**Statistical Science**

# Chapter 3.1 Logical Re-scaling

ReCap. Quantitative Reasoning(Ch 1)
Quantities (Ch2)
Re-Scaling (Ch3)
3.1 Logical Re-scaling
3.2 Operations on Ratio Scale Quantities
3.3 Descriptive Statistics and Rescaling
3.4 Unit Conversion and Rigid Rescaling

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Not here last time?
     Course Outline
Study guide
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on chalk board

**Recap** Chapter 1
Quantitative reasoning: Example of scallops, which combined stats and models
**Recap** Chapter 2
Quantities: Five part definition
Measurements made on four types of scale: nominal, ordinal, interval, ratio
Data collection, recording, and error checking
Graphical and tabular display of fully defined quantities
Units are useful in reasoning about quantities (Lab 2)

Distinguish derived from base units, then define standard multiples.
Understand and interpret symbolic notation of science concepts.
Accurate calculation from symbolic notation.

Dimensions (groups of similar units) are useful in quantitative reasoning.

Today: **Rescaling Quantities**

Begin with logical rescaling (from one type of unit to another).

**Wrap-up**:
Re-scaling is a common technique in quantitative biology.
Logical re-scaling = re-scaling from one type of measurement scale to another.

Draw arrows in table from right to left, to start.

**Logical Rescaling** (Schneider 2009, Chapter 5.2)
Logical rescaling changes the type of measurement scale. There are 12 possible rescalings among the 4 types of measurement scale.

Half are in the direction of a less detailed scale, shown as leftward pointing arrows in Table 3.1.

All of these rescalings occur in the ecological literature. All can be executed with standard computer packages for data manipulation.

**Table 3.1**

Logical rescaling of quantities.

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  less detail                                   more detail

   Nominal        Ordinal       Interval          Ratio
                                   <——————————————————
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Then add arrowheads to table, pointing right.

There are 6 possible rescalings in the direction of more informative scales, represented by rightward pointing arrows in Table 3.1.

These logical rescalings require that information be added, either by remeasurement, or by combining several quantities to generate a more detailed scale. For example, an interval scale measurement of temperature in degrees centigrade must be combined with a single-valued quantity, the freezing point of water in degrees Kelvin, to obtain temperature on a ratio scale. Another example is the combination of several nominal scale classifications of habitat (e.g., good/bad, wet/dry, sunny/shady) to produce a single ranking of habitat on a rank scale of, say, 1 to 5. Yet another example is taking the difference of two measurements on an interval scale (such as calendar date) to obtain a ratio scale measurement. Taking a difference guarantees a ratio scale quantities. Taking the ratio of two differences (as in the mathematical operation of differentiation) guarantees a ratio scale quantity.

Logical rescaling has many applications. For example, it may be necessary to recalibrate a quantity from a ratio to ordinal or nominal scale if data are uneven in quality. A series of annual observations that began as casual observations, and then became more standardized to greater detail over the years, could all be converted to a nominal scale (presence or absence of a phenomenon) that would be consistent across the entire series.

Another application of logical rescaling is exploratory data analysis to discover pattern. Rescaling to a less detailed quantity often makes it easier to pick out pattern. For example, a series of satellite images can be remeasured to a nominal scale (presence or absence of weather fronts) to obtain a useful quantity for understanding the effects of weather systems on bird migration ( Alerstam 1990).

One common application of logical rescaling is the conversion of interval or ratio scale data to a rank type of scale, for statistical evaluation of outcomes via nonparametric methods. The advantage of this, before the common availability of computers, was that all possible outcomes could be tabulated, allowing an exact estimate of Type I error, the error of accepting a difference that does not exist. Computers now make it possible to use randomization tests ( Manly 1991) to estimate Type I error without rescaling quantities to ranks. These randomization tests have better discriminating capacity than tests that rescale the data to ranks. In statistical jargon, randomization tests have lower Type II error than those based on rescaling to ranks. Despite the clear advantages of randomization tests over tests that reduce data to ranks, the rank-based relics have remained in use because of their availability in statistical packages for computers.

Rescaling to a nominal scale is used in classification, including taxonomy. Clustering algorithms transform quantities measured on several types of scale ( Jardine and Sibson 1971) to a nominal scale quantity, the classification.

Rescaling to a more detailed scale is also useful. A common example of this is ordination, which combines several quantities measured on any type of scale into one quantity measured on a ratio scale. The purpose of analysis may be to rank objects, but most ordination techniques produce interval or ratio scale quantities, not ordinal scale quantities. The literature on techniques is vast ( Seal 1964, Kershaw and Looney 1985, McGarigal *et al* 2000) but attention to type of measurement scale is rare ( Gower 1987).

Another look at 3.1

Above each of the 12 arrowheads in Table 3.1, place a check mark if you have used this form of logical rescaling.

Study Guide (How to do well on quizzes)

For each lecture: What is the principle concept?

Can you do a calculation based on the concept?

Can you extend the calculation to a different context?