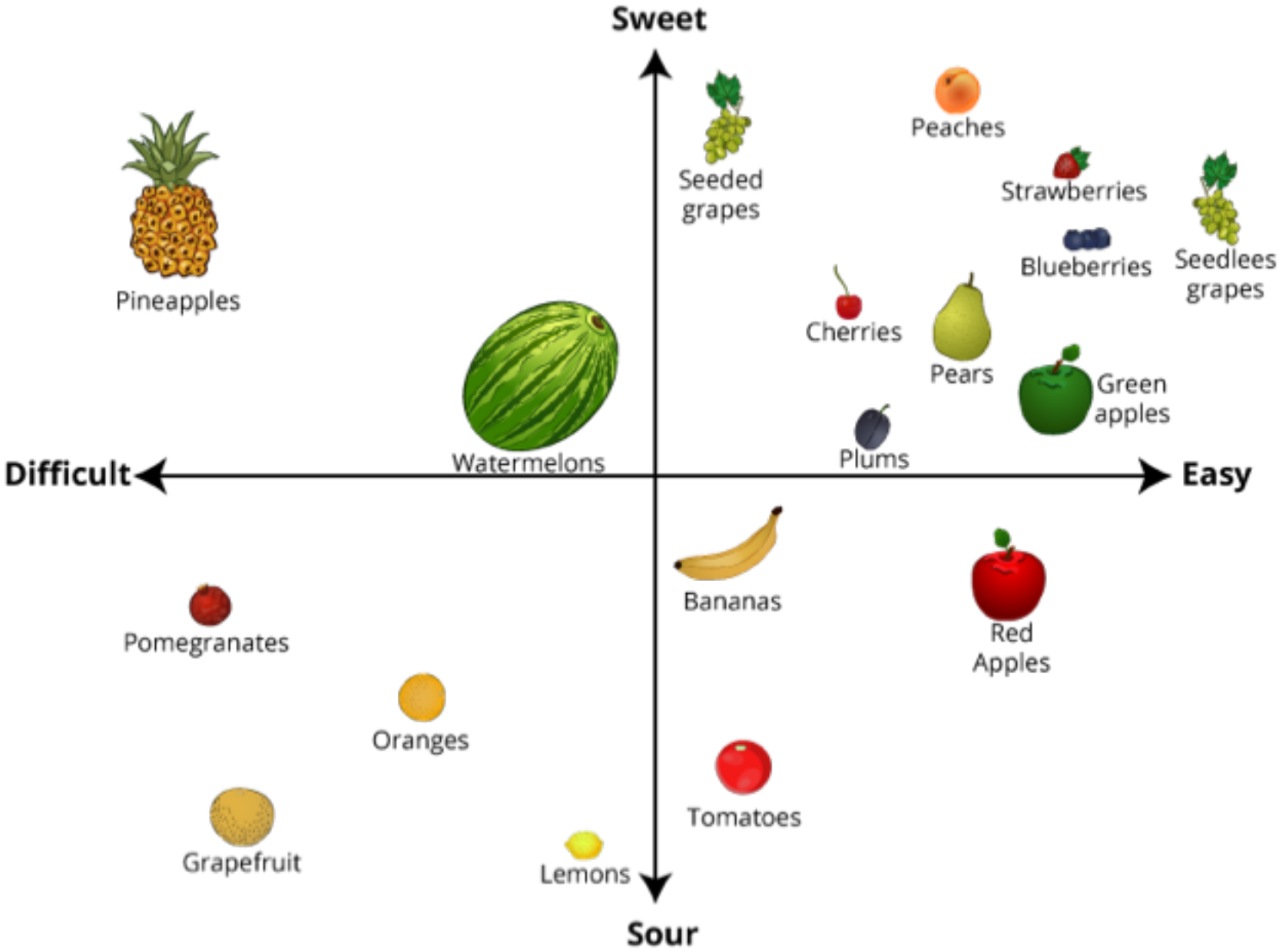
Ordination in reduced space
1.0. An introduction

Pierre Legendre
Département de sciences biologiques
Université de Montréal
http://www.NumericalEcology.com/

Ordination objective

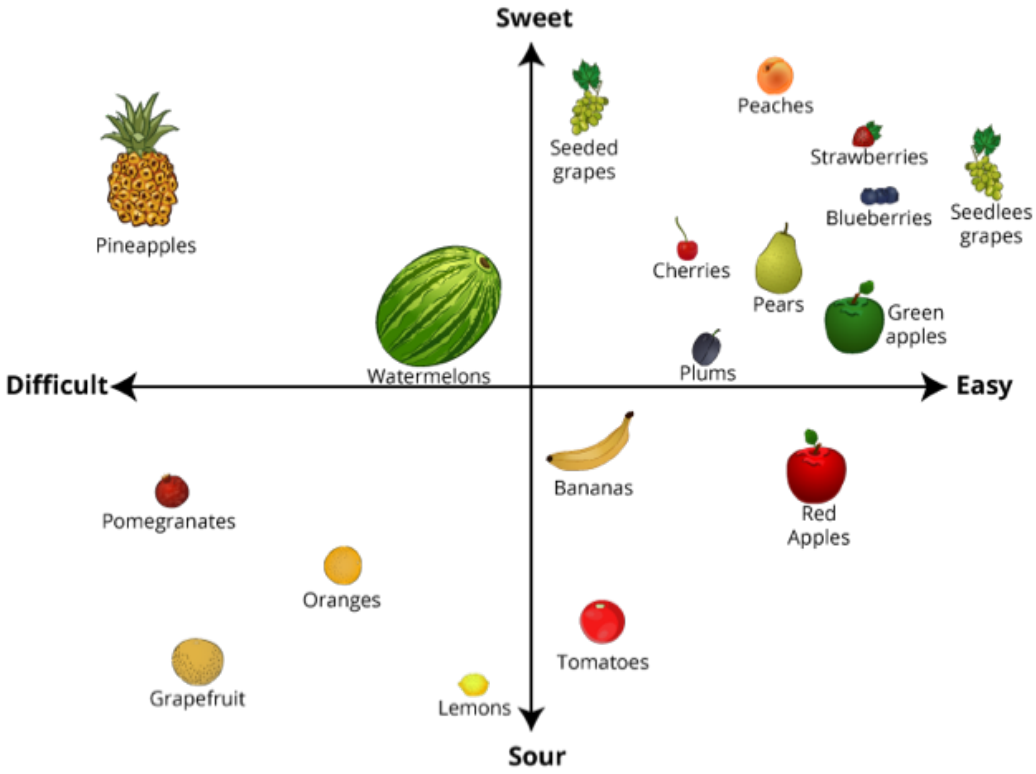
The main objective of ordination is to display the objects (which are often sampling sites in ecology) into a (multivariate) *dispersion diagram*, also called a *scatter plot*.

Here is an example of a scatterplot in 2 dimensions:



Ordination in reduced space

- The axes disperse the fruits according to identifiable criteria: easy or difficult to peel, sweet or sour taste.
- Similar fruits are together; their distances to one another are small.
- Very different fruits are far from one another; their distances are large.
- The plot is a good representation [or *model*] **of the distances** among fruits, considering the variables used for axes.



Ordination (from the Latin *ordinatio*, the action of setting in order) is the arrangement of units in some order.

The term ordination, widely used in multivariate statistics, actually comes from ecology where it refers to the representation of objects (sites, stations, relevés, etc.) as points along one or several reference axes.

David W. Goodall

➢ In 1954, the vegetation ecologist David Goodall was the first to use factor analysis in community ecology. Goodall proposed the term "ordination" to designate this type of analysis, a term now widely used in textbooks and publications in community ecology and other fields.

David Goodall was born in London on 04 April 1914. This picture shows him at his desk at Edith Cowan University in Western Australia in June 2009.

In April 2018, he turned 104 years old. He was then Australia's oldest **active** scientist. He passed away on 10 May 2018.

Web page: https://en.wikipedia.org/wiki/David_W._Goodall

Run the following R code

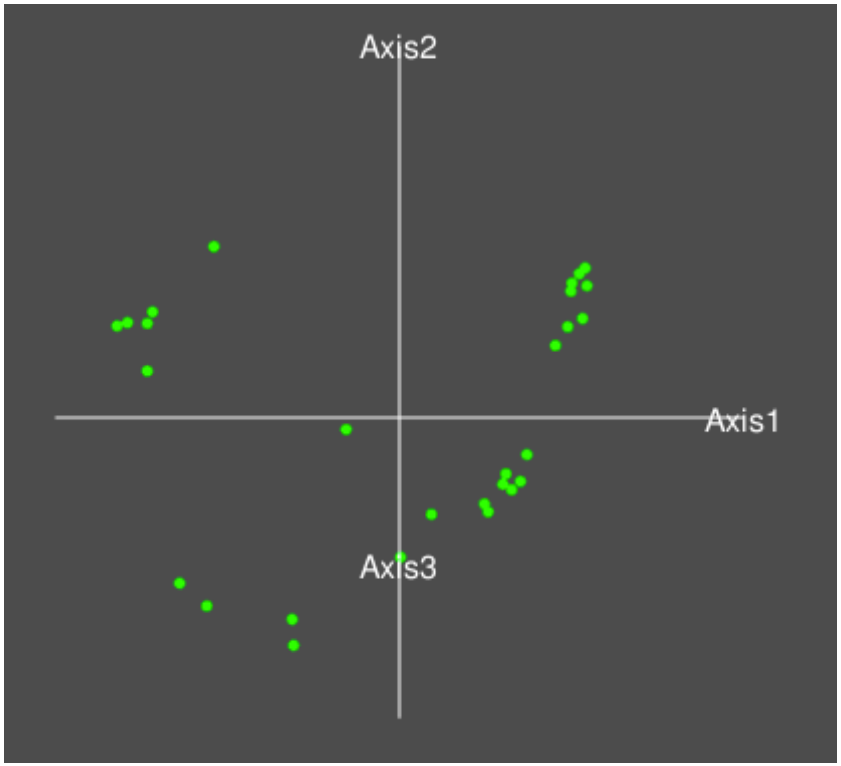
File 'Spiders_28x12_spe.txt' is one of the data files available for this course

```
spiders = read.table(file.choose())
# Hellinger transformation of the spider data
library(vegan)
spiders.hel = decostand(spiders,"hellinger")

# PCA using function prcomp() of {stats}
pca.spiders = prcomp(spiders.hel)
spiders.sites = summary(pca.spiders)$x[,1:3]

library(rgl)
rgl.open()
rgl.points(spiders.sites,color="green",size=6)

rgl.lines(x=c(-1,1),y=c(0,0),z=c(0,0))
rgl.lines(y=c(-1,1),x=c(0,0),z=c(0,0))
rgl.lines(z=c(-1,1),x=c(0,0),y=c(0,0))

rgl.texts(1,0,0,"Axis1")
rgl.texts(0,1,0,"Axis2")
rgl.texts(0,0,1,"Axis3")
```

Rotate the graph in 3-D by moving the axes

- Is there a position where the points have maximum dispersion?

- What is the statistical term for "dispersion"?




```
# What is the variance of the points along the 3 axes?
apply(spiders.sites,2,var)

# What are the first 3 eigenvalues of the PCA?
summary(pca.spiders)$sdev[1:3]^2
```

The difficulty with ecological data is that they are multivariate. Each variable represents a dimension in an ordination that would thus have many dimensions.

In ecology, several descriptors are usually observed for each object under study. – For example, hundreds of species and many environmental variables may be observed at each site.

In most instances, ecologists are interested in describing the main trends of variation of the objects with respect to all descriptors, not only a few of them.

In the Ordination chapter, I will describe the most important methods that allow us to find the projection into a space that best summarizes the data in a few dimensions, usually 2 or 3.

Four ordination methods

Method	Dissimilarity preserved	Types of variables
Principal component analysis (PCA)	Euclidean distance	Quantitative variables in linear relationships, dimensionally homogeneous or standardized
Correspondence analysis (CA)	Chi-square distance	Frequency or presence-absence data, dimensionnellement homogeneous, non-negative
Principal coordinate analysis (PCoA); classical (or metric) multidimensional scaling	Any dissimilarity measure	Quantitative, semi-quantitative, qualitative, or mixed variables
Non-metric multidimensional scaling (nMDS)	Any dissimilarity measure	Quantitative, semi-quantitative, qualitative, or mixed variables

End of section