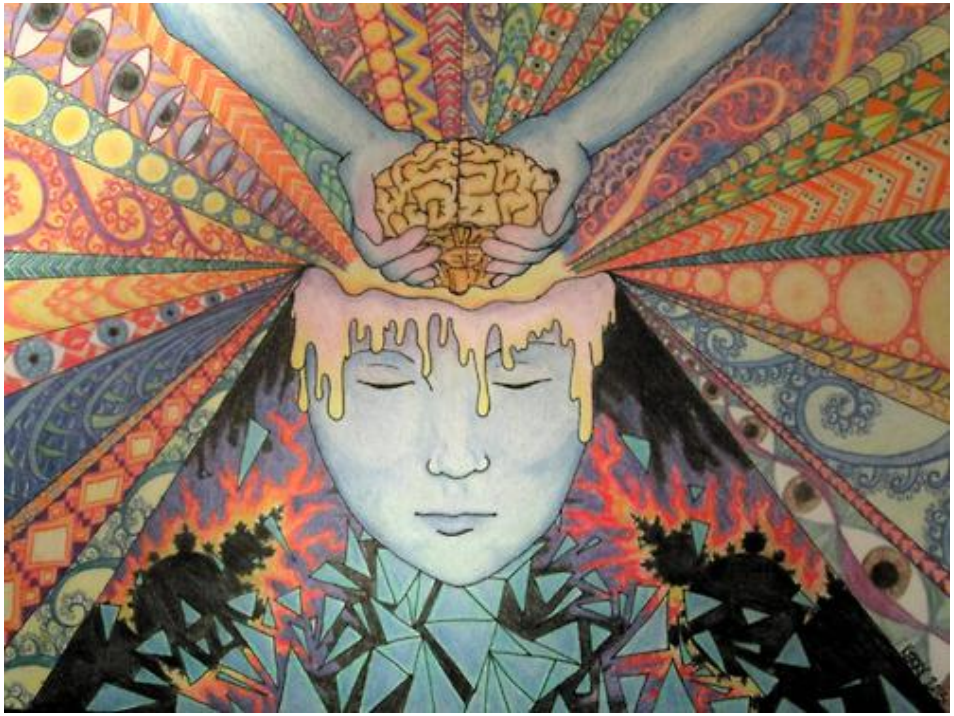
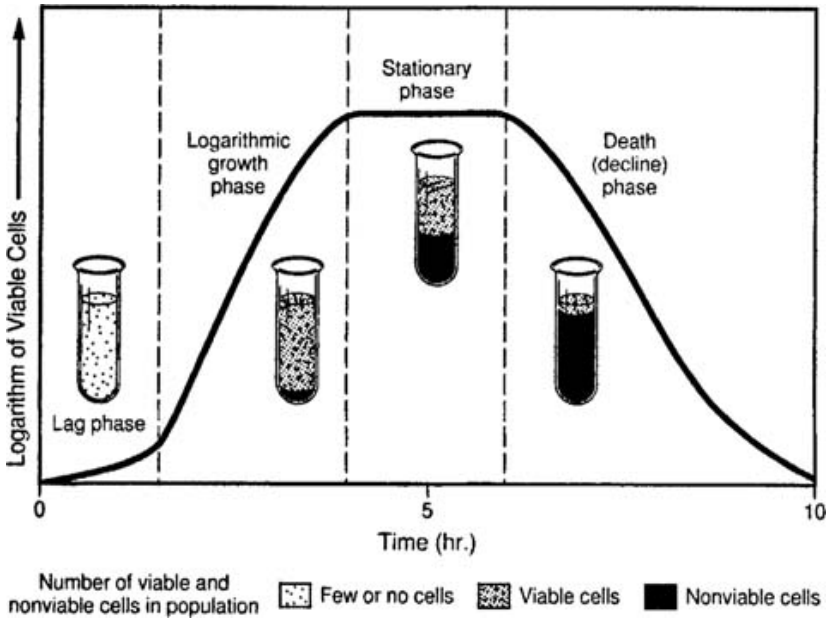
Expand your minds

Lecture 12



The relationship I would like to fit between two continuous variables is curvy!

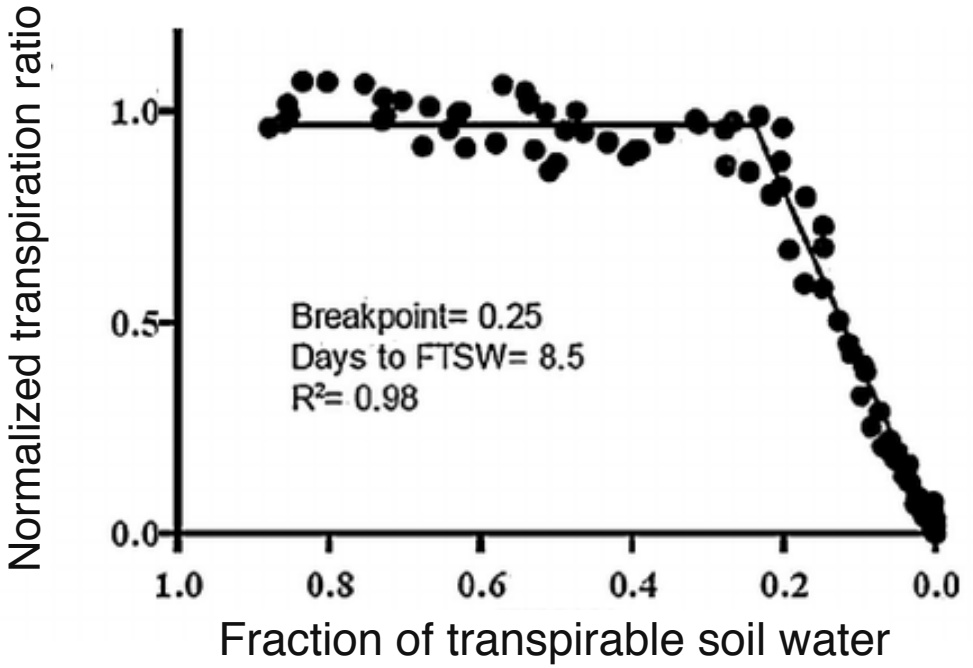


$$f(x) = \frac{L}{1 + e^{-k(x - x_0)}}$$

Nonlinear regression

`nls` (base)

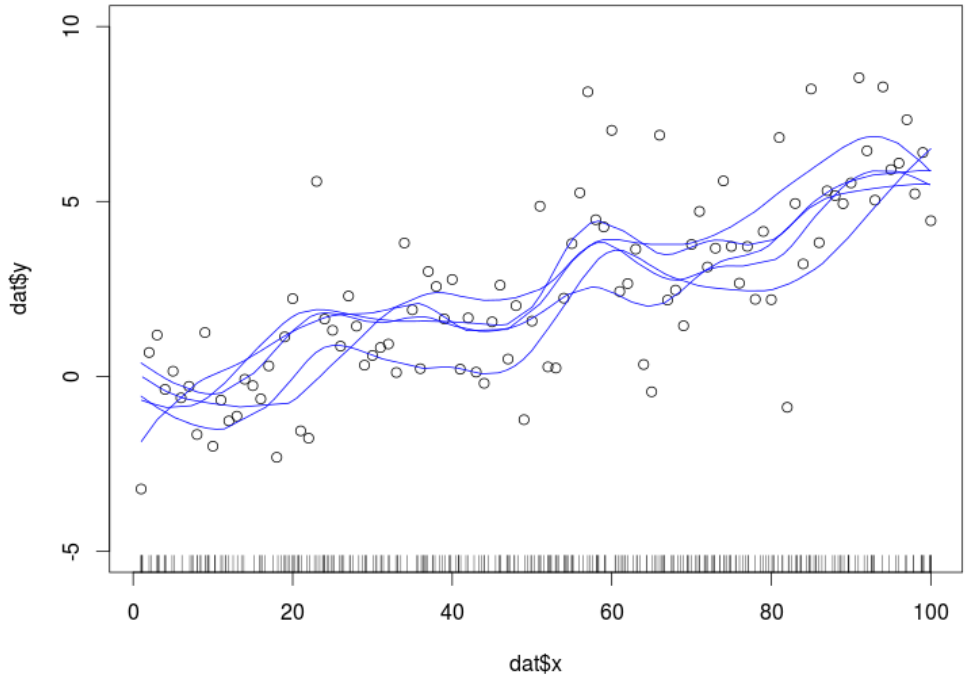
The relationship between
two continuous may have a discontinuity!



Fuentealba, M.P., Zhang, J., Kenworthy, K., Erickson, J., Kruse, J. & Trenholm, L. (2016) Transpiration responses of warm-season turfgrass in relation to progressive soil drying. Scientia Horticulturae, 198, 249–253.

Segmented / piecewise regression / breakpoint analysis
`segmented` (a package)

I don't know, and don't care what function to make between my two continuous variables, but I do want one!



Generalised additive models

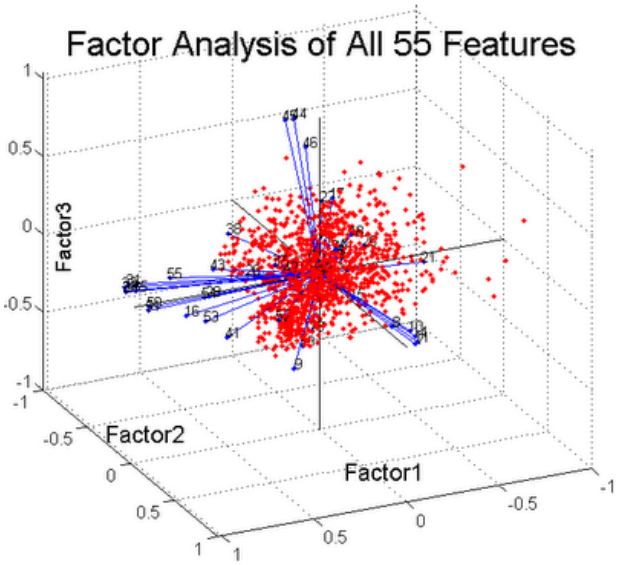
`mgcv` (a package)

I have multiple response variables!

Table 3. Results of the physico-chemical parameters and metals analysed in natural waters of the upper Rio Doce River basin (Quadrilátero Ferrífero)

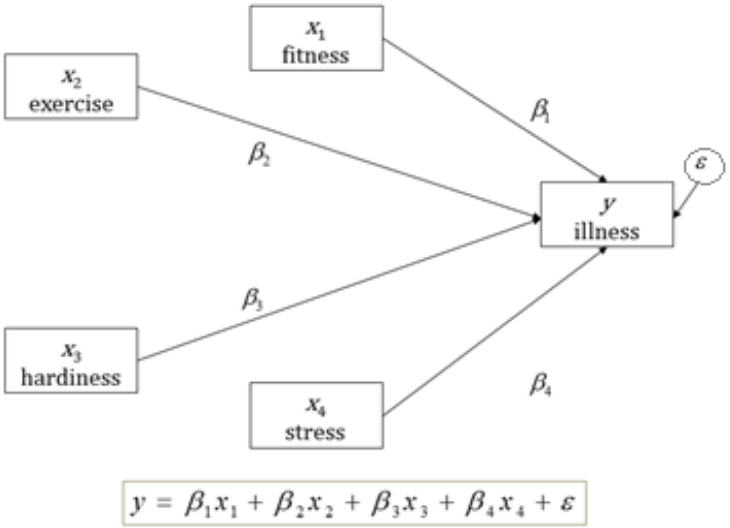
Sample	pH	DOC[a,e] / (mg L^{-1})	Temperature / °C	Alc[b,f]	Cond[g] / µS	ORP[h] / mV	Turb[i] / NTU	Resis[j] / kΩ	TDS[k] / (mg L^{-1})	Cl[a] / (mg L^{-1})	Ba[a] / (µg L^{-1})	Ca[a] / (mg L^{-1})	Fe[a] / (µg L^{-1})	K[a] / (mg L^{-1})	Mg[a] / (mg L^{-1})	Mn[a] / (µg L^{-1})	Na[a] / (mg L^{-1})	S[a] / (mg L^{-1})	Sr[a] / (µg L^{-1})
S1A	5.92	2.79	24.0	ND[c]	10.8	155	6.57	90.4	6.9	0.98	8.7	1.22	4342.0	0.98	0.16	112.6	1.3	0.34	4.8
S1B	5.30	1.40	24.1	4.3	26.8	102	4.10	39.5	15.6	4.49	1.3	0.76	253.1	0.11	0.03	32.4	0.3	0.11	2.1
S2A	6.64	2.62	25.0	ND	28.6	108	7.29	35.0	17.9	2.41	14.7	1.35	11.5	0.32	0.65	31.6	0.3	0.09	6.4
S2B	6.16	1.17	27.4	11.9	19.5	58	32.60	48.6	12.5	4.49	54.3	2.05	36.9	0.32	0.79	4.4	0.5	0.13	7.7
S2C	7.70	1.51	22.4	5.0	11.2	268	64.80	87.6	7.2	0.50	6.9	1.54	77.6	0.06	0.45	35.7	0.3	< LOQ[d]	3.1
S3A	6.33	ND	22.7	7.6	19.8	109	2.81	50.3	12.4	ND	9.9	0.83	82.2	2.50	0.25	78.7	0.6	0.17	8.8
S3B	6.29	3.88	18.0	5.0	7.8	211	3.74	98.2	6.6	ND	8.1	2.00	10.6	0.45	0.33	72.6	1.0	0.45	12.7
S4A	7.45	2.71	19.1	17.5	41.2	59	36.80	24.1	26.1	ND	7.7	2.42	68.8	0.60	1.47	9.8	1.0	0.14	11.8
S4B	6.73	0.72	16.0	18.4	39.8	207	0.99	24.9	26.4	ND	9.4	4.06	65.2	0.36	1.99	6.4	1.5	0.27	16.7
S5	7.09	1.40	24.4	6.0	7.5	79	34.30	132.1	4.7	2.66	6.7	0.52	70.5	1.90	0.15	21.7	0.4	0.07	2.1
S6	7.25	1.48	25.7	36.4	127.3	45	267.00	0.0	80.7	2.33	27.3	6.27	680.0	0.95	2.40	105.3	12.3	3.15	11.0
S7	6.89	1.38	22.2	8.9	35.5	62	279.00	28.2	22.5	0.66	20.8	2.48	356.3	1.86	0.88	234.6	2.5	0.22	4.3
S8	7.30	< 0.50	21.4	8.9	20.5	61	9.67	48.0	13.1	4.66	10.4	1.37	71.7	0.18	0.62	2.0	0.4	0.07	3.9
S9A	5.40	3.83	15.6	2.0	8.0	247	1.24	119.7	5.2	0.50	5.9	1.65	469.4	0.48	0.14	8.3	1.5	0.19	2.1
S9B	6.22	2.20	16.8	3.0	4.6	183	ND	189.9	3.0	0.75	1.3	0.30	104.0	0.12	0.14	3.9	0.3	< LOQ	0.9
S10	5.75	3.63	13.9	2.5	5.0	218	0.79	172.7	4.0	ND	6.0	0.92	119.1	0.26	0.09	5.6	1.0	0.09	2.0

[a]Standard deviation calculated by replicate analyses was less than 10%; [b]Given in mg $CaCO_3$ L^{-1}; [c]ND: Not determined; [d]LOQ: Limit of quantification; [e]DOC: dissolved organic carbon; [f]Alc: alkalinity; [g]Cond: conductivity; [h]ORP: redox potential; [i]Turb: turbidity; [j]Resis: resistivity; [k]TDS: total dissolved solids.

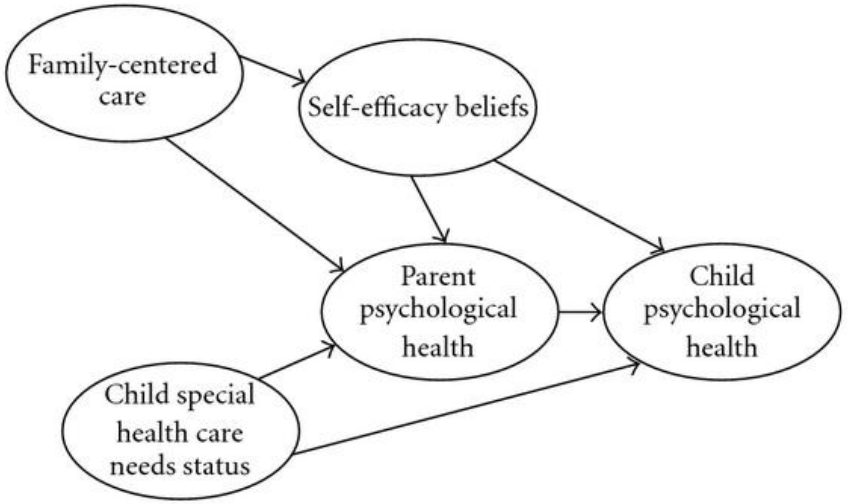


Multivariate analyses (PCA, NMDS, RDA, clustering, constrained ordination, …)
`vegan` (a package); multivariate *taskview*

I have a network / system of variables

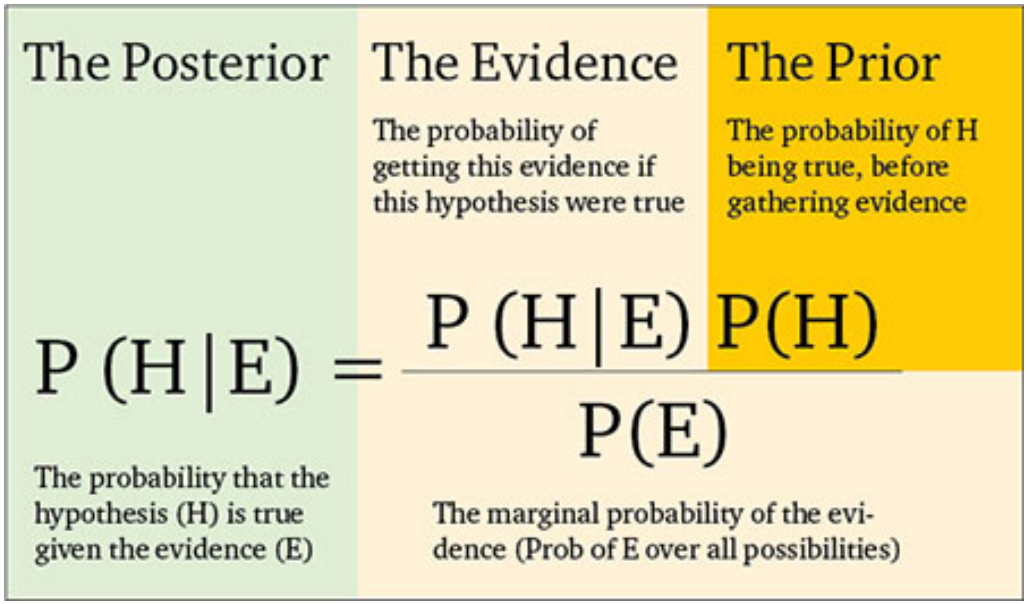


Multiple regression



Path analysis / structural equation modelling
`sem` and **`laavan`** (packages)

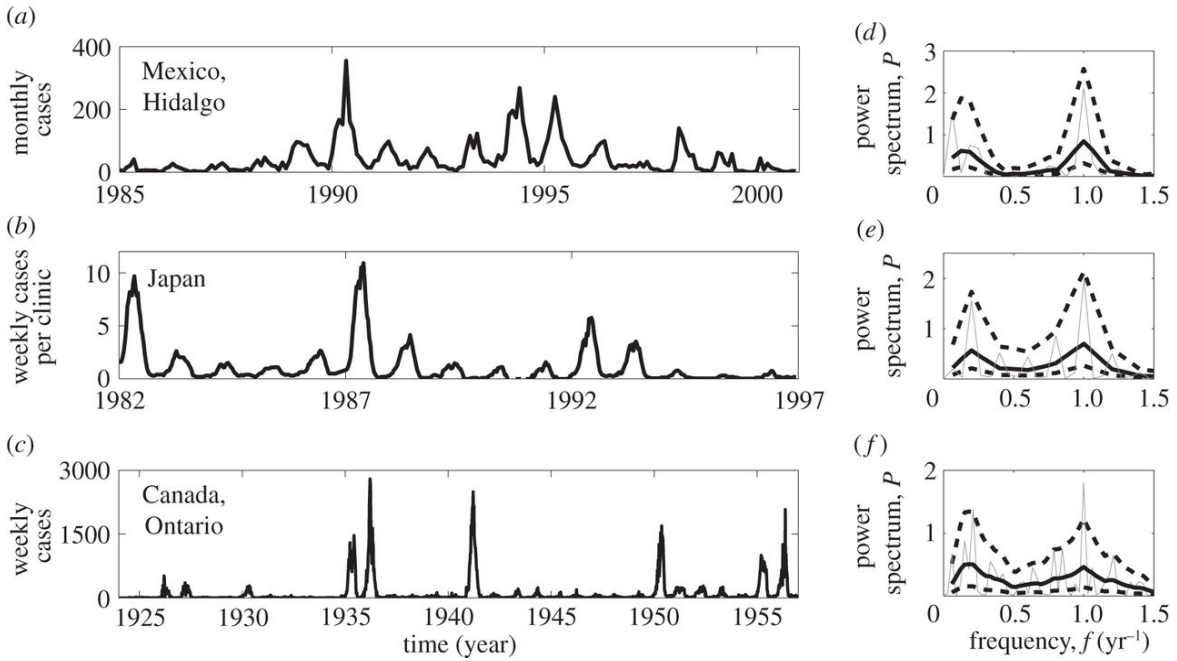
I have some prior information



Bayesian methods

`RStan` (packages) (Book: Statistical Rethinking by McElreath)

I have a series of values through time

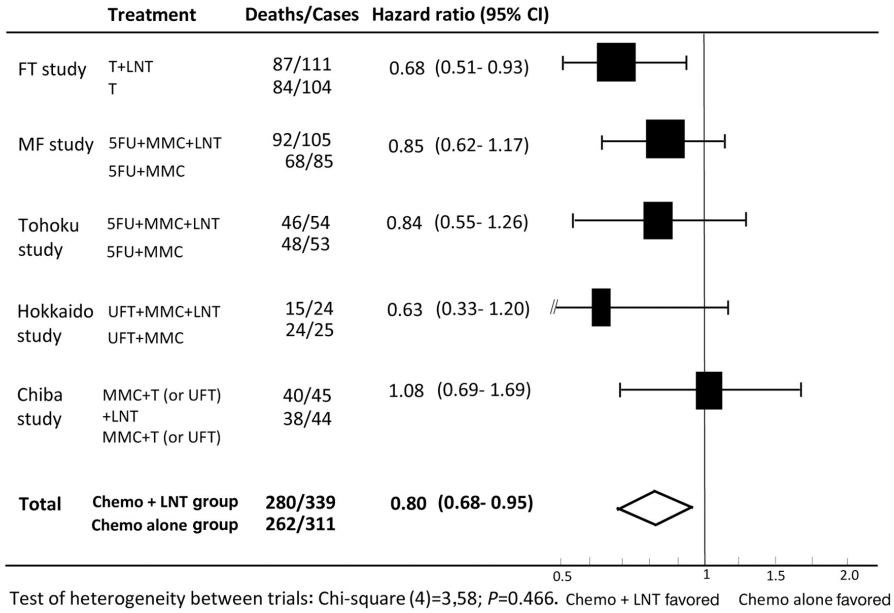


Rozhnova, G., Metcalf, C.J.E. & Grenfell, B.T. (2013) Characterizing the dynamics of rubella relative to measles: the role of stochasticity. Journal of The Royal Society Interface, 10.

Time series analyses

Many base functions (acf); `forecast`, `rEDM` packages

I’m reviewing and analysing the results of many studies



Oba, K., Kobayashi, M., Matsui, T., Kodera, Y. & Sakamoto, J. (2009) Individual patient based meta-analysis of lentinan for unresectable/ recurrent gastric cancer. Anticancer research, 29, 2739–45.

Meta-analysis
metafor package (and others)

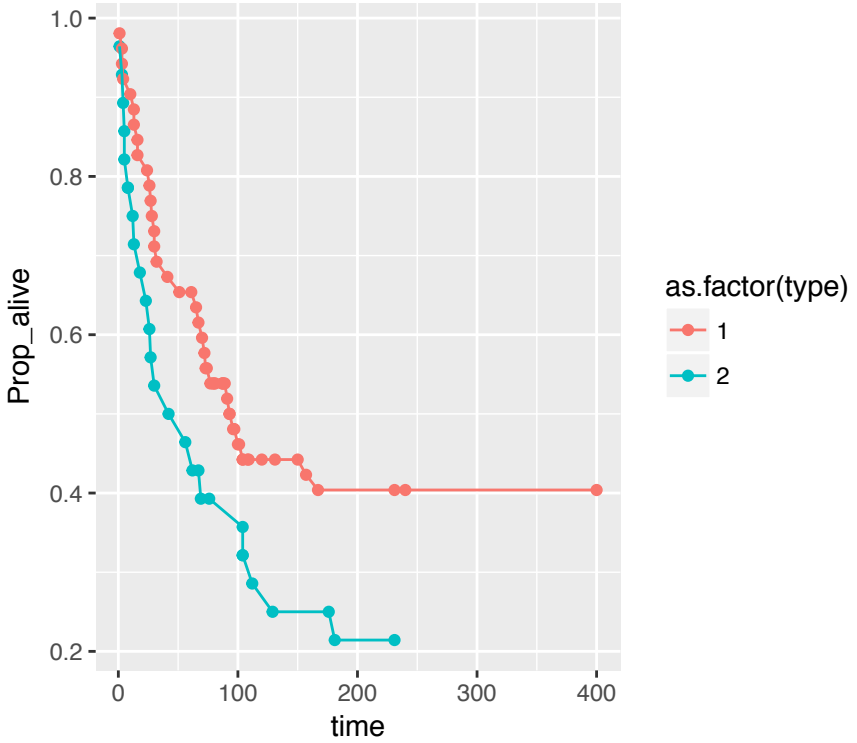
My response variable is the amount of time until something happened

type	time	delta
1	1	1
1	3	1
1	3	1
1	4	1
1	10	1
1	13	1
1	13	1
1	16	1
1	16	1
1	24	1
1	26	1
1	27	1
1	28	1
1	30	1

type
Tumor DNA profile
(1=Aneuploid Tumor, 2=Diploid Tumor)

time
Time to death or on-study time, weeks

delta
Death indicator (0=alive, 1=dead)



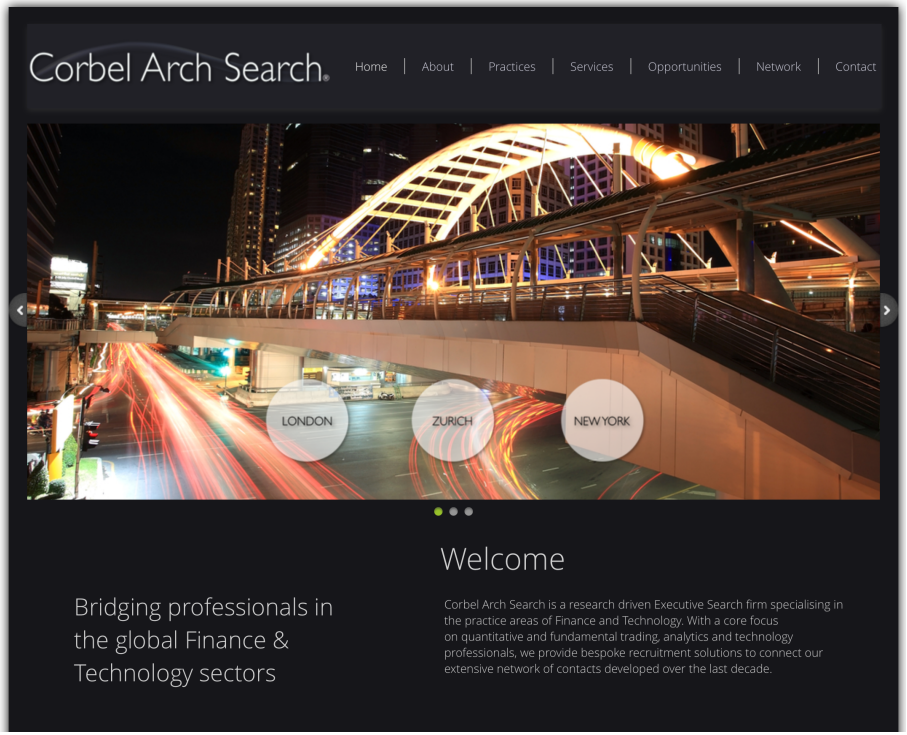
Survival analysis
`survival` package (and others)

I want to work as a data scientist / analyst and makes lots of money

The most common first job (within our recruitment area of quant trading and finance technology), after completing a Masters / PhD in a science was “quantitative researcher” or “quantitative analyst” or “data scientist” .

The most common skills required for this (and therefore possibly something to think of covering / including in the course are):

- Understanding or exposure to Machine Learning Techniques (over the past 3 years this has become a must)
- Experience working with large data sets (data manipulation and visualization)
- Experience with numerical programming in an object-oriented language is useful
- Languages: Java / C / Python (or at least one scripting language or some exposure / project with a scripting language such as Perl / Python).
- Research languages: R or Matlab
- Time series analysis and forecasting, this is very relevant for finance



Machine learning, time series analysis, forecasting

I can't fix my residuals

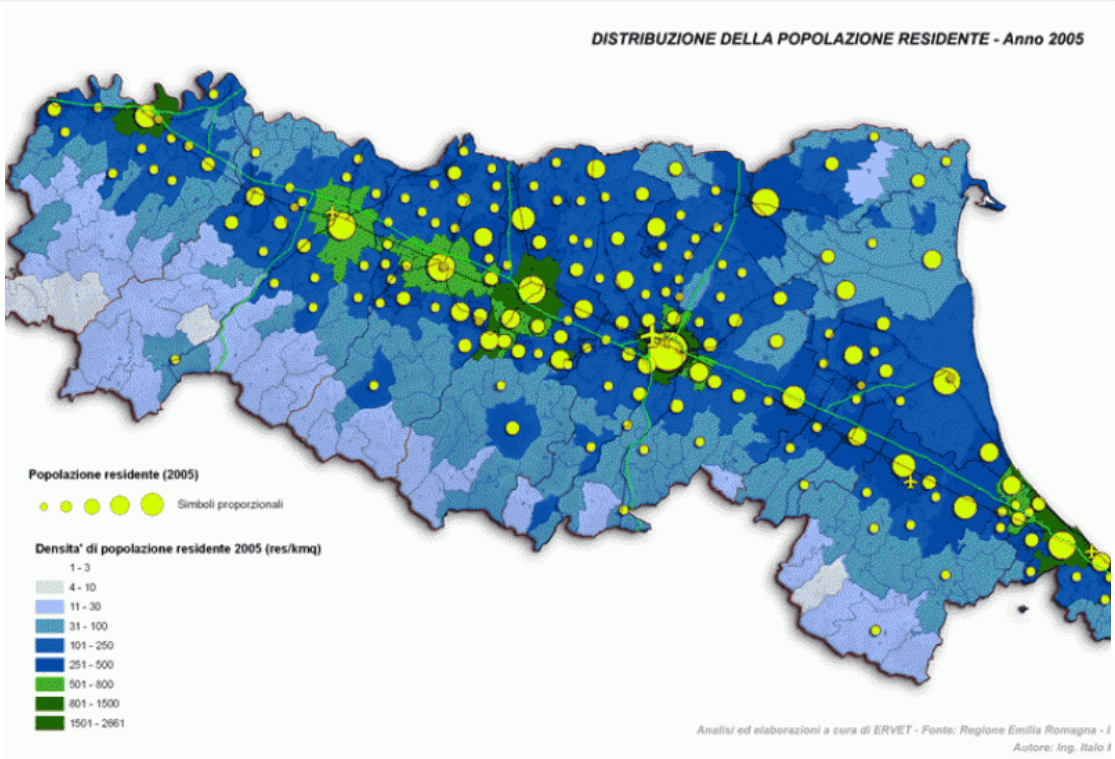
Kruskal–Wallis

Somewhat equivalent to

one-way analysis of variance

Nonparametric analysis
`base` package (and others)

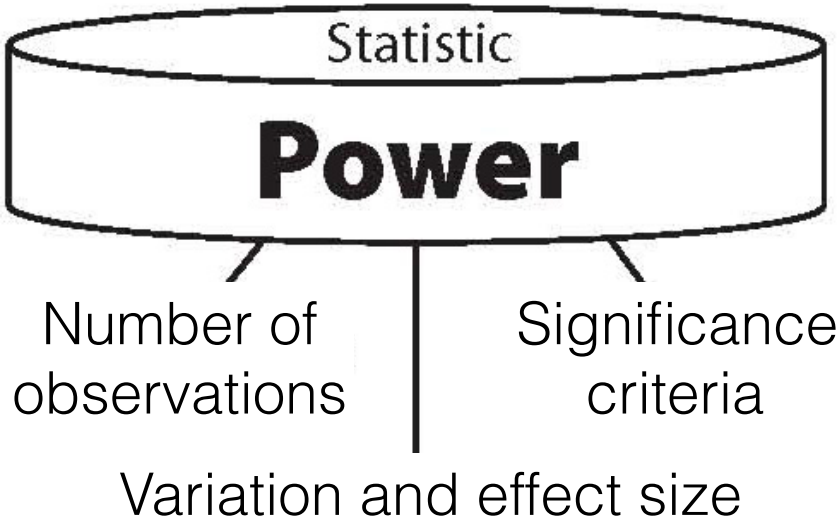
My data points are distributed in space, and I have their locations (e.g. latitude & longitude)



Spatial analysis

`spatial` taskview

I want to make sure my planned experiment has adequate statistical power



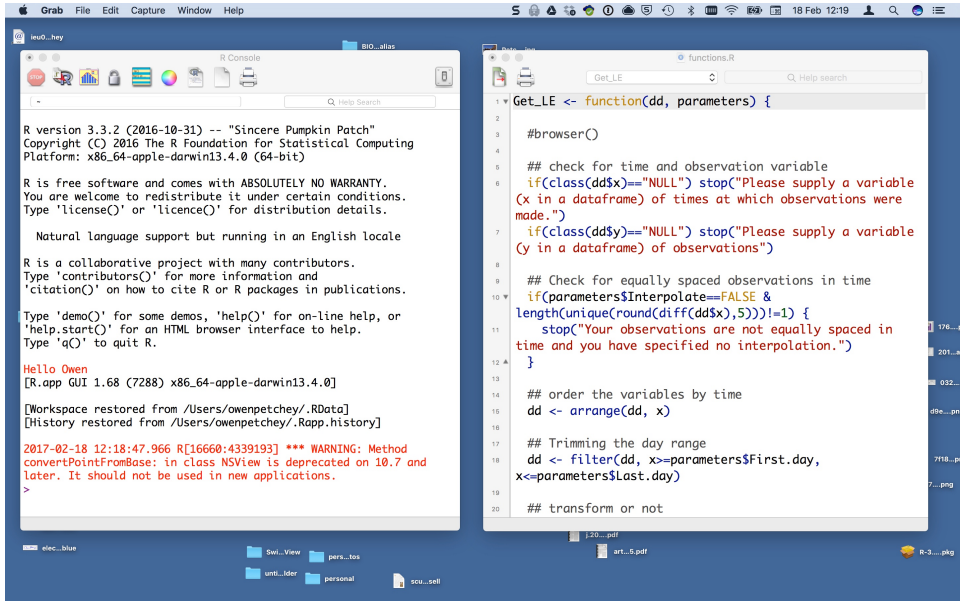
Power analysis
`pwr` package

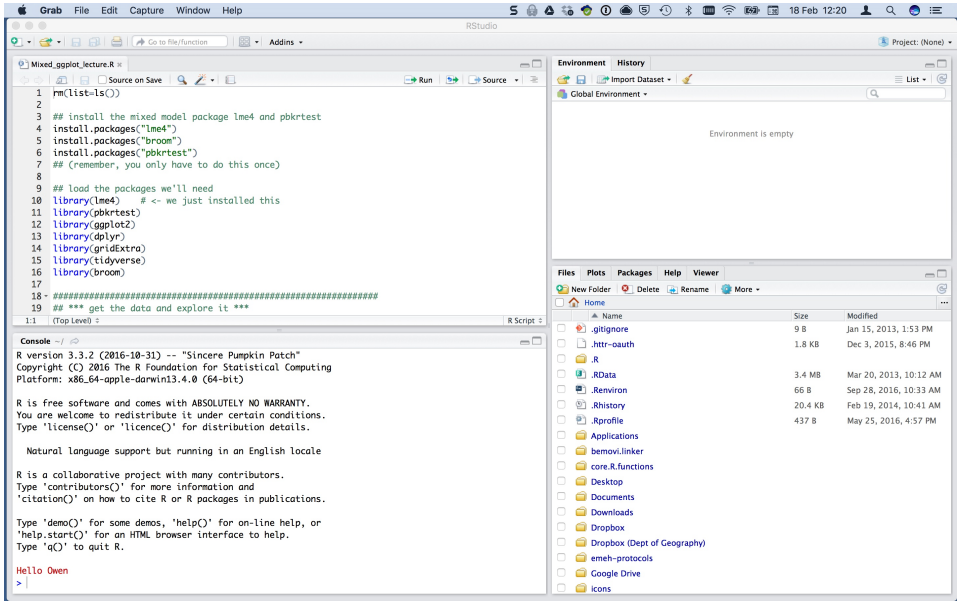
Multiple books about each

Some methods are not mutually exclusive

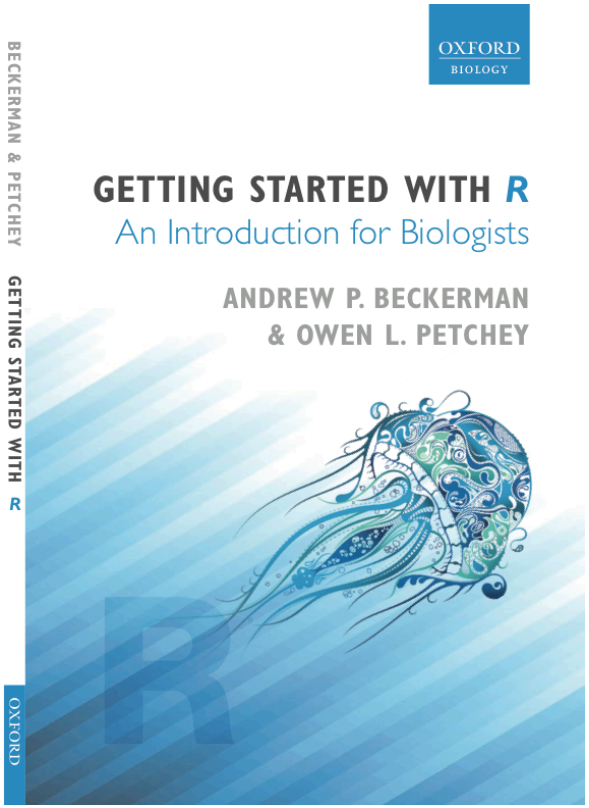
E.g. Bayesian methods can be used for most of them.

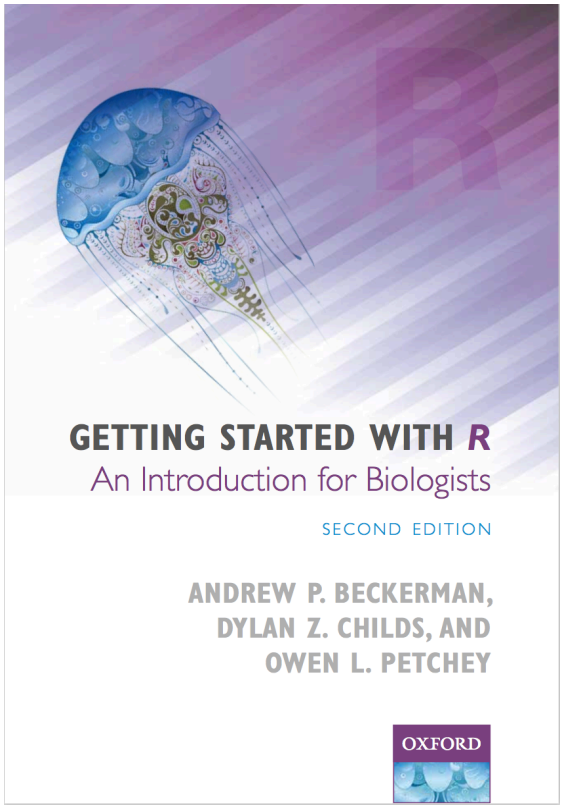
R / RStudio evolves





R / RStudio evolves

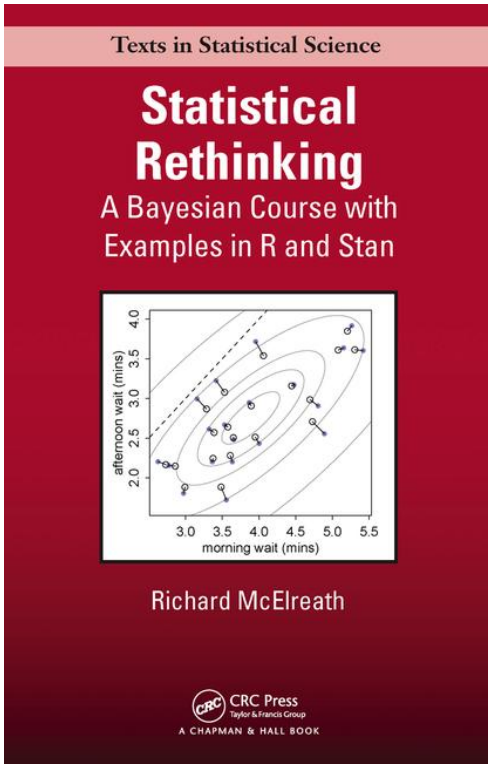


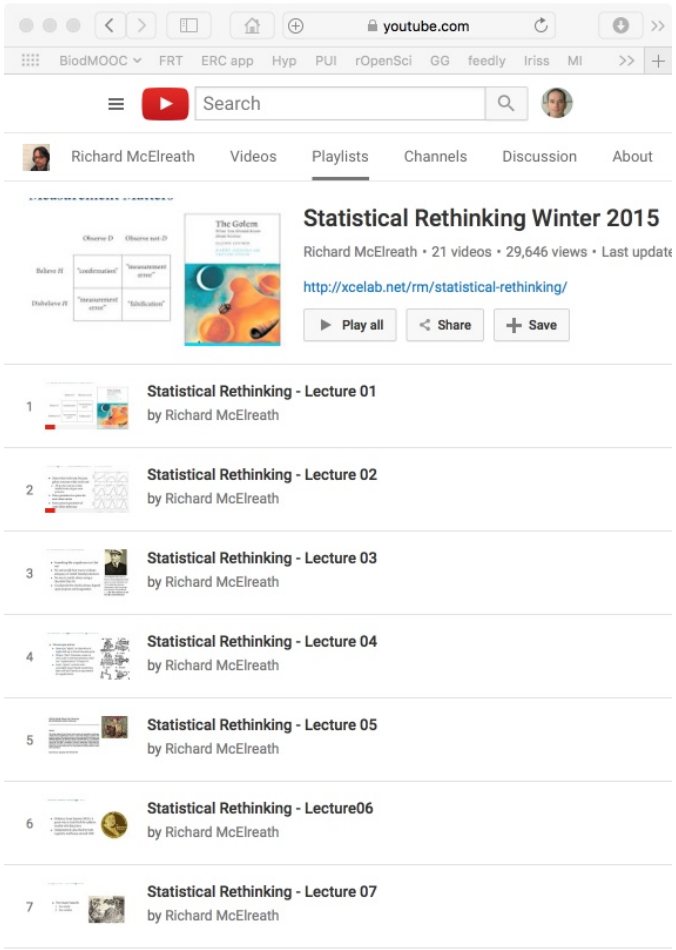


Statistical methods and thinking evolves

"There was a time in applied statistics when even ordinary multiple regression was considered cutting edge, something for only experts to fiddle with."

Multilevel Bayesian Modelling





Can all problems be solved with data and analyses?

Necessary but not sufficient