(n)

50% Confidence Intervals: ± 0.67 s.e.
95% Confidence Intervals: ± 2 s.e.

Very simple situations assuming
Independence among units ++

Precision for Change

s.e. (state(2) – state(1)) ?

$$var(x_2-x_1) = var(x_2) + var(x_1) - 2\,cov(x_1,x_2)$$

Monitoring/Surveillance Designs

⇨Components of variability (σ),
in space and time

1) Spatial variability: structured (not independent), number of units depend on questions asked (eg management units)

2) Temporal variability: structured (not independent), different components such as detectability (measurement error) and process variability (intrinsic variability), changes often non linear

More realistic designs – hard to derive analytical formulas, but easy to simulate (MC)

10 plots
10 years
Response=presence/absence

Prob_presence = f(plots, years, detectability)
Presence = Bernoulli (Prob_presence)

Prob_pres

Spatial variability +

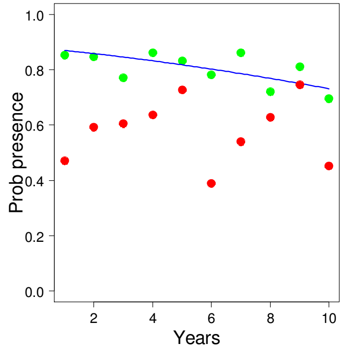
Temporal trends +

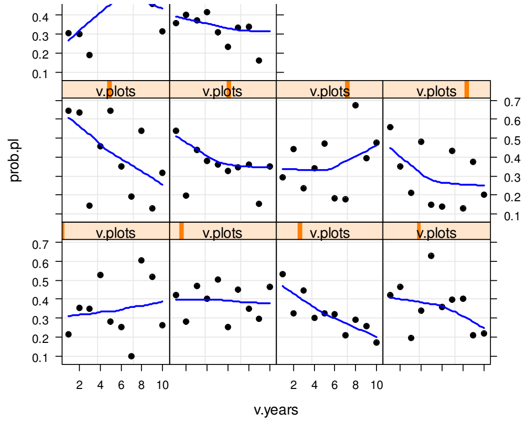
Detectability

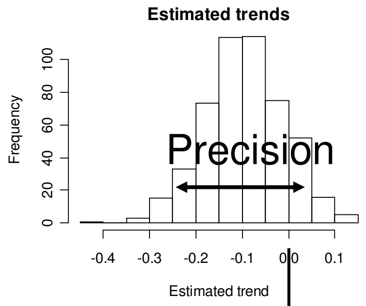
Temporal trends can be site-specific
Temporal trends can have structure (AR)
Spatial variability can be autocorrelated and/or depend on environmental variables

Can be analysed using generalised linear mixed models (with plots as random effects)

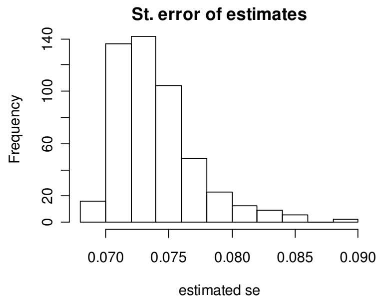
```
In R(free software - available as scripts):
Change: ca. 15% for 10 years
# design characteristics + components of variability
n.plots=10        # number of plots
n.years=10        # number of years
sigma.y = 0.3     # yearly variation in probability of presence
sigma.d = 0.5     # variation in detectability
bias.d = -2       # decline in obs probabilities due to lower detectability
sigma.p=0.5       # spatial variability among plots
sigma.tp=0.03     # spatial variability in trends among plots
```





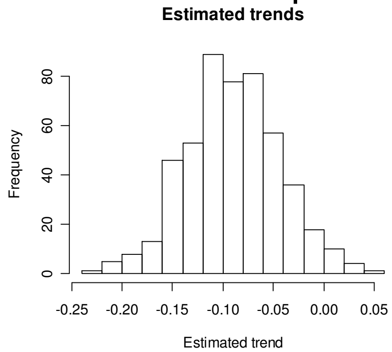


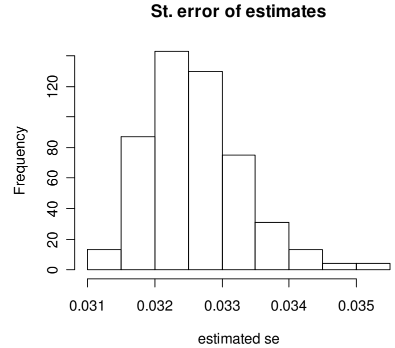
No change



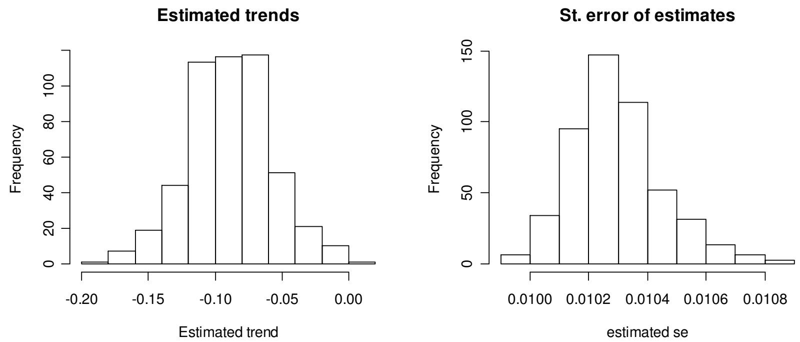
St. err of 0.075
50% CI : ± 0.05
88% to 73 [62-82%]
95% CI: ± 0.15
88% to 73 [38-92%]

With number of plots = 50





St. err of 0.0325
50% CI : ± 0.022
88% to 73 [69-77 %]
95% CI: ± 0.065
88% to 73 [59-84 %]



500 plots
[x 10; s.e. sqrt(10)]

St. err of 0.0103
50% CI : ± 0.007
88% to 73 [72-74 %]
95% CI: ± 0.02
88% to 73 [69-77 %]

Conclusions (1):
- Don't forget there are two components of uncertainty: bias and precision

Bias is best removed at the design stage, often hard to rely upon a posteriori adjustments (possible in principle…; design vs model-based inference)

Precision of a given sampling design "easy" to assess using simulating tools as available in R

We need to know the components of variability and to be able to use models implemented or written in R (e.g. detectability models need some programming; software GENPRES very useful but limited in scope)

Conclusions (2)
Uncertainty is often misunderstood, or misused – need to use precise language

- Null hypothesis tests are to be avoided: hard to explain, only evidence against and sometimes understood as evidence for (i.e. probability that the null hypothesis – eg no change – is true)

Use Confidence Intervals at different levels (nothing sacred about 95%:

50 [0.67], 90 [1.6], 95 [2], 99 [2.6] %)

Be careful regarding their interpretation (they are not probabilities, except in the context of Bayesian statistics)