Trees for health – forever

Implementing sustainable medicinal bark use in Southern Africa.

Symposium and Workshop at Willow Park, Johannesburg, South Africa

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On data and sampling

by

Christoph Kleinn

Institute of Forest Management

Georg-August-Universität Göttingen

- Göttingen is a nice place ...
  ... and it has ist place in science and history.

- The mathematician, surveyor, astronomist, etc. ... CF Gauss has lived and worked in Göttingen (the one who first described the normal distribution).

- The brothers Grimm were pro-fessors at Universität Göttingen (the ones with the fairy tales – Snowwhite etc.).

Background of this presentation

- *Sustainability of utilization of natural renewable resources* means essentially that the resource base is not damaged, not on the short and not on the long run.

- If we wish to guarantee sustainability, we must have some basic information on the resource, in particular on
  - the existing growing stock and
  - the changes (increment, regeneration, mortality).

Background

- With respect to this basic information on the resource there are some basic issues and challenges:

  - How to define which data are actually required ?
  - How to gather those data efficiently ?
  - How to convert that data to information ?
  - How to disseminate the information ?
  - How to make sure that that information is then being properly used ?

General question

What is the role of data and information and its procurement for the sustainable management of renewable natural resources

?

A recent example (from global change research) that stresses the role of quantitative methods in empirical research →

Also in this section

Climate change

Heat and light

An unexplained anomaly in the climate seems to have been the result of bad data

CLIMATOLOGY is an inexact science at the best of times. Unfortunately it has become, over the past couple of decades, a politically charged one as well. As the debate about global warming—and what, if anything, to do about it—has gathered pace, uncertainties in the data that would be of merely academic interest in other disciplines have acquired enormous practical significance. And one of the most curious uncertainties of all is the apparent discrepancy between what is happening to temperatures at the Earth's surface and what is happening in the troposphere—the lowest layer of the atmosphere, and thus the part that is in contact with that surface.

The troposphere is where most of the air is found and where most of the weather occurs. Computer models predict that, if global warming is really happening, temperatures in the troposphere should rise along with those on the surface. Recorded surface temperatures are, indeed, rising. However, both data from weather balloons and observations made by satellites suggest that temperatures in the troposphere have remained constant since the 1970s. Over the tropics they may even have dropped. This counter-intuitive result has caused sceptics to question how much warming, if any, is actually going on.

There are, of course, three possibilities. One is that the sceptics are right. A second is that the models are wrong. And the third is that there is something wrong with the data. Three papers published in this week's issue of *Science* suggest that the third possibility is the correct one.

Day and night

The first of these studies, conducted by Steven Sherwood of Yale University and his colleagues, examined data from weather balloons. For the past 40 years, weather stations around the world have released these balloons twice a day at the same time—midday and midnight Greenwich Mean Time. Each balloon carries a small, expendable measuring device called a radiosonde that sends back information on atmospheric pressure, humidity and, most importantly for this study, temperature.

Unfortunately, data from radiosondes come with built-in inaccuracies. For example, their thermometers, which are supposed to be measuring the temperature of the air itself (that is, the temperature in the shade) are often exposed to, and thus heated by, the sun's rays. To compensate for this, a correction factor is routinely applied to the raw data. The question is, is that correction factor correct?

Dr Sherwood argues that it is not. In particular, changes in radiosonde design intended to reduce the original problem of over-heating have not always been accommodated by reductions in the correction factors for more recently collected data. Those data have thus been over-corrected, reducing the apparent temperature below the actual temperature.

Dr Sherwood and his colleagues hit on a ruse to test this idea. Because weather stations around the world release their balloons simultaneously, some of the measurements are taken in daylight and some in darkness. By comparing the raw data, the team was able to identify a trend: recorded night-time temperatures in the troposphere (night being the ultimate form of shade) have indeed risen. It is only daytime temperatures that seem to have dropped. Previous work, which has concentrated on average values, failed to highlight this distinction, which seems to have been caused by over-correction of the daytime figures. When the team corrected the erroneous corrections, the result agreed with the models of the troposphere and with records of the surface temperature. The improvement was particularly noticeable in the tropics, an area that had previously appeared to have high surface temperatures but far cooler tropospheric temperatures than had been expected.

The second piece of work looked at satellite measurements of tropospheric temperatures. For the past two decades, microwave detectors, placed on a series of satellites flying in orbits that take them over both poles, have been used to calculate the troposphere's temperature. (Microwaves radiated from the atmosphere contain a host of information about its temperature and humidity.) Here, too, the data are problematic. Because the satellites

are looking down through the whole atmosphere, measuring the temperature of the troposphere requires subtracting the effects of the stratosphere—the atmospheric layer above it. But when this has been done, the result suggests, like the over-corrected data from the radiosondes, that the troposphere is cooling down relative to the surface.

However, Carl Mears and Frank Wentz of Remote Sensing Systems, a firm based in Santa Rosa, California, think that this trend, too, is an artefact. It is caused, they believe, because the orbital period of a satellite changes slowly over that satellite's lifetime, as its orbit decays due to friction with the outer reaches of the atmosphere. If due allowance is not made for such changes, spurious long-term trends can appear in the data. Dr Mears and Dr Wentz plugged this observation into a model, and the model suggested that the apparent cooling the satellites had observed is indeed such a spurious trend. Correct for orbital decay and you see not cooling, but warming.

The third paper, by Ben Santer of the Lawrence Livermore National Laboratory in California and his colleagues, argues that it is, indeed, errors in the data that are to blame for disagreements between the predictions of computer models about how the troposphere should behave and what the weather balloons and satellites actually detect. Dr Santer's team compared 19 different computer models. All agreed that the troposphere should be getting warmer. Individual models have their individual faults, of course. But unless all contain some huge, false underlying assumption that is invisible to the world's climatologists, the fact that all of them trend in the same direction reinforces the idea that it is the data which are spurious rather than the models' predictions.

It is, nevertheless, doubtful that these papers will end the matter. Studying the climate is a hard problem for three reasons. The system itself is incredibly complex. There is only one such system, so comparative studies are impossible. And controlled experiments are equally impossible. So there will always be uncertainty and therefore room for dissent. How policymakers treat that dissent is a political question, not a scientific one. ■

The economist, 13.08.2005

It is a good habit ...

- **not only to discuss results, but also ask about data quality and where the data come from, and**

- **not to *believe* in the results of an empirical study (even though they might be completely plausible) but question them critically.**

... in that sense, our role in the bark project was

- to assist on statistical and methodological issues,
- to contribute developing bark volume and bark yield models,
- to contribute developing sampling systems for estimation of the growing stock of bark harvested trees.

Statistical sampling

- Statistical sampling is a data collection tool; it provides methodologically sound (and defendable!) results.
- Randomization is the *only generally accepted* selection "philosophy" for the class of sampling techniques that we deal with here (introduced by Sir RA Fisher in the 1920/30s).
- Concepts like "fairness", objectivity", "representativeness" should not be used as a general basis for sample selection.
- Guided subjective or arbitrary selection is not statistical sampling.
  We may not apply statistical analysis techniques to such samples!

One classification of empirical studies

Studies with a sound statistical basis

- need to adhere strictly to very clear rules,
- allow statistical estimations and extrapolations,
- allow statistical testing and significance inferences.

Others: case studies

- do NOT allow statistical analysis in the sense of extrapolations or statistical inference,
- serve to obtain general insight into a problem,
- serve to generate hypothesis that must then be tested by a statistically sound study.

The particular situation for bark estimation

We need information

- about growing stock → inventory

- **about growth → repeated observations**

- **about wound reactions → experiments**

We tried to address all these points in our relatively short project.

Studies on sampling in the bark project:

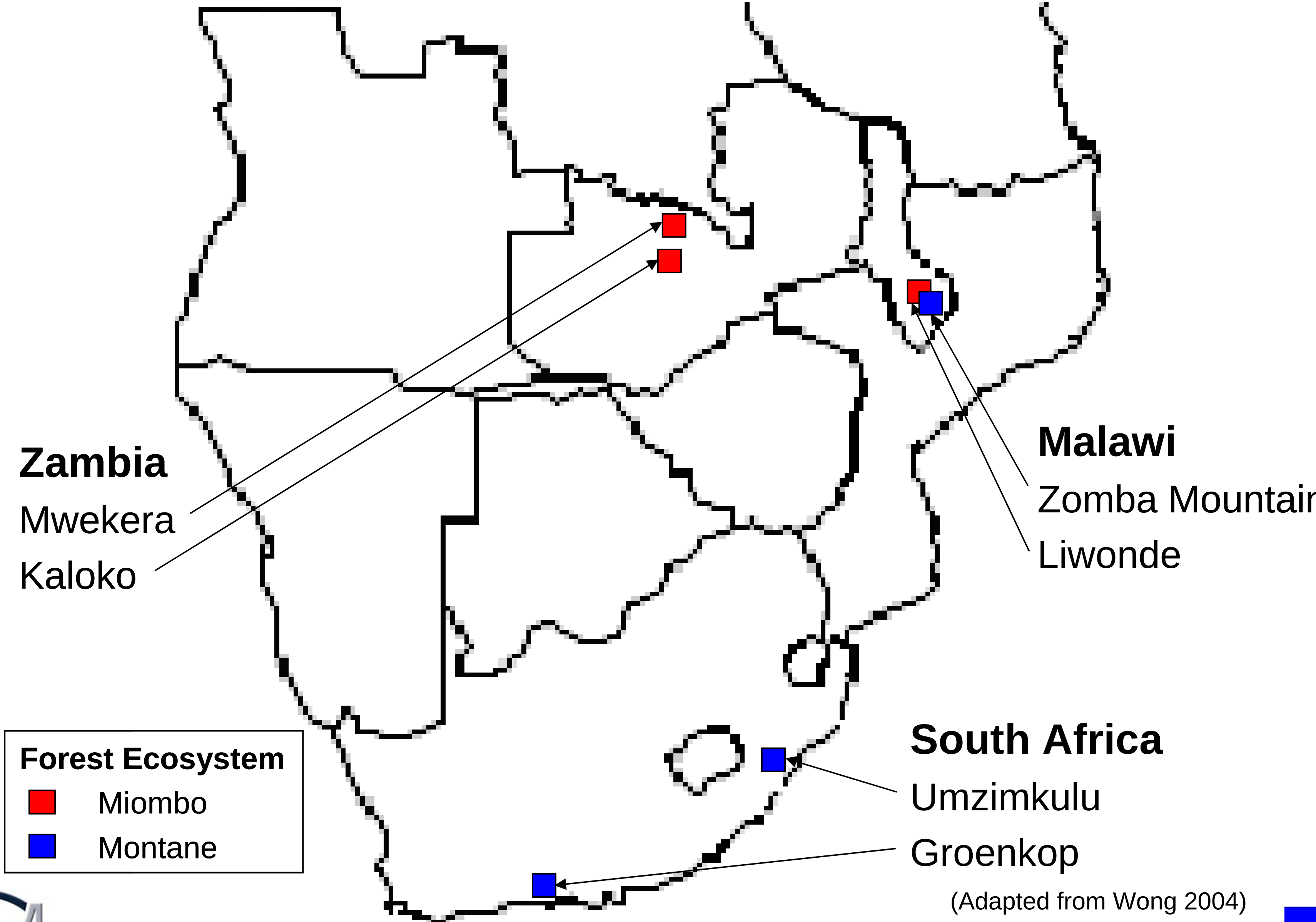
Three major studies on sampling were carried out (of which we present here a brief overview only):

- **Groenkop (South Africa) – *thanks Coert et al.***
  ***Data were readily available*.**

- **Mwekera (Zambia) – *thanks Fabian et al.***
  Trees mapped on 13ha of miombo* woodlands *for sampling simulations.

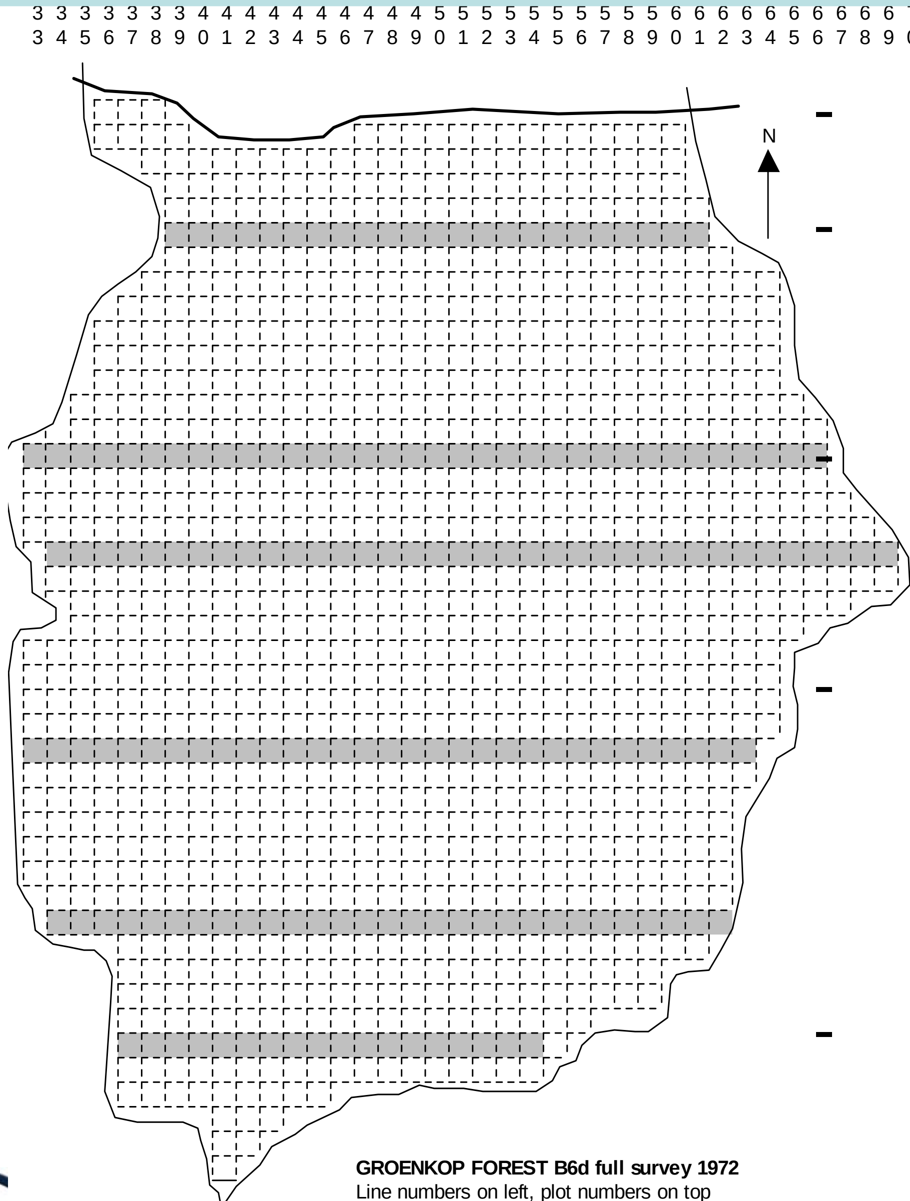
- **Liwonde (Malawi) – *thanks Tembu et al.***
  ***Test inventory*.**

Sites for the sampling studies



(Adapted from Wong 2004)

1. The Groenkop census data



GROENKOP FOREST B6d full survey 1972
Line numbers on left, plot numbers on top

- **Census in 1972.**
- **The area was subdivided into 1131 square plots of 200m² each (total 22ha).**
- **Data were recorded per tree per plot for all trees with dbh > 10cm.**
- **Repeated measurements of "gray" plots in 04/80, 01/89, 04/97 allowed assessment of some changes.**
- **→ Allows a simulation of a restricted set of sampling options.**

Observed bark harvested species

Podocarpus falcatus	171
Ocotea bullata	81
Ilex mitis	266
Cassine papillosa	740
Olinia ventosa	41
Curtisia dentata	1661
Rapanea melanophloeos	205

Illustration: spatial distribution of one species

Podocarpus falcatus (*N*=171)

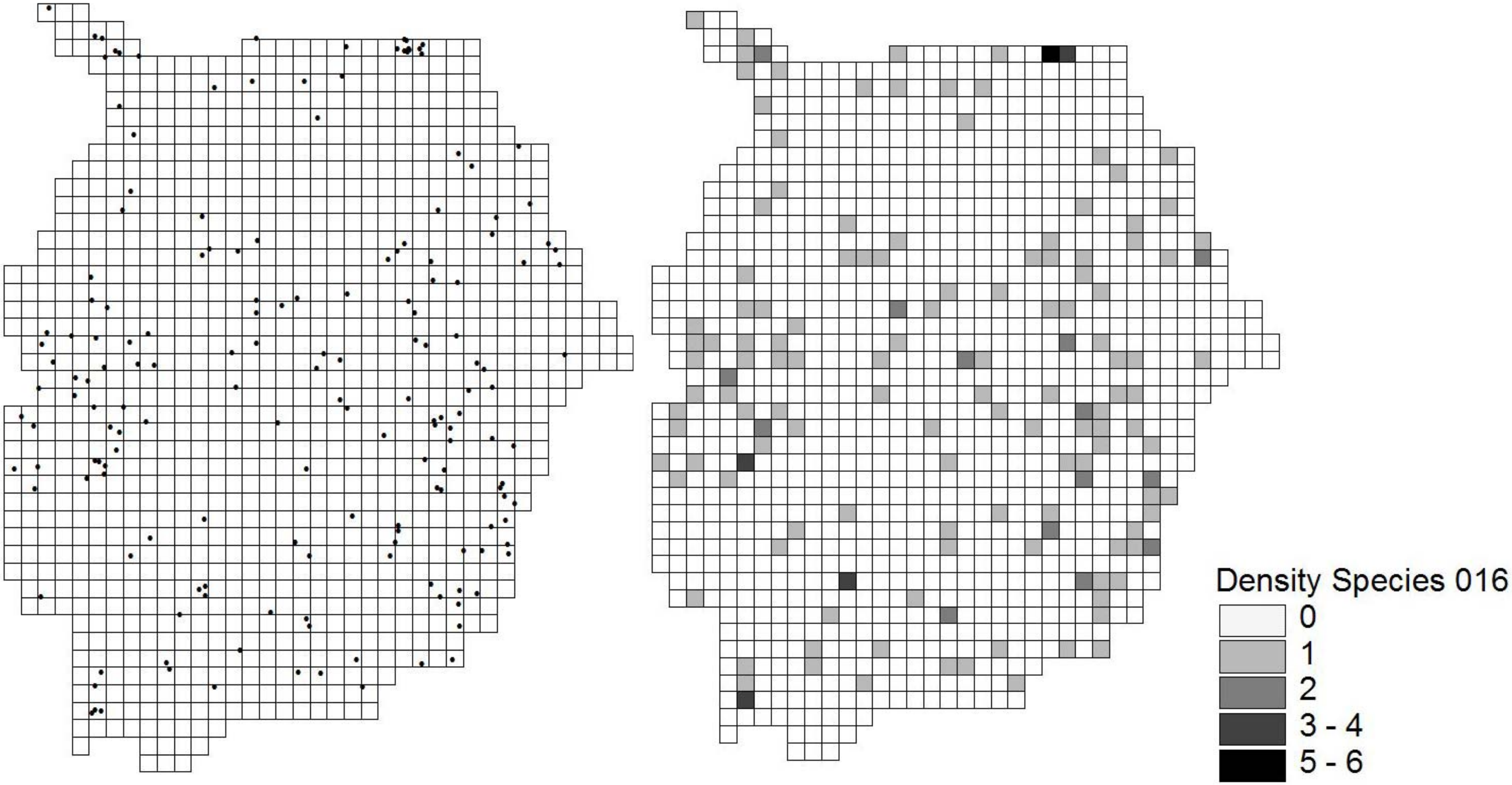
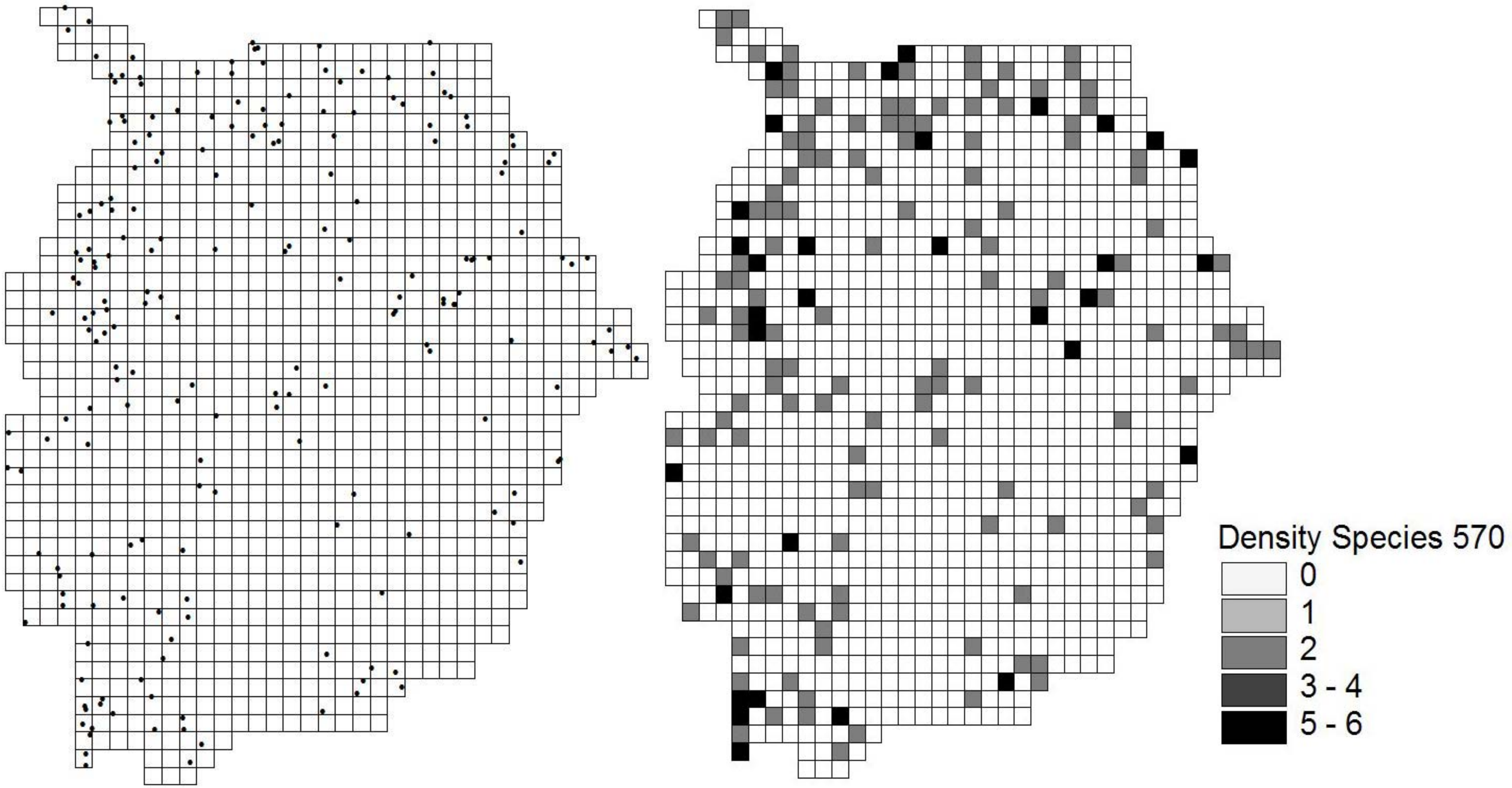


Illustration: spatial distribution of one species

Rapanea melanophloeos (N=205)



Some conclusions from analysis of Groenkop data

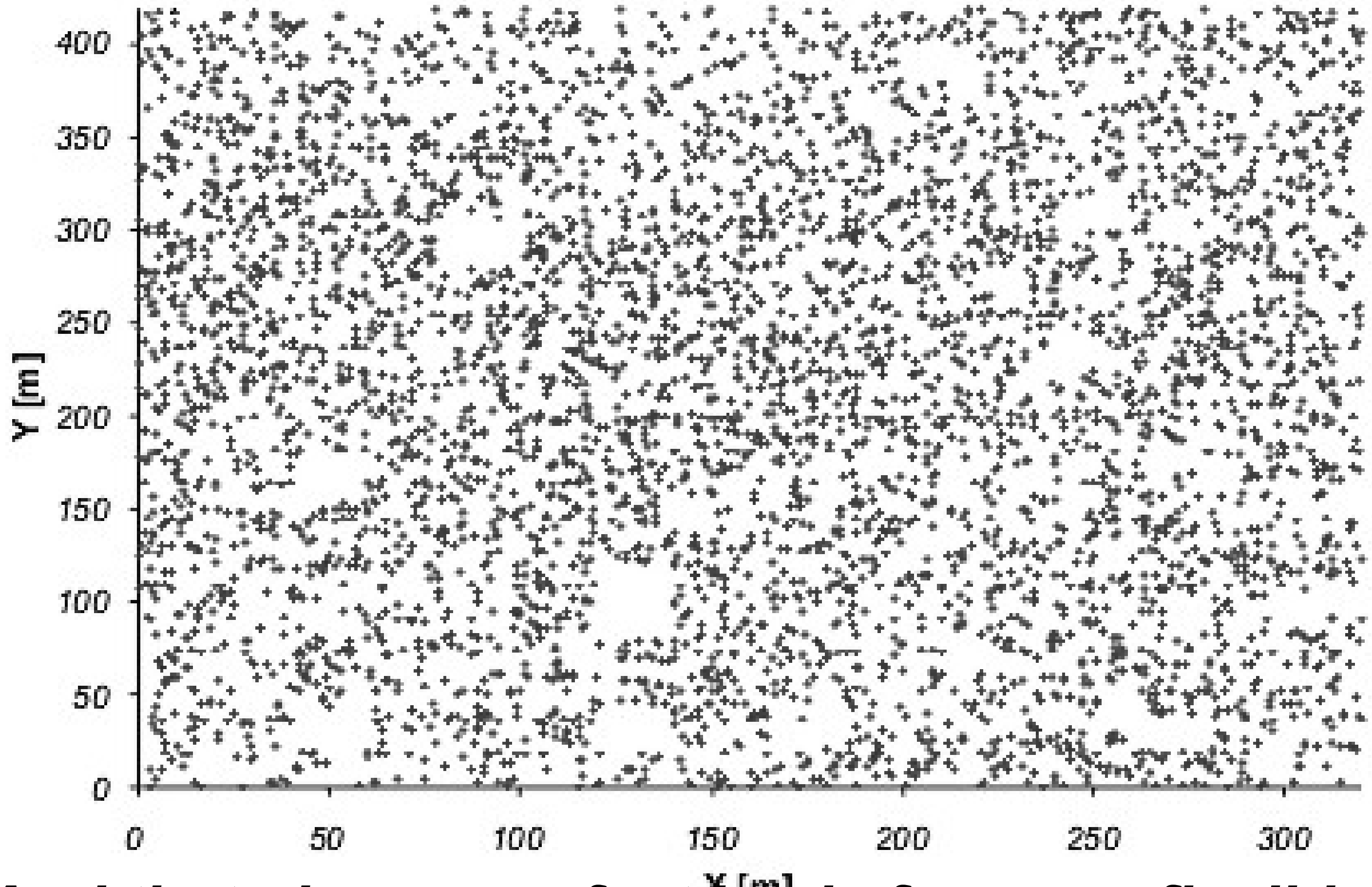
- The spatial arrangement of the bark harvested species is diverse and differs from species to species.
- Analysis of spatial autocorrelation suggests that larger plots may be used than the 200m² plots used in the census.
- Suggestion:

For larger inventory areas: Systematic sampling with about 500m² plot size (Circular ones are usually easier established).

For smaller areas: transects should be used for practical reasons, either crossing the entire stand or with a defined fixed length.

2. Tree mapping in Mwekera forest (Zambia)

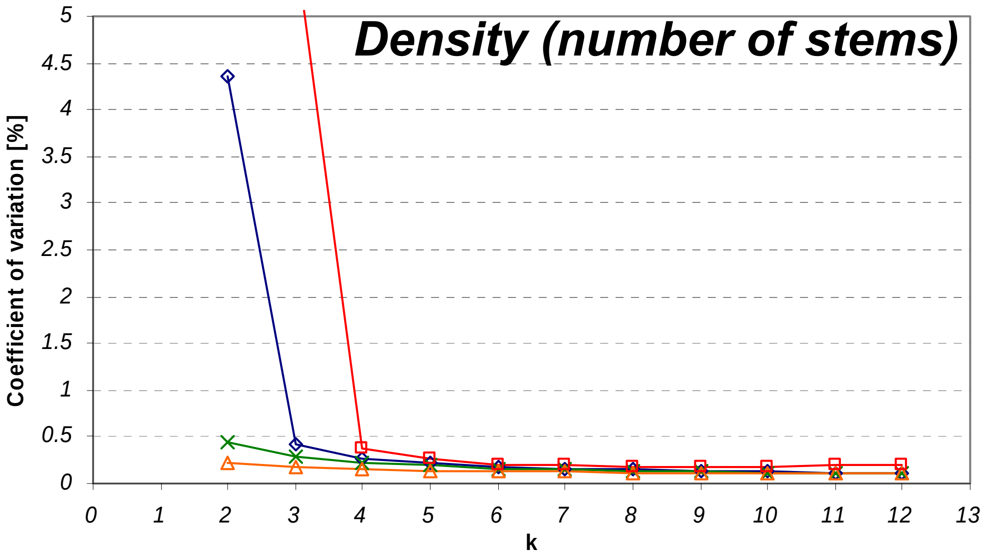
A miombo woodland area of about 13ha was completely mapped for tree positions.

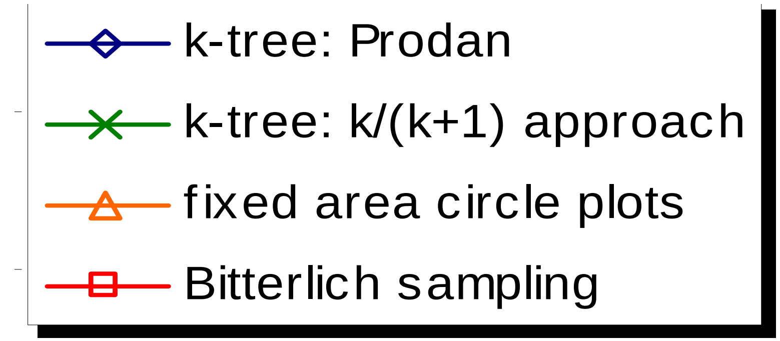


***And that gives a perfect basis for more flexible sampling simulations** (thanks to Dr. František Vilčko).*

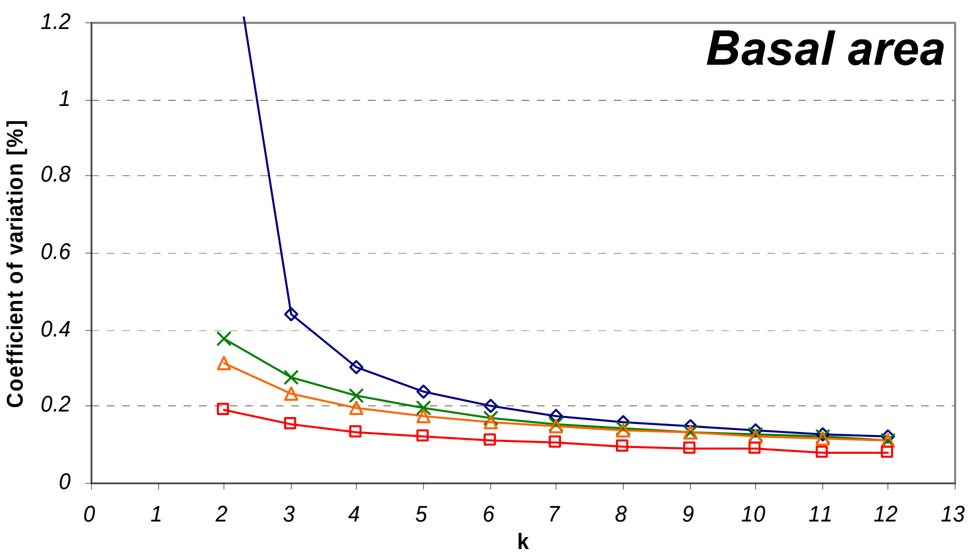
IWW

Among the results: comparing different plot designs for the same expected number of trees per plot





The results indicated that *k*-tree sampling (with *k*>5) may be a viable option - for its simplicity of implementation.



3. Pilot inventory in Liwonde forest (Malawi)

150 sample plots were established from which 8 different plot designs were simulated:

- fixed area plots of 5 different sizes and
- 3 variations of *k*-tree plots.

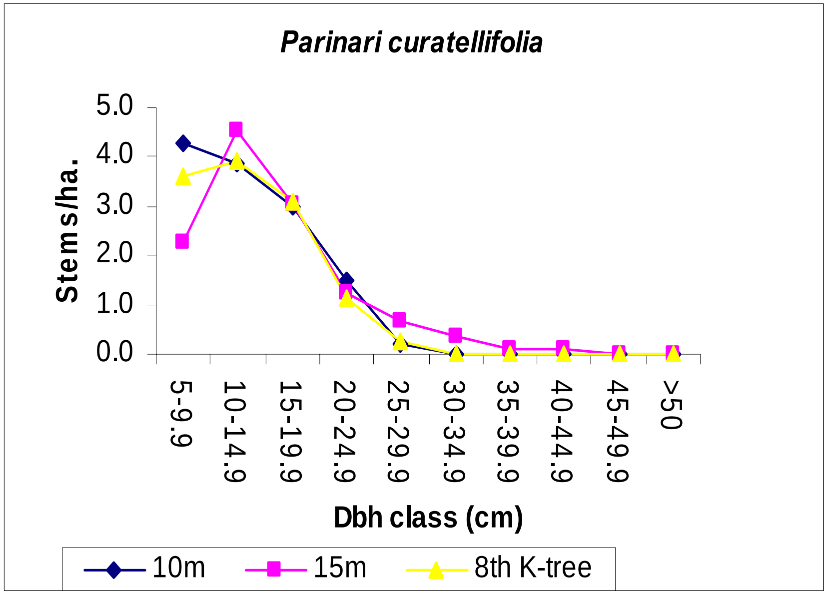
Overall conclusion (similar to Mwekera simulations):

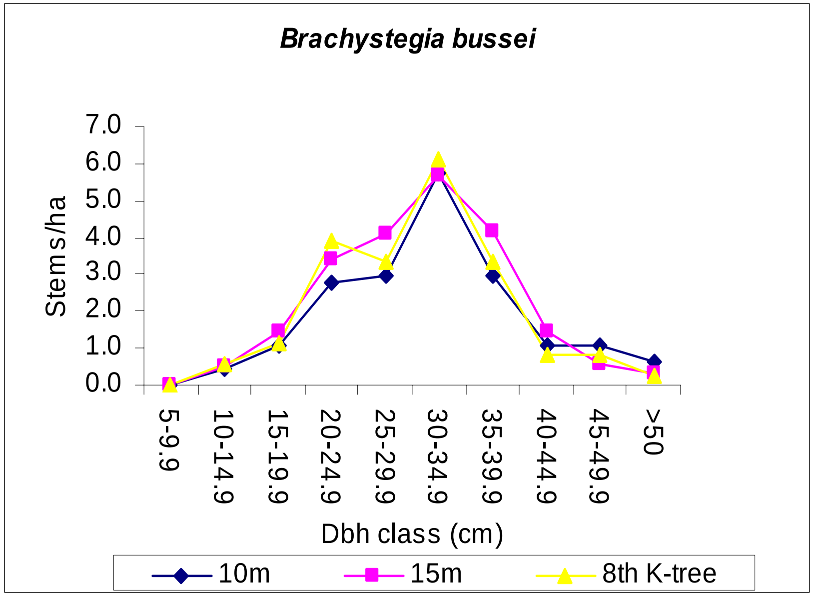
k-tree plots have advantages from a practical point of view, though they are statistically not superior.

For all three studies:

The data sets do certainly have much more potential for analysis than we were able to do in the limited project time!

Example from study 3:
diameter distributions (from Tembu - FRIM)

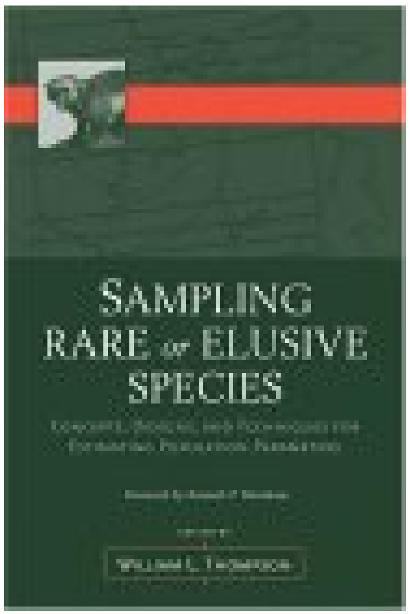




Sampling for rare events (eventually)

A very actual topic – in many disciplines.

A recent textbook is dedicated exclusively to it:



Synopsis
Information regarding population status and abundance of rare species plays a key role in resource management decisions. Ideally, data should be collected using statistically sound sampling methods, but by their very nature, rare or elusive species pose a difficult sampling challenge.
Sampling Rare or Elusive Species describes the latest sampling designs and survey methods for reliably estimating occupancy, abundance, and other population parameters of rare, elusive, or otherwise hard-to-detect plants and animals.

In a recent forest inventory meeting several papers on that topic were given (Annual FIA meeting Oct. 2005, Portland) .

Sampling for rare events

However –

- there are no miracles to be expected from sampling for rare species and
- one must always be aware of high errors.

- While many researchers expect that “fancy” plot designs (such as adaptive cluster sampling, guided transect sampling, ...) are the solution, we could not prove their superiority for our conditions.

But those are definitively more complex and error-prone plot designs when it comes to field work !

Overall conclusion

It appears that a standard techniques like systematic sampling with *k*-tree plots or fixed area plots allows a reasonably good estimation of the growing stock of bark harvested species.

(After all, this does also comply with the principle "keep it simple" – for field implementation and for analysis)


Thanks
ckleinn@gwdg.de