Model Based Statistics in Biology

Chapter 2.2 Types of Measurement Scale

ReCap (Ch 1, Ch 2.1)
Ch2 Quantities
2.1 Five part definition
2.2 Types of measurement scale
2.3 Data collection, recording, and error checking
2.4 Graphical and tabular display of data
Critique of graphs and tables (Lab 5)
2.5 Ratio Scale Units
Base
Standard Multiples
Commonly used units in biology
2.6 Dimensions

on chalk board

Not here last time?
Course Outline
Name on roster
Questionnaire results

Discussion of Cards Lab:
Anybody come up with "wrong" rule that works?
In 1997 mutually exclusive pairs introduced ("test" cards), before going to multiple working hypotheses ("crucial" cards).
Ask for discussion of this, comparison of "test" and "crucial."
In 1998 crucial cards only.

ReCap Chapter 1

The Role of Statistics in Science

Statistics have come to play a central role in the biological, psychological, and health sciences.

Model Based Statistics in Biology

Simplification required to deal with uncertainty and with biological complexity

△ Verbal, graphical, and formal model (equations)

Models are used to make: useful calculations (species extinction)
decisions (experiments. yes/no)

Role of statistics: Development of models (exploratory analysis)
Formal evaluation of models (confirmatory analysis)

Quantitative reasoning about biological phenomena.

Not a course in math. Not a course in rote learning of list of tests.
It is a course in how to think with measured quantities.
It will integrate models with statistics.

ReCap Chapter 2.1

Models express ideas about the relation of quantities.
Quantities defined in 5 parts.

Wrap-up

Measurements are made on nominal, ordinal, interval, or ratio scales.

Quizzes are time limited (10-20 minutes before end of class)
because one component of learning is active engagement with material

Collaboration is encouraged in labs, in exercises, in note taking.
For example, use e-mail to exchange data sets.
Collaboration is not encouraged on quizzes and exams.
These are individual efforts.
Set-up of the room a problem (sitting adjacent)
So: Two versions of exams
Quiz today: Not collaborative. Open book. (just like exams)

I hand out the quiz as quickly as possible, 10-20 minutes before end of class.
To speed it up, someone from class helps me.

Types of Measurement Scale (Schneider 2009 *Quantitative Ecology* Chapter 3.5)

In 1946 the psychologist S.S. Stevens (*Science* 103:677) distinguished 4 types of measurement scale. This was published in a widely distributed journal, to address the claim (made by some hard-line physicists) that presence/absence, or ranks, were not legitimate types of measurement.

Nominal. Outcome of measurement is "yes" or "no" also coded as 0 or 1

Ordinal. Outcome is ranking: 1st, 2nd, 3rd, etc.
No information about magnitude of difference from one rank to next.

Interval. Number of units known, but zero point does not mean 'nothing'
Example of compass direction 0^o does not mean "no direction."
Direction is relative to this arbitrary point
Indices are often on an interval scale.
Index of relative abundance might be zero,
yet there were some animals present (undetected).
Other examples are dates (2 January, Julian day 180)
Latitude/longitude

Ratio. Both number of units and zero point are known.
Example of degrees Kelvin. Can say that there is no heat content at 0^o K
In contrast, 0^o C does not mean "no temperature." still heat, so it is interval.
Example of a count.
Can take ratios or doublings
Example of intrinsic rate of increase. A population with $r = 5\%\ \text{year}^{-1}$ has twice the intrinsic rate of increase as a population with $r = 2.5\%\ \text{year}^{-1}$
In contrast, can't take twice 20 January

Types of Measurement Scale

Ratio vs interval.

Ratio scale time (your age) versus interval scale time (calendar date)
Ratio scale length (lake diameter) versus interval scale (lat/long).

Note on interval scale measurements.
These can often be converted to ratio scale, by taking a difference.
For example, 45^o means NorthEast, it is interval scale.

A sailboat turns 45^o (from 0^o to 45^o, from 30^o to 75^o , etc)
The difference in direction is on a ratio scale.

Measurement procedure determines the type of scale.

Nominal, ordinal, and ratio scales are commonly encountered in both the natural and social sciences.

Ratio and interval measurements are sometimes grouped together as cardinal,

leading to: Nominal, Ordinal, Cardinal.

Nominal, ordinal, interval, and ratio scales differ in the amount of information.

These four types of scales are important in understanding differences among statistical procedures.

Examples: ANOVA based on nominal scale explanatory variable (classes).
Regression based on interval or ratio scale explanatory variable.
Logistic regression for nominal scale counts (yes/no to a %)
Poisson regression for ratio scale counts.

Many 'non-parametric' tests reduce interval or ratio scale to a less informative rank scale and so can give different results than using the interval or ratio scale data for analysis.