Anovas RWI Resilience

AJ Perez-Luque ((???))

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Resilience ANOVAs

- Partimos de los datos obtenidos de resiliencia para los RWI (./analysis/chronos/analysis_splines.md))

```
machine <- 'ajpelu'
# machine <- 'ajpeluLap'
di <- paste0('/Users/', machine, '/Dropbox/phd/phd_repos/qpyr_dendro/', sep = '')

# Read diameters data
re <- read.csv(file=paste0(di, 'data/resilience/resilience_rwi.csv'), header=TRUE, sep=',')
```

Asumptions

- Explorar si se cumplen los supuestos de normalidad y homocedasticidad. Tenemos que comprobar que cada uno de los grupos son normales (1995,2005,2012; site: SJ, CaH, CaL; e interactions)

Normalidad

```
normtestA <- rbind(nrcA, nrtA, nrsA, nrrsA)
normtestA %>% pander()
```

disturb_year	statistic	p_value	var
1995	0.7653	0	rc
2005	0.9625	0.1126	rc
2012	0.9435	0.01861	rc
1995	0.9857	0.799	rt
2005	0.9376	0.01082	rt
2012	0.9836	0.7114	rt
1995	0.8233	0	rs
2005	0.9683	0.1964	rs
2012	0.9264	0.00403	rs
1995	0.8238	0	rrs
2005	0.9568	0.06517	rrs
2012	0.9741	0.3383	rrs

```
write.csv(normtestA,
          file=paste0(di, '/out/anovas_resilience/rwi/normo_disturb_year.csv'), row.names = F)
```

```
normtestB <- rbind(nrcB, nrtB, nrsB, nrrsB)
normtestB %>% pander()
```

site	statistic	p_value	var
SJ	0.7237	0	rc

site	statistic	p_value	var
caH	0.8259	1e-05	rc
caL	0.8463	3e-05	rc
SJ	0.9748	0.2484	rt
caH	0.9791	0.585	rt
caL	0.9497	0.04967	rt
SJ	0.8871	5e-05	rs
caH	0.8214	1e-05	rs
caL	0.9887	0.9354	rs
SJ	0.8034	0	rrs
caH	0.9102	0.00199	rrs
caL	0.9286	0.00839	rrs

```
write.csv(normtestB,
          file=paste0(di, '/out/anovas_resilience/rwi/normo_site.csv'), row.names = F)
```

```
normtestAB <- rbind(nrcAB, nrtAB, nrsAB, nrrsAB)
normtestAB %>% pander()
```

disturb_year	site	statistic	p_value	var
1995	SJ	0.8093	0.00119	rc
1995	caH	0.9494	0.5144	rc
1995	caL	0.8885	0.06366	rc
2005	SJ	0.9814	0.9507	rc
2005	caH	0.9657	0.7896	rc
2005	caL	0.9375	0.3513	rc
2012	SJ	0.9816	0.9528	rc
2012	caH	0.9459	0.4625	rc
2012	caL	0.972	0.8863	rc
1995	SJ	0.9225	0.1106	rt
1995	caH	0.9433	0.4253	rt
1995	caL	0.9437	0.4306	rt
2005	SJ	0.8994	0.04018	rt
2005	caH	0.9703	0.8619	rt
2005	caL	0.9655	0.787	rt
2012	SJ	0.9821	0.9581	rt
2012	caH	0.9647	0.7733	rt
2012	caL	0.9698	0.8556	rt
1995	SJ	0.9439	0.2842	rs
1995	caH	0.8192	0.00655	rs
1995	caL	0.9511	0.5424	rs
2005	SJ	0.8819	0.01911	rs
2005	caH	0.9481	0.4954	rs
2005	caL	0.9484	0.4997	rs
2012	SJ	0.956	0.4677	rs
2012	caH	0.9526	0.5656	rs
2012	caL	0.9424	0.4133	rs
1995	SJ	0.8829	0.01993	rrs
1995	caH	0.8944	0.07816	rrs
1995	caL	0.9315	0.2876	rrs
2005	SJ	0.9236	0.1165	rrs
2005	caH	0.9489	0.5077	rrs

disturb_year	site	statistic	p_value	var
2005	caL	0.9433	0.4261	rrs
2012	SJ	0.9577	0.4987	rrs
2012	caH	0.8702	0.03399	rrs
2012	caL	0.982	0.9814	rrs

```
write.csv(normtestAB,
          file=paste0(di, '/out/anovas_resilience/rwi/normo_disturb_year_site.csv'), row.names = F)
```

```
# rm(nrcA, nrcB, nrcAB,
#    nrsA, nrsB, nrsAB,
#    nrrsA, nrrsB, nrrsAB,
#    nrtA, nrtB, nrtAB)
```

- No se cumplen los requisitos de normalidad

Heterocedasticidad

fk_stat	fk_pvalue	lev_stat	lev_pvalue	factor	response
26.4	1.854e-06	16.02	5.1e-07	disturb_year	rs
39.2	3.081e-09	20.94	9.973e-09	site	rs
47.55	1.202e-07	11.46	1.931e-12	interaction(disturb_year, site)	rs
38.67	4.012e-09	15.67	6.769e-07	disturb_year	rc
9.58	0.008314	4.701	0.0105	site	rc
51	2.618e-08	7.717	1.504e-08	interaction(disturb_year, site)	rc
24.99	3.736e-06	15.54	7.545e-07	disturb_year	rt
2.391	0.3026	1.205	0.3027	site	rt
12.26	0.1401	1.512	0.158	interaction(disturb_year, site)	rt
32.75	7.745e-08	17.03	2.223e-07	disturb_year	rrs
8.853	0.01196	6.114	0.002814	site	rrs
45.97	2.41e-07	10.33	2.621e-11	interaction(disturb_year, site)	rrs

- Tampoco se cumplen los requisitos de homogeneidad de varianzas entre grupos

Transformación datos

Log

- Probamos a transformar los datos con log y reanalizar los supuestos de homocedasticidad

fk_stat	fk_pvalue	lev_stat	lev_pvalue	factor	response
17.93	0.0001276	9.613	0.0001193	disturb_year	logrs
36.16	1.404e-08	28.41	3.711e-11	site	logrs
27.17	0.0006601	4.159	0.0001728	interaction(disturb_year, site)	logrs

fk_stat	fk_pvalue	lev_stat	lev_pvalue	factor	response
9.209	0.01001	6.175	0.002661	disturb_year	logrc
3.358	0.1866	1.978	0.1421	site	logrc
22.51	0.004058	3.766	0.0004995	interaction(disturb_year, site)	logrc
9.209	0.01001	6.175	0.002661	disturb_year	logrt
3.358	0.1866	1.978	0.1421	site	logrt
22.51	0.004058	3.766	0.0004995	interaction(disturb_year, site)	logrt
2.543	0.2804	1.734	0.1821	disturb_year	logrrs
2.425	0.2975	0.7345	0.4824	site	logrrs
11.49	0.1754	1.768	0.09388	interaction(disturb_year, site)	logrrs

- Tampoco se cumplen

ANOVAS

- Utilizamos una custom function

OJO SOLO 2005 y 2012

```
# Only 2005 and 2012
re <- re %>% filter(disturb_year != 1995) %>% as.data.frame()
vars <- c('disturb_year','site')
re$disturb_year <- factor(re$disturb_year)
```

Recovery

Table 6: ANOVA table: rc

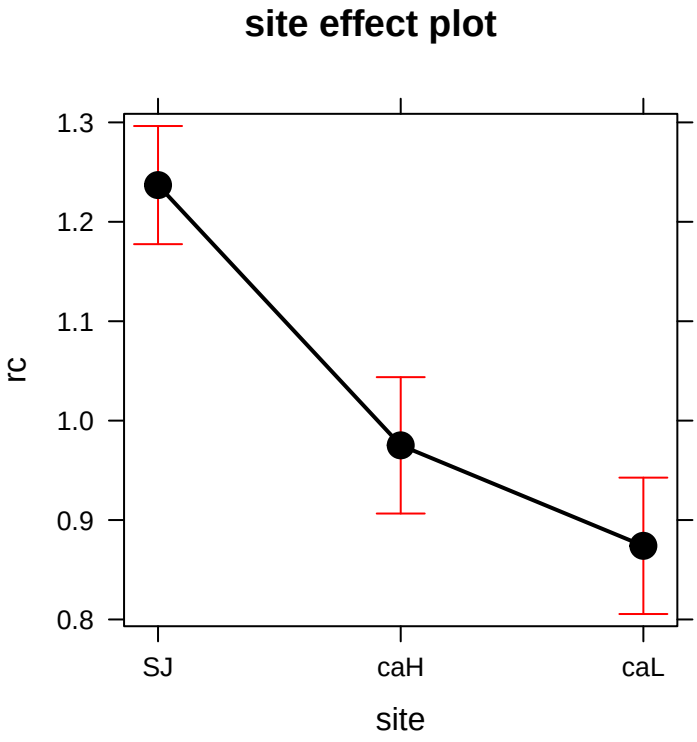
term	df	sumsq	meansq	statistic	p.value
disturb_year	1	1.373	1.373	38.33	**0**
site	2	2.495	1.247	34.83	**0**
disturb_year:site	2	0.1717	0.08587	2.398	**0.09646**
Residuals	94	3.366	0.03581		

	Statistic
R^2	0.55
adjR^2	0.52
σ_e	0.19
F	22.56
p	0.00
df_m	6.00
logLik	27.67
AIC	-41.35
BIC	-23.11
dev	3.37
df_e	94.00

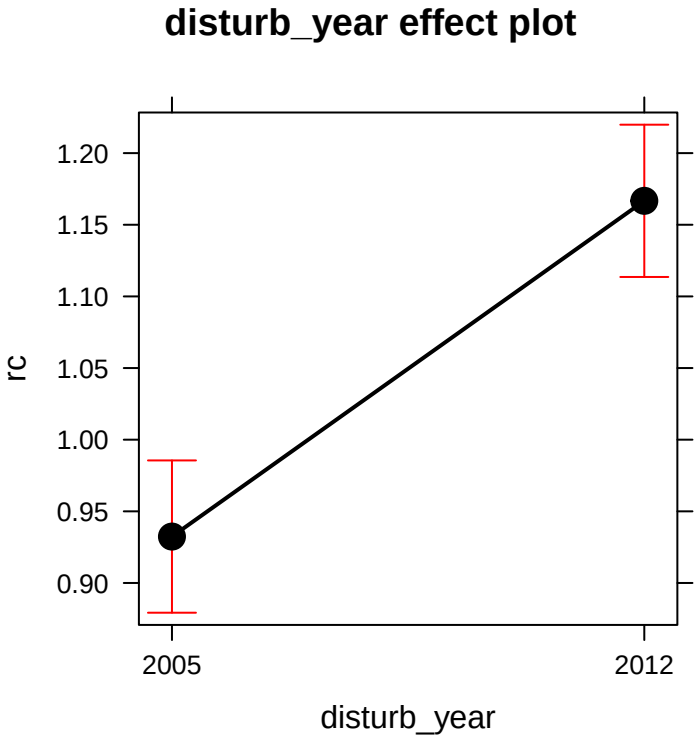
```r
# Post hoc Define model
mymodel <- aov_rc$mymodel
postH_rc <- phc(mymodel = mymodel, resp_var = resp_var)
```

```
##
## ### Event ###
## $lsmeans
##  disturb_year    lsmean         SE df  lower.CL  upper.CL
##  2005         0.9166547 0.02700904 94 0.8630276 0.9702817
##  2012         1.1407760 0.02700904 94 1.0871489 1.1944031
##
## Results are averaged over the levels of: site
## Confidence level used: 0.95
##
## $contrasts
##  contrast      estimate         SE df t.ratio p.value
##  2005 - 2012 -0.2241213 0.03819655 94  -5.868  <.0001
##
## Results are averaged over the levels of: site
##
##  disturb_year    lsmean         SE df  lower.CL  upper.CL .group
##  2005         0.9166547 0.02700904 94 0.8551315 0.9781778  a
##  2012         1.1407760 0.02700904 94 1.0792529 1.2022992   b
##
## Results are averaged over the levels of: site
## Confidence level used: 0.95
## Conf-level adjustment: bonferroni method for 2 estimates
## significance level used: alpha = 0.01
##
## ### Clu pop ###
## $lsmeans
##  site    lsmean         SE df  lower.CL  upper.CL
##  SJ   1.2369397 0.02992124 94 1.1775304 1.2963491
##  caH  0.9751421 0.03455008 94 0.9065421 1.0437421
##  caL  0.8740642 0.03455008 94 0.8054642 0.9426642
##
## Results are averaged over the levels of: disturb_year
## Confidence level used: 0.95
##
## $contrasts
##  contrast   estimate         SE df t.ratio p.value
##  SJ - caH  0.2617976 0.04570546 94   5.728  <.0001
##  SJ - caL  0.3628756 0.04570546 94   7.939  <.0001
##  caH - caL 0.1010779 0.04886119 94   2.069  0.1240
##
## Results are averaged over the levels of: disturb_year
## P value adjustment: bonferroni method for 3 tests
##
##  site    lsmean         SE df  lower.CL  upper.CL .group
##  caL  0.8740642 0.03455008 94 0.7898457 0.9582827  a
##  caH  0.9751421 0.03455008 94 0.8909236 1.0593606  a
##  SJ   1.2369397 0.02992124 94 1.1640044 1.3098751   b
##
```

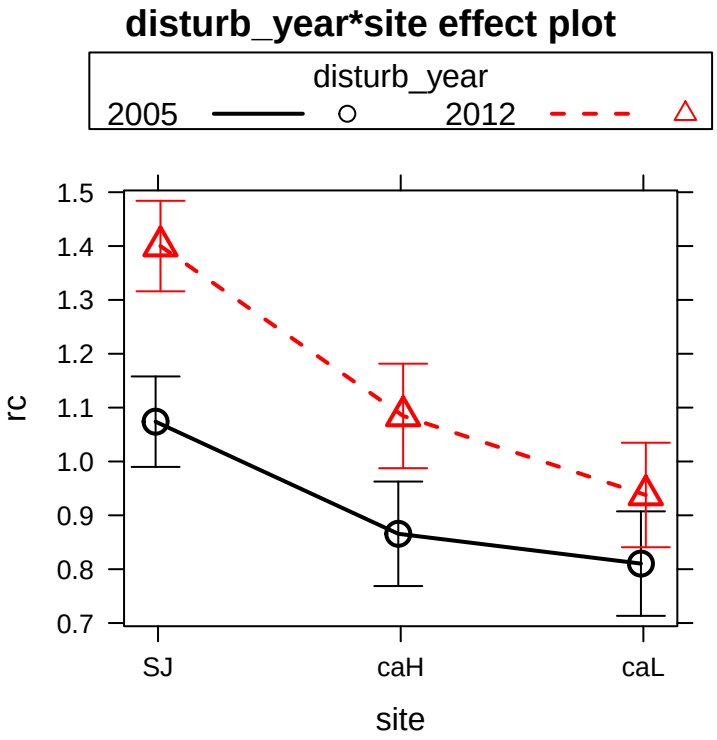
```
## Results are averaged over the levels of: disturb_year
## Confidence level used: 0.95
## Conf-level adjustment: bonferroni method for 3 estimates
## P value adjustment: bonferroni method for 3 tests
## significance level used: alpha = 0.01
##
## ### Event:Clu pop ###
## $lsmeans
##  disturb_year site    lsmean         SE df  lower.CL  upper.CL
##  2005         SJ   1.0738954 0.04231503 94 0.9898780 1.1579129
##  2012         SJ   1.3999840 0.04231503 94 1.3159665 1.4840015
##  2005         caH  0.8657062 0.04886119 94 0.7686911 0.9627212
##  2012         caH  1.0845780 0.04886119 94 0.9875630 1.1815931
##  2005         caL  0.8103624 0.04886119 94 0.7133474 0.9073774
##  2012         caL  0.9377660 0.04886119 94 0.8407509 1.0347810
##
## Confidence level used: 0.95
##
## $contrasts
##  contrast               estimate         SE df t.ratio p.value
##  2005,SJ - 2012,SJ   -0.32608857 0.05984249 94  -5.449  <.0001
##  2005,SJ - 2005,caH   0.20818928 0.06463727 94   3.221  0.0263
##  2005,SJ - 2012,caH  -0.01068260 0.06463727 94  -0.165  1.0000
##  2005,SJ - 2005,caL   0.26353305 0.06463727 94   4.077  0.0014
##  2005,SJ - 2012,caL   0.13612948 0.06463727 94   2.106  0.5680
##  2012,SJ - 2005,caH   0.53427785 0.06463727 94   8.266  <.0001
##  2012,SJ - 2012,caH   0.31540598 0.06463727 94   4.880  0.0001
##  2012,SJ - 2005,caL   0.58962163 0.06463727 94   9.122  <.0001
##  2012,SJ - 2012,caL   0.46221805 0.06463727 94   7.151  <.0001
##  2005,caH - 2012,caH -0.21887188 0.06910015 94  -3.167  0.0311
##  2005,caH - 2005,caL  0.05534377 0.06910015 94   0.801  1.0000
##  2005,caH - 2012,caL -0.07205980 0.06910015 94  -1.043  1.0000
##  2012,caH - 2005,caL  0.27421565 0.06910015 94   3.968  0.0021
##  2012,caH - 2012,caL  0.14681208 0.06910015 94   2.125  0.5436
##  2005,caL - 2012,caL -0.12740357 0.06910015 94  -1.844  1.0000
##
## P value adjustment: bonferroni method for 15 tests
ps
```



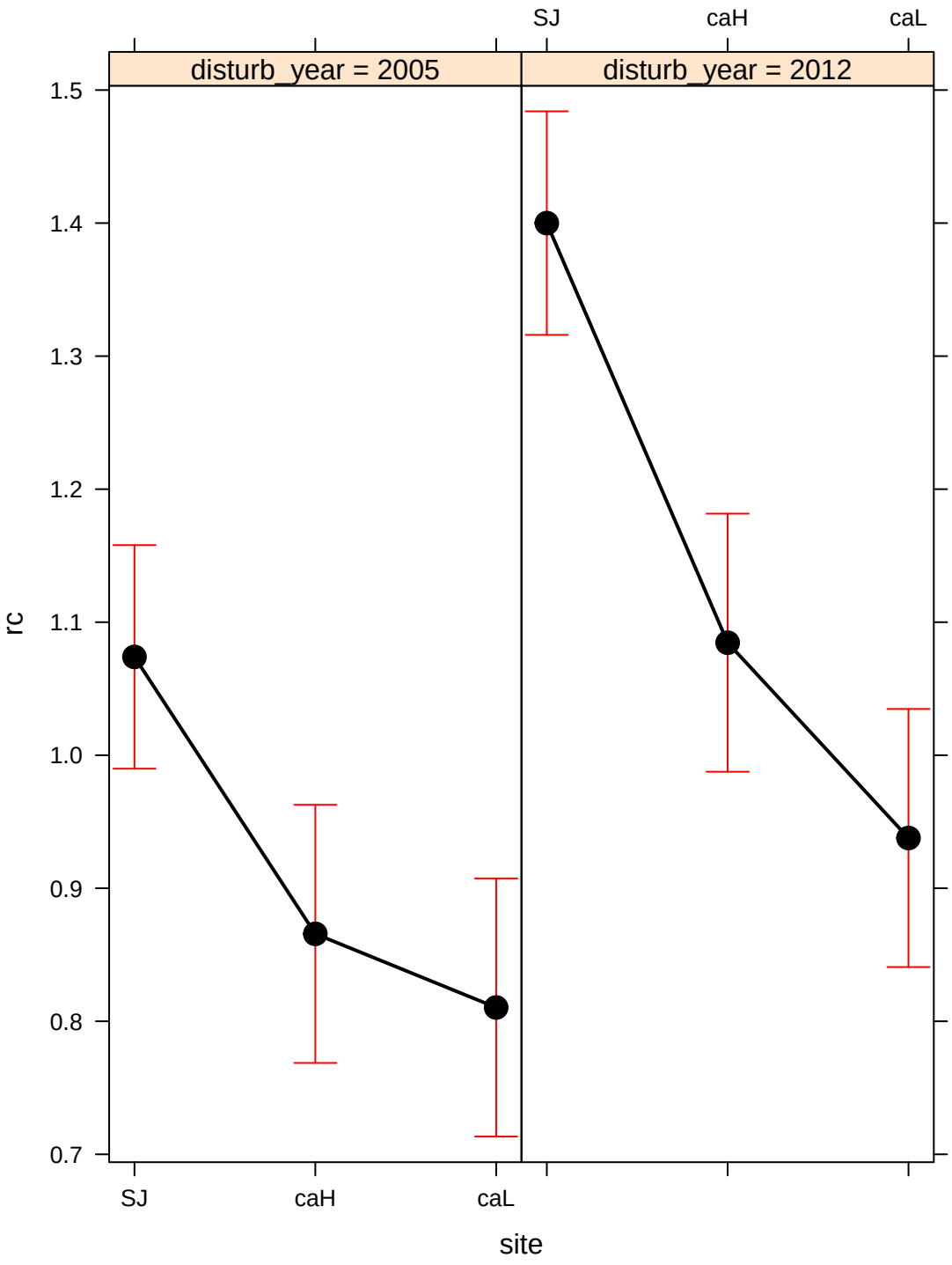

```
pd
```




```
picollapse
```


disturb_year*site effect plot
disturb_year
2005
2012
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
rc
SJ
caH
caL
site

```
pi
```


disturb_year*site effect plot
SJ
caH
caL
disturb_year = 2005
disturb_year = 2012
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
rc
SJ
caH
caL
site

Resistance

Table 8: ANOVA table: rt

term	df	sumsq	meansq	statistic	p.value
disturb_year	1	0.2085	0.2085	9.792	**0.00233**
site	2	1.527	0.7637	35.86	**0**
disturb_year:site	2	0.7454	0.3727	17.5	**0**
Residuals	94	2.002	0.02129		

	Statistic
R^2	0.55
adjR^2	0.53
σ_e	0.15
F	23.30
p	0.00
df_m	6.00
logLik	53.66
AIC	-93.33
BIC	-75.09
dev	2.00
df_e	94.00

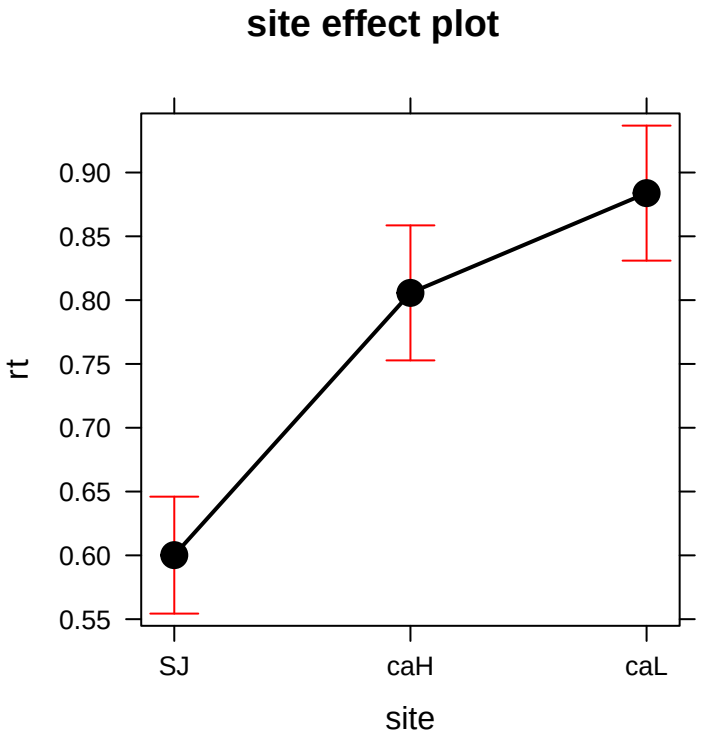
```
# Post hoc Define model
mymodel <- aov_rt$mymodel
postH_rt <- phc(mymodel = mymodel, resp_var = resp_var)
```

```
##
## ### Event ###
## $lsmeans
##  disturb_year    lsmean         SE df  lower.CL  upper.CL
##  2005         0.7285968 0.02082753 94 0.6872433 0.7699504
##  2012         0.7978604 0.02082753 94 0.7565069 0.8392140
##
## Results are averaged over the levels of: site
## Confidence level used: 0.95
##
## $contrasts
##  contrast       estimate         SE df t.ratio p.value
##  2005 - 2012 -0.06926357 0.02945458 94  -2.352  0.0208
##
## Results are averaged over the levels of: site
##
##  disturb_year    lsmean         SE df  lower.CL  upper.CL .group
##  2005         0.7285968 0.02082753 94 0.6811544 0.7760393  a
##  2012         0.7978604 0.02082753 94 0.7504179 0.8453029  a
##
## Results are averaged over the levels of: site
## Confidence level used: 0.95
## Conf-level adjustment: bonferroni method for 2 estimates
## significance level used: alpha = 0.01
##
## ### Clu pop ###
```

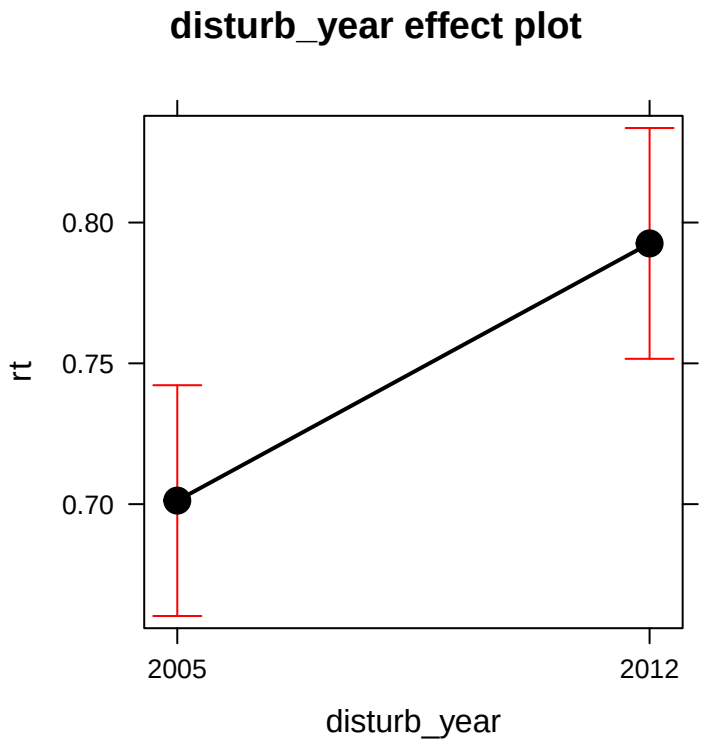
```
## $lsmeans
##  site    lsmean         SE df  lower.CL  upper.CL
##  SJ   0.6001707 0.02307323 94 0.5543583 0.6459832
##  caH  0.8056734 0.02664267 94 0.7527738 0.8585731
##  caL  0.8838417 0.02664267 94 0.8309420 0.9367413
##
## Results are averaged over the levels of: disturb_year
## Confidence level used: 0.95
##
## $contrasts
##  contrast     estimate         SE df t.ratio p.value
##  SJ - caH  -0.20550269 0.03524493 94  -5.831  <.0001
##  SJ - caL  -0.28367091 0.03524493 94  -8.049  <.0001
##  caH - caL -0.07816823 0.03767842 94  -2.075  0.1223
##
## Results are averaged over the levels of: disturb_year
## P value adjustment: bonferroni method for 3 tests
##
##  site    lsmean         SE df  lower.CL  upper.CL .group
##  SJ   0.6001707 0.02307323 94 0.5439280 0.6564135  a
##  caH  0.8056734 0.02664267 94 0.7407299 0.8706170   b
##  caL  0.8838417 0.02664267 94 0.8188981 0.9487852   b
##
## Results are averaged over the levels of: disturb_year
## Confidence level used: 0.95
## Conf-level adjustment: bonferroni method for 3 estimates
## P value adjustment: bonferroni method for 3 tests
## significance level used: alpha = 0.01
##
## ### Event:Clu pop ###
## $lsmeans
##  disturb_year site    lsmean         SE df  lower.CL  upper.CL
##  2005         SJ   0.4552091 0.03263047 94 0.3904205 0.5199976
##  2012         SJ   0.7451324 0.03263047 94 0.6803439 0.8099210
##  2005         caH  0.8645179 0.03767842 94 0.7897065 0.9393293
##  2012         caH  0.7468290 0.03767842 94 0.6720176 0.8216404
##  2005         caL  0.8660635 0.03767842 94 0.7912521 0.9408749
##  2012         caL  0.9016198 0.03767842 94 0.8268084 0.9764312
##
## Confidence level used: 0.95
##
## $contrasts
##  contrast                estimate         SE df t.ratio p.value
##  2005,SJ - 2012,SJ   -0.289923388 0.04614645 94  -6.283  <.0001
##  2005,SJ - 2005,caH  -0.409308846 0.04984386 94  -8.212  <.0001
##  2005,SJ - 2012,caH  -0.291619920 0.04984386 94  -5.851  <.0001
##  2005,SJ - 2005,caL  -0.410854480 0.04984386 94  -8.243  <.0001
##  2005,SJ - 2012,caL  -0.446410736 0.04984386 94  -8.956  <.0001
##  2012,SJ - 2005,caH  -0.119385458 0.04984386 94  -2.395  0.2789
##  2012,SJ - 2012,caH  -0.001696532 0.04984386 94  -0.034  1.0000
##  2012,SJ - 2005,caL  -0.120931092 0.04984386 94  -2.426  0.2575
##  2012,SJ - 2012,caL  -0.156487348 0.04984386 94  -3.140  0.0339
##  2005,caH - 2012,caH  0.117688926 0.05328533 94   2.209  0.4444
##  2005,caH - 2005,caL -0.001545634 0.05328533 94  -0.029  1.0000
```

```
##  2005,caH - 2012,caL -0.037101891 0.05328533 94  -0.696  1.0000
##  2012,caH - 2005,caL -0.119234560 0.05328533 94  -2.238  0.4141
##  2012,caH - 2012,caL -0.154790817 0.05328533 94  -2.905  0.0687
##  2005,caL - 2012,caL -0.035556256 0.05328533 94  -0.667  1.0000
##
## P value adjustment: bonferroni method for 15 tests
```

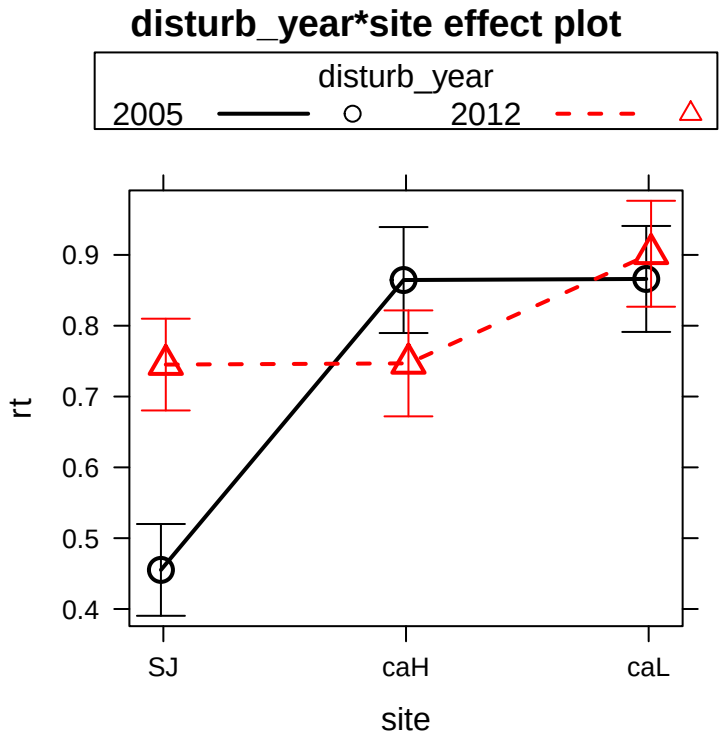
```
ps
```



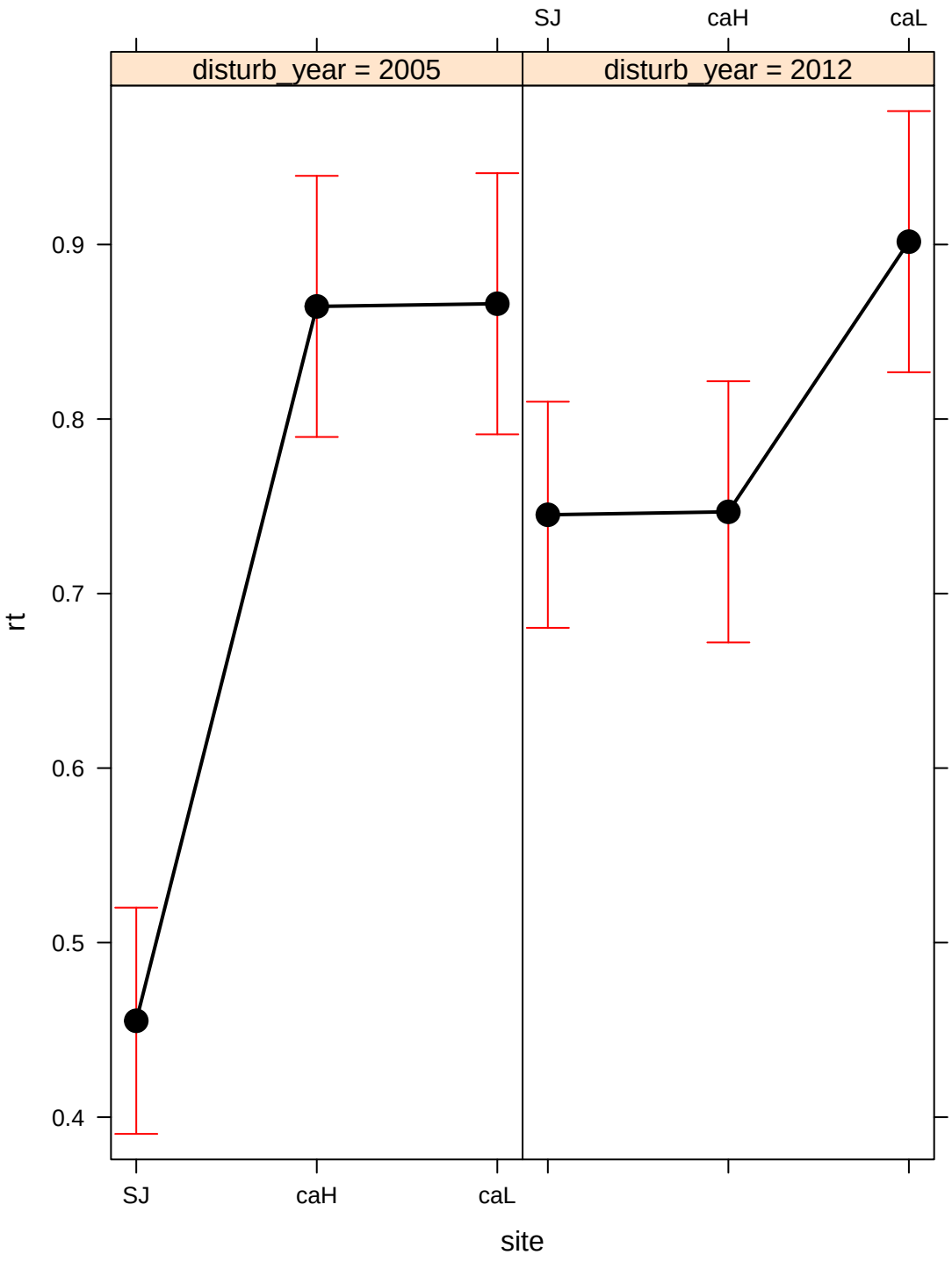

```
pd
```




```
picollapse
```




```
pi
```



Relative Resilience

Table 10: ANOVA table: rrs

term	df	sumsq	meansq	statistic	p.value
disturb_year	1	0.8719	0.8719	55.07	**0**
site	2	1.194	0.597	37.71	**0**
disturb_year:site	2	0.09764	0.04882	3.083	**0.05047**
Residuals	94	1.488	0.01583		

	Statistic
R^2	0.59
adjR^2	0.57
σ_e	0.13
F	27.33
p	0.00
df_m	6.00
logLik	68.48
AIC	-122.96
BIC	-104.73
dev	1.49
df_e	94.00

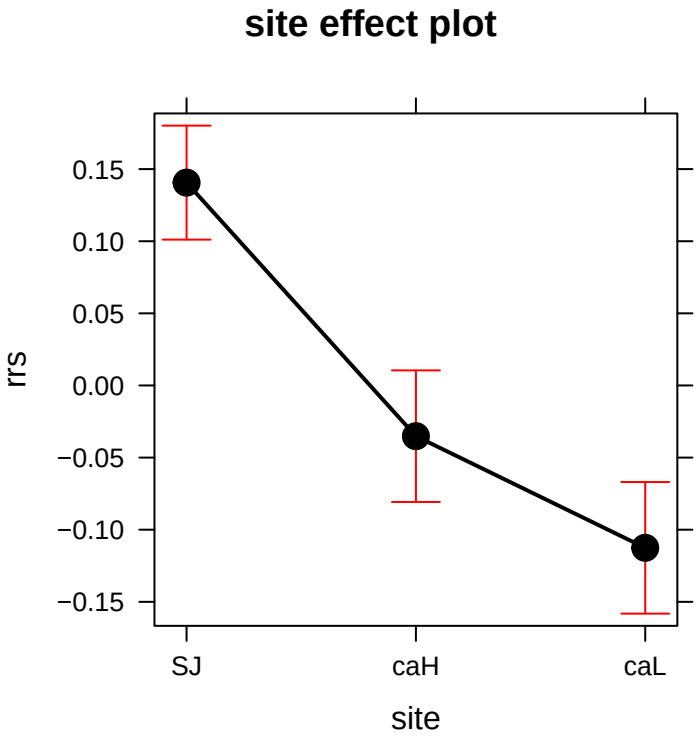
```
# Post hoc Define model
mymodel <- aov_rrs$mymodel
postH_rrs <- phc(mymodel = mymodel, resp_var = resp_var)
```

```
##
## ### Event ###
## $lsmeans
##  disturb_year      lsmean         SE df   lower.CL    upper.CL
##  2005         -0.09203152 0.01795911 94 -0.1276897 -0.05637329
##  2012          0.08729792 0.01795911 94  0.0516397  0.12295615
##
## Results are averaged over the levels of: site
## Confidence level used: 0.95
##
## $contrasts
##  contrast      estimate         SE df t.ratio p.value
##  2005 - 2012 -0.1793294 0.02539801 94  -7.061  <.0001
##
## Results are averaged over the levels of: site
##
##  disturb_year      lsmean         SE df    lower.CL    upper.CL .group
##  2005         -0.09203152 0.01795911 94 -0.13294007 -0.05112296  a
##  2012          0.08729792 0.01795911 94  0.04638937  0.12820648   b
##
## Results are averaged over the levels of: site
## Confidence level used: 0.95
## Conf-level adjustment: bonferroni method for 2 estimates
## significance level used: alpha = 0.01
##
## ### Clu pop ###
```

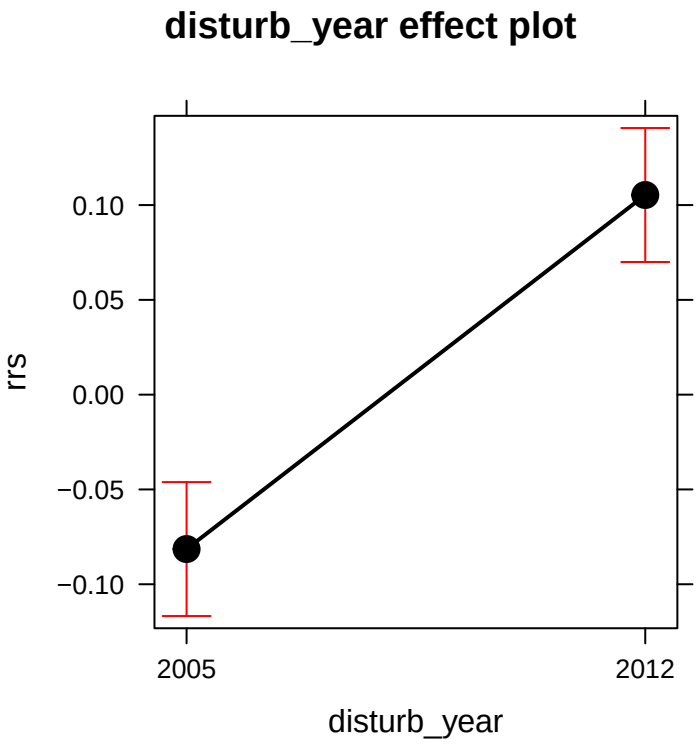
```
## $lsmeans
##  site      lsmean         SE df    lower.CL    upper.CL
##  SJ    0.14062958 0.01989552 94  0.10112657  0.18013260
##  caH  -0.03516178 0.02297337 94 -0.08077593  0.01045238
##  caL  -0.11256820 0.02297337 94 -0.15818235 -0.06695404
##
## Results are averaged over the levels of: disturb_year
## Confidence level used: 0.95
##
## $contrasts
##  contrast    estimate         SE df t.ratio p.value
##  SJ - caH  0.17579136 0.03039091 94   5.784  <.0001
##  SJ - caL  0.25319778 0.03039091 94   8.331  <.0001
##  caH - caL 0.07740642 0.03248924 94   2.383  0.0576
##
## Results are averaged over the levels of: disturb_year
## P value adjustment: bonferroni method for 3 tests
##
##  site      lsmean         SE df    lower.CL    upper.CL .group
##  caL  -0.11256820 0.02297337 94 -0.16856754 -0.05656885  a
##  caH  -0.03516178 0.02297337 94 -0.09116113  0.02083757  a
##  SJ    0.14062958 0.01989552 94  0.09213272  0.18912644   b
##
## Results are averaged over the levels of: disturb_year
## Confidence level used: 0.95
## Conf-level adjustment: bonferroni method for 3 estimates
## P value adjustment: bonferroni method for 3 tests
## significance level used: alpha = 0.01
##
## ### Event:Clu pop ###
## $lsmeans
##  disturb_year site      lsmean         SE df     lower.CL     upper.CL
##  2005         SJ    0.01386758 0.02813651 94 -0.041998125  0.069733280
##  2012         SJ    0.26739159 0.02813651 94  0.211525885  0.323257290
##  2005         caH  -0.12599273 0.03248924 94 -0.190500882 -0.061484569
##  2012         caH   0.05566917 0.03248924 94 -0.008838986  0.120177328
##  2005         caL  -0.16396940 0.03248924 94 -0.228477554 -0.099461241
##  2012         caL  -0.06116699 0.03248924 94 -0.125675149  0.003341164
##
## Confidence level used: 0.95
##
## $contrasts
##  contrast               estimate         SE df t.ratio p.value
##  2005,SJ - 2012,SJ   -0.25352401 0.03979104 94  -6.371  <.0001
##  2005,SJ - 2005,caH   0.13986030 0.04297923 94   3.254  0.0237
##  2005,SJ - 2012,caH  -0.04180159 0.04297923 94  -0.973  1.0000
##  2005,SJ - 2005,caL   0.17783698 0.04297923 94   4.138  0.0011
##  2005,SJ - 2012,caL   0.07503457 0.04297923 94   1.746  1.0000
##  2012,SJ - 2005,caH   0.39338431 0.04297923 94   9.153  <.0001
##  2012,SJ - 2012,caH   0.21172242 0.04297923 94   4.926  0.0001
##  2012,SJ - 2005,caL   0.43136099 0.04297923 94  10.036  <.0001
##  2012,SJ - 2012,caL   0.32855858 0.04297923 94   7.645  <.0001
##  2005,caH - 2012,caH -0.18166190 0.04594673 94  -3.954  0.0022
##  2005,caH - 2005,caL  0.03797667 0.04594673 94   0.827  1.0000
```

```
##  2005,caH - 2012,caL -0.06482573 0.04594673 94  -1.411  1.0000
##  2012,caH - 2005,caL  0.21963857 0.04594673 94   4.780  0.0001
##  2012,caH - 2012,caL  0.11683616 0.04594673 94   2.543  0.1894
##  2005,caL - 2012,caL -0.10280241 0.04594673 94  -2.237  0.4143
##
## P value adjustment: bonferroni method for 15 tests
```

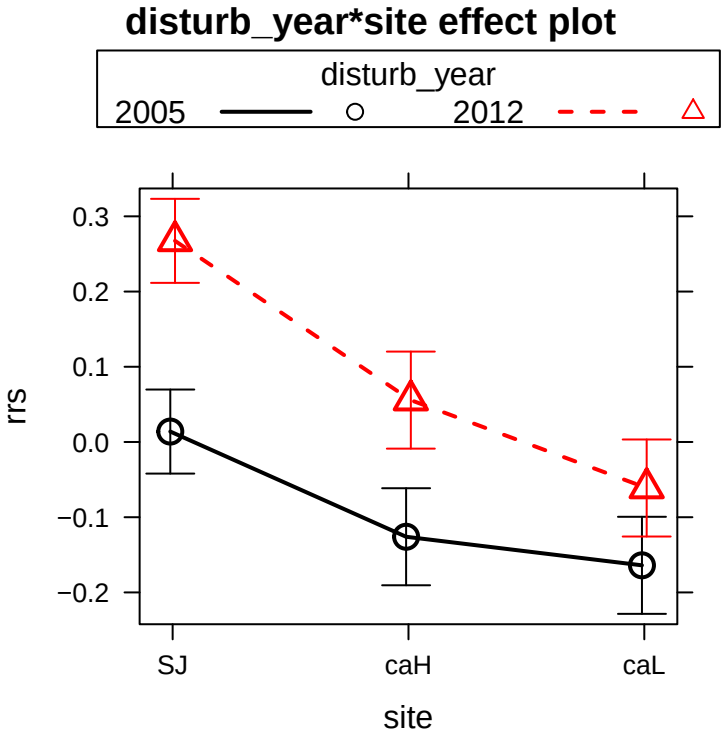
```
ps
```



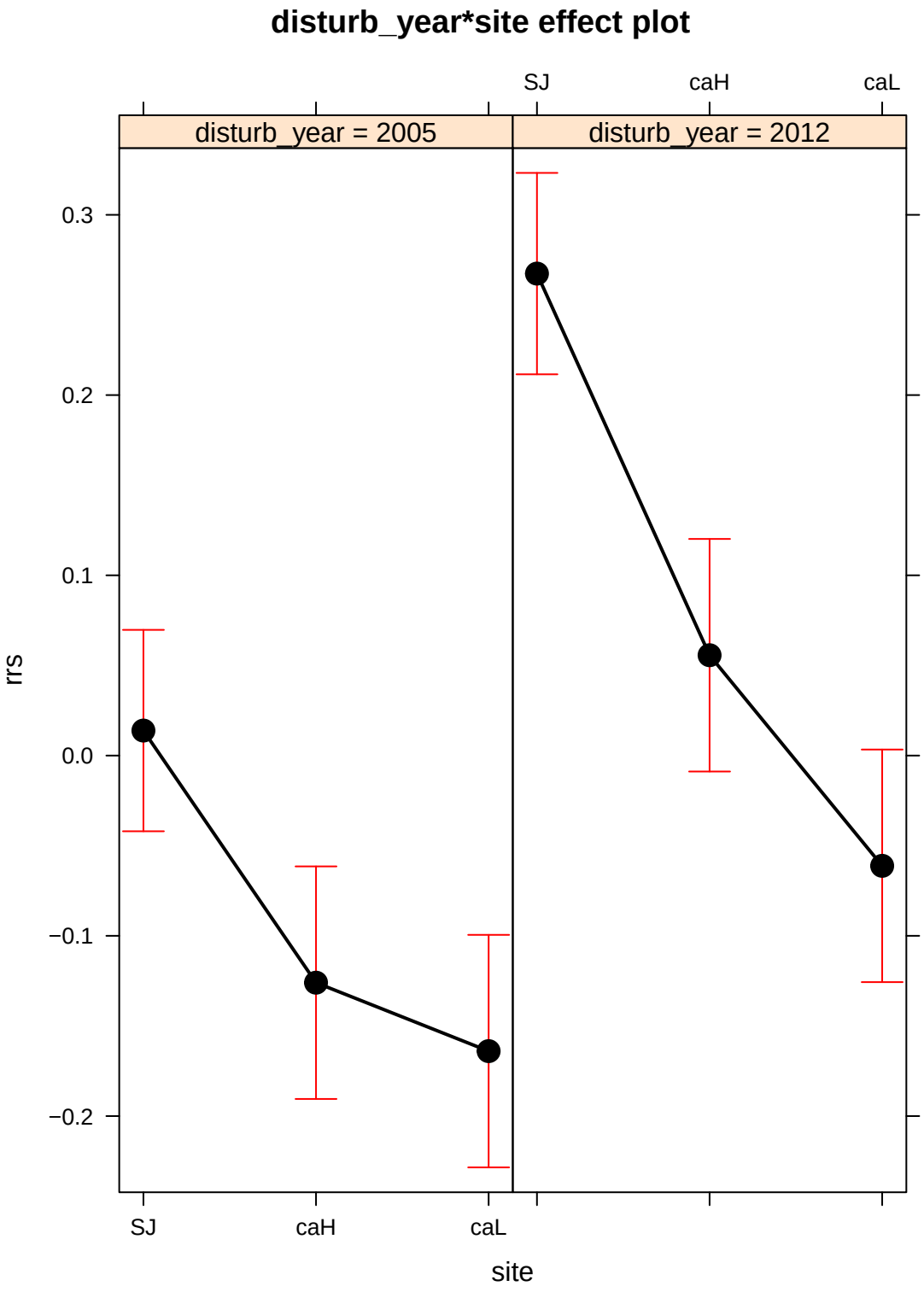

```
pd
```




```
picollapse
```




```
pi
```


disturb_year*site effect plot
SJ
caH
caL
disturb_year = 2005
disturb_year = 2012
0.3
0.2
0.1
0.0
−0.1
−0.2
rrs
SJ
caH
caL
site

Resilience

Table 12: ANOVA table: rs

term	df	sumsq	meansq	statistic	p.value
disturb_year	1	1.933	1.933	86.93	**0**
site	2	0.02174	0.01087	0.4888	0.6149
disturb_year:site	2	1.194	0.5972	26.86	**0**
Residuals	94	2.09	0.02224		

	Statistic
R^2	0.60
adjR^2	0.58
σ_e	0.15
F	28.32
p	0.00
df_m	6.00
logLik	51.50
AIC	-89.00
BIC	-70.76
dev	2.09
df_e	94.00

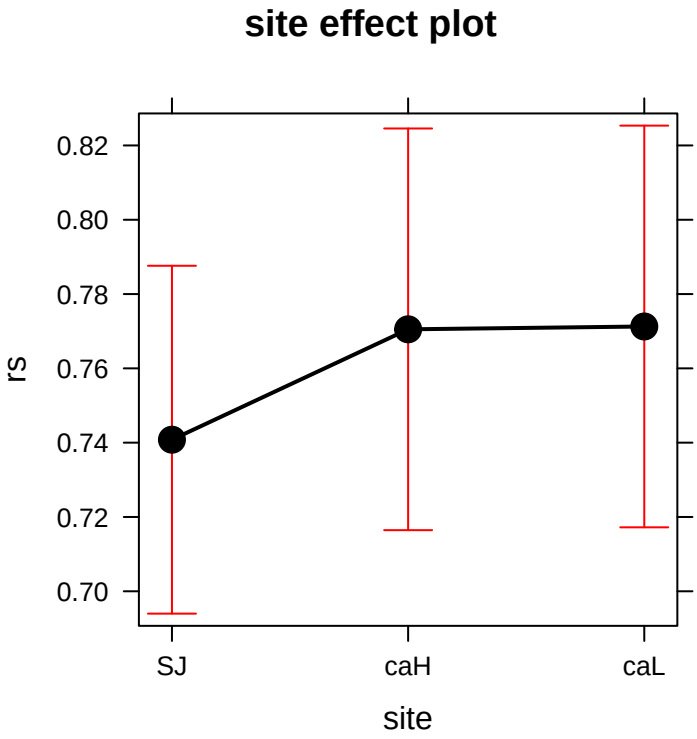
```
# Post hoc Define model
mymodel <- aov_rs$mymodel
postH_rs <- phc(mymodel = mymodel, resp_var = resp_var)
```

```
##
## ### Event ###
## $lsmeans
##  disturb_year    lsmean         SE df  lower.CL  upper.CL
##  2005         0.6365653 0.02128366 94 0.5943061 0.6788245
##  2012         0.8851583 0.02128366 94 0.8428991 0.9274175
##
## Results are averaged over the levels of: site
## Confidence level used: 0.95
##
## $contrasts
##  contrast     estimate         SE df t.ratio p.value
##  2005 - 2012 -0.248593 0.03009964 94  -8.259  <.0001
##
## Results are averaged over the levels of: site
##
##  disturb_year    lsmean         SE df  lower.CL  upper.CL .group
##  2005         0.6365653 0.02128366 94 0.5880839 0.6850468  a
##  2012         0.8851583 0.02128366 94 0.8366769 0.9336398   b
##
## Results are averaged over the levels of: site
## Confidence level used: 0.95
## Conf-level adjustment: bonferroni method for 2 estimates
## significance level used: alpha = 0.01
##
## ### Clu pop ###
```

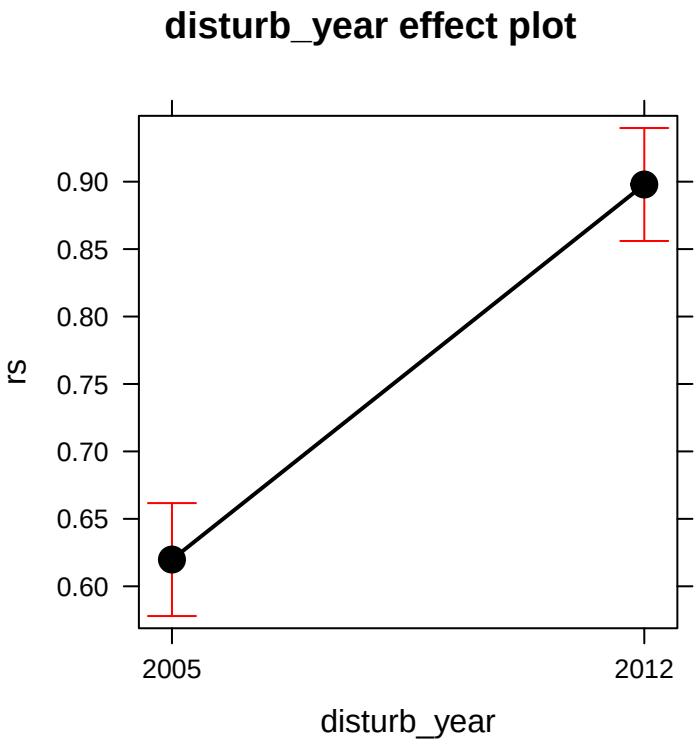
```
## $lsmeans
##  site    lsmean         SE df  lower.CL  upper.CL
##  SJ   0.7408003 0.02357854 94 0.6939846 0.7876161
##  caH  0.7705117 0.02722615 94 0.7164535 0.8245698
##  caL  0.7712735 0.02722615 94 0.7172153 0.8253316
##
## Results are averaged over the levels of: disturb_year
## Confidence level used: 0.95
##
## $contrasts
##  contrast       estimate         SE df t.ratio p.value
##  SJ - caH  -0.0297113289 0.03601681 94  -0.825  1.0000
##  SJ - caL  -0.0304731365 0.03601681 94  -0.846  1.0000
##  caH - caL -0.0007618076 0.03850359 94  -0.020  1.0000
##
## Results are averaged over the levels of: disturb_year
## P value adjustment: bonferroni method for 3 tests
##
##  site    lsmean         SE df  lower.CL  upper.CL .group
##  SJ   0.7408003 0.02357854 94 0.6833258 0.7982748  a
##  caH  0.7705117 0.02722615 94 0.7041458 0.8368775  a
##  caL  0.7712735 0.02722615 94 0.7049076 0.8376393  a
##
## Results are averaged over the levels of: disturb_year
## Confidence level used: 0.95
## Conf-level adjustment: bonferroni method for 3 estimates
## P value adjustment: bonferroni method for 3 tests
## significance level used: alpha = 0.01
##
## ### Event:Clu pop ###
## $lsmeans
##  disturb_year site    lsmean         SE df  lower.CL  upper.CL
##  2005         SJ   0.4690766 0.03334508 94 0.4028692 0.5352841
##  2012         SJ   1.0125240 0.03334508 94 0.9463166 1.0787315
##  2005         caH  0.7385252 0.03850359 94 0.6620754 0.8149749
##  2012         caH  0.8024981 0.03850359 94 0.7260484 0.8789479
##  2005         caL  0.7020941 0.03850359 94 0.6256444 0.7785439
##  2012         caL  0.8404528 0.03850359 94 0.7640030 0.9169026
##
## Confidence level used: 0.95
##
## $contrasts
##  contrast               estimate         SE df t.ratio p.value
##  2005,SJ - 2012,SJ   -0.54344740 0.04715707 94 -11.524  <.0001
##  2005,SJ - 2005,caH  -0.26944854 0.05093546 94  -5.290  <.0001
##  2005,SJ - 2012,caH  -0.33342151 0.05093546 94  -6.546  <.0001
##  2005,SJ - 2005,caL  -0.23301750 0.05093546 94  -4.575  0.0002
##  2005,SJ - 2012,caL  -0.37137617 0.05093546 94  -7.291  <.0001
##  2012,SJ - 2005,caH   0.27399886 0.05093546 94   5.379  <.0001
##  2012,SJ - 2012,caH   0.21002588 0.05093546 94   4.123  0.0012
##  2012,SJ - 2005,caL   0.31042989 0.05093546 94   6.095  <.0001
##  2012,SJ - 2012,caL   0.17207123 0.05093546 94   3.378  0.0159
##  2005,caH - 2012,caH -0.06397297 0.05445230 94  -1.175  1.0000
##  2005,caH - 2005,caL  0.03643104 0.05445230 94   0.669  1.0000
```

```
##  2005,caH - 2012,caL -0.10192762 0.05445230 94  -1.872  0.9650
##  2012,caH - 2005,caL  0.10040401 0.05445230 94   1.844  1.0000
##  2012,caH - 2012,caL -0.03795465 0.05445230 94  -0.697  1.0000
##  2005,caL - 2012,caL -0.13835866 0.05445230 94  -2.541  0.1904
##
## P value adjustment: bonferroni method for 15 tests
```

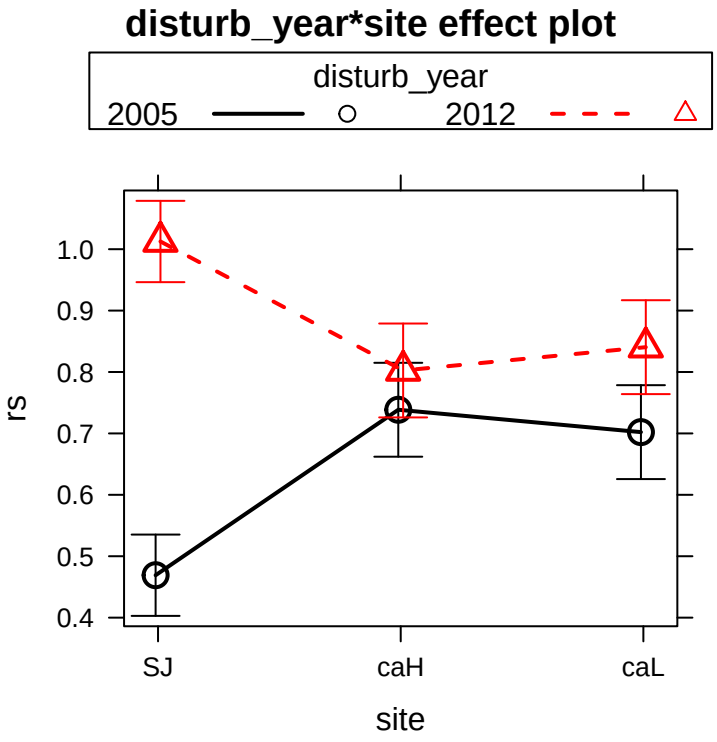
```
ps
```



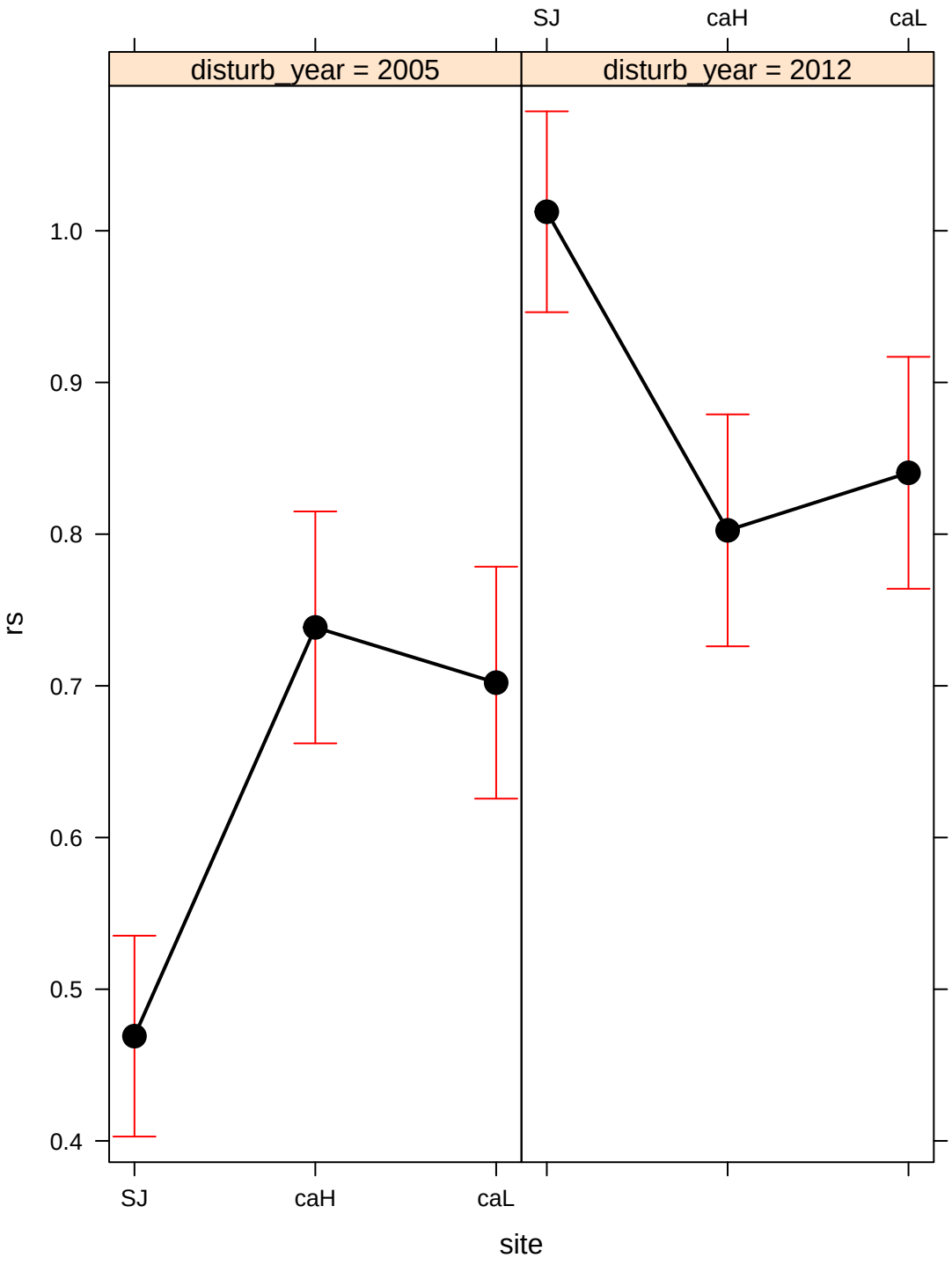

```
pd
```




```
picollapse
```




```
pi
```



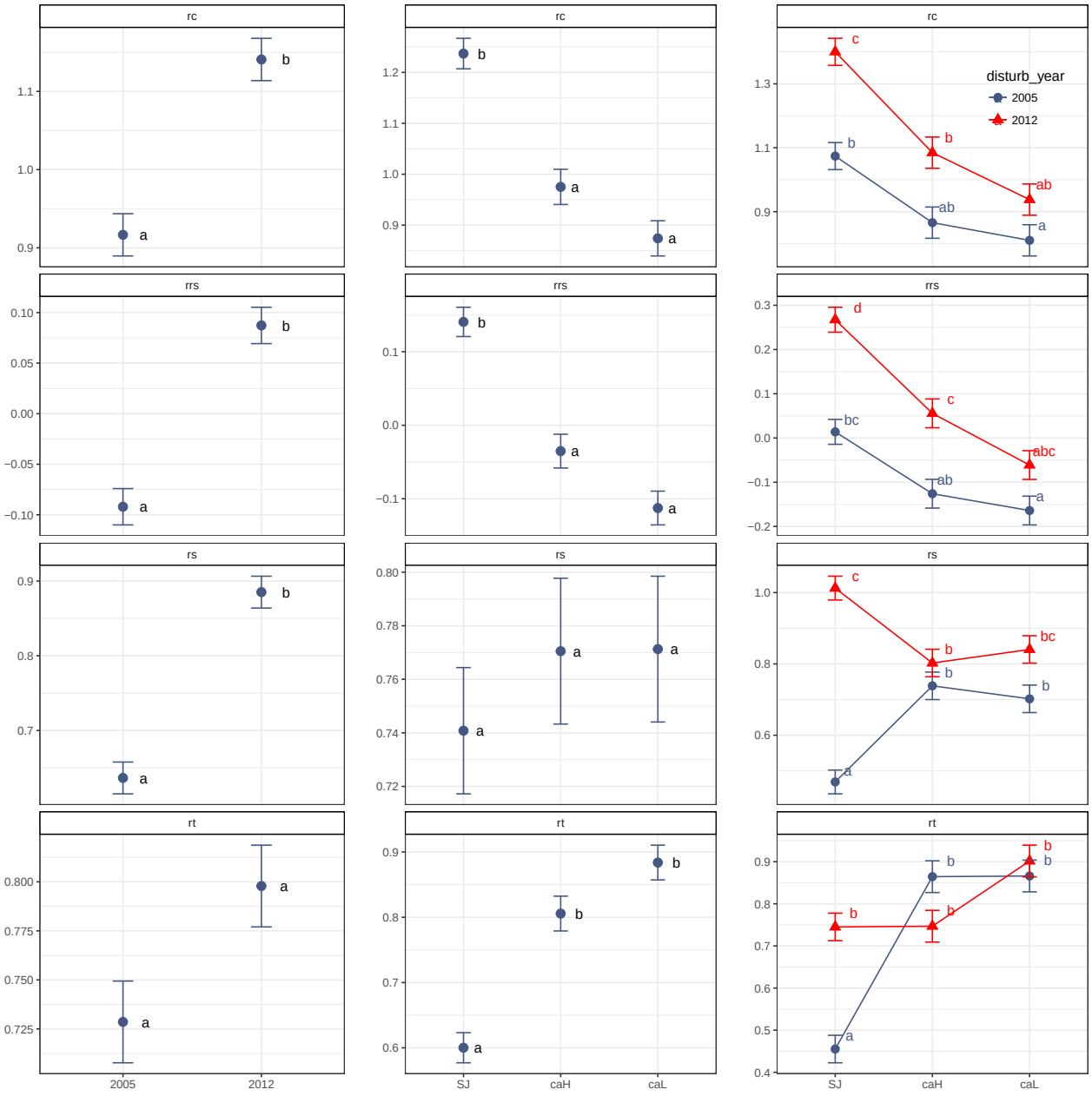

```
plot_mds <- means_distub_site %>%
  ggplot(aes(x=site, y=lsmean, group=disturb_year, colour=disturb_year)) +
  geom_point(aes(shape=disturb_year), size=3) +
  geom_line() +
  theme_bw() + xlab('') + ylab('') +
  facet_wrap(~var, scales='free_y', ncol = 1) +
```

```
  geom_text(aes(y=lsmean+SE, label=letras), nudge_x = 0.15)+
  theme(strip.background = element_rect(colour = "black", fill = "white"),
        legend.position = c(0.8, 0.93),
        legend.background = element_blank()) +
  scale_colour_manual(values = c(micolor, "red"))


plot_mdsSE <- plot_mds + geom_errorbar(mierrorbarSE, size=.5, width=.15)
plot_mdsCI <- plot_mds + geom_errorbar(mierrorbar, size=.5, width=.15)
```

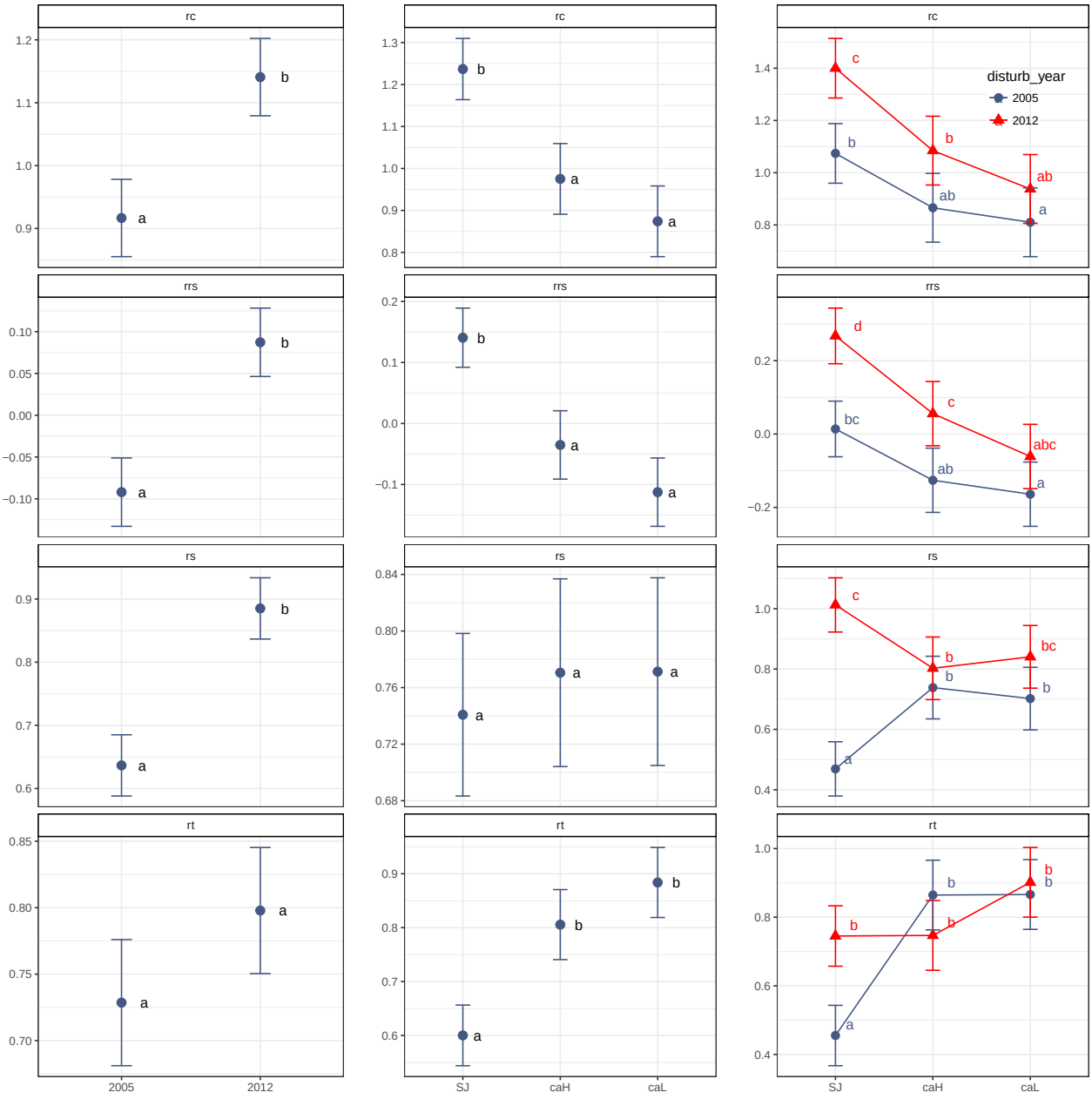
mean + sd

```
grid.arrange(plot_mdSE, plot_msSE, plot_mdsSE, ncol=3)
```



mean + ci

```
grid.arrange(plot_mdCI, plot_msCI, plot_mdsCI, ncol=3)
```




```
## pdf
##   2
```

```
## pdf
##   2
```

term	df	sumsq	meansq	statistic	p.value	var
disturb_year	1	1.373	1.373	38.33	1.556e-08	rc
site	2	2.495	1.247	34.83	4.807e-12	rc
disturb_year:site	2	0.1717	0.08587	2.398	0.09646	rc
Residuals	94	3.366	0.03581	NA	NA	rc
disturb_year	1	0.2085	0.2085	9.792	0.002334	rt
site	2	1.527	0.7637	35.86	2.665e-12	rt
disturb_year:site	2	0.7454	0.3727	17.5	3.458e-07	rt

term	df	sumsq	meansq	statistic	p.value	var
Residuals	94	2.002	0.02129	NA	NA	rt
disturb_year	1	1.933	1.933	86.93	5.039e-15	rs
site	2	0.02174	0.01087	0.4888	0.6149	rs
disturb_year:site	2	1.194	0.5972	26.86	5.951e-10	rs
Residuals	94	2.09	0.02224	NA	NA	rs
disturb_year	1	0.8719	0.8719	55.07	5.143e-11	rrs
site	2	1.194	0.597	37.71	9.468e-13	rrs
disturb_year:site	2	0.09764	0.04882	3.083	0.05047	rrs
Residuals	94	1.488	0.01583	NA	NA	rrs

```
aovas_model_summary <- aov_rc$model_summary %>% mutate(var = 'rc') %>%
  bind_rows(aov_rt$model_summary %>% mutate(var = 'rt')) %>%
  bind_rows(aov_rs$model_summary %>% mutate(var = 'rs')) %>%
  bind_rows(aov_rrs$model_summary%>% mutate(var = 'rrs'))

write.csv(aovas_model_summary,
          file=paste0(di, '/out/anovas_resilience/rwi/anovas_summary_modelos.csv'), row.names = F)


gm <- apply(aovas_model_summary, 1, formatC, digits = 2, format = "f")
rownames(gm) <- paste0("$",c("R^2","\\mathrm{adj}R^2","\\sigma_e","F","p","df_m","\\mathrm{logLik}","AI
colnames(gm) <- c("rc", "rt", "rs", "rrs")

pander(gm)
```

	rc	rt	rs	rrs
R^2	0.5454180	0.5534895	0.6010548	0.5924522
adjR^2	0.5212382	0.5297389	0.5798343	0.5707742
σ_e	0.1892386	0.1459279	0.1491238	0.1258303
F	22.55668	23.30427	28.32427	27.32956
p	8.427951e-15	3.708927e-15	2.098287e-17	5.601013e-17
df_m	6	6	6	6
logLik	27.67460	53.66418	51.49779	68.48203
AIC	-41.34920	-93.32836	-88.99559	-122.96405
BIC	-23.11301	-75.09217	-70.75940	-104.72786
dev	3.366256	2.001725	2.090362	1.488327
df_e	94	94	94	94
$variable$	rc	rt	rs	rrs

ROBUST ANOVA

- Ver Wilcox (2005, 2012)
- Vamos a realizar un Robust factorial ANOVA. En concreto:
- Two-way robust factorial ANOVA on M-estimator
- pkg WRS2

```r
robustANOVA <- function(df, resp_var, factores,
        alpha, nboot, treshold) {
  # alpha: alpha ci for huber m-estimation
  # nboot: numer of iterations
  # treshoold for letter (posthoc)
  # See http://rcompanion.org/rcompanion/d_08a.html

  set.seed(123)

  # Create interaction
  df$interaction <- interaction(df$disturb_year, df$site)

  # Formulas
  formulaFull <- as.formula(paste0(resp_var,  " ~ ",
                                   paste(factores, collapse = '+')))

  formula_A <- as.formula(paste0(resp_var,  " ~ ", factores[1]))
  formula_B <- as.formula(paste0(resp_var,  " ~ ", factores[2]))
  formula_AB <- as.formula(paste0(resp_var,  " ~ interaction"))


  # Produce Huber M-estimators and confidence intervals by group
  mest <- groupwiseHuber(formulaFull, data = df, ci.type = 'wald', conf.level = alpha)
  mest_a <- groupwiseHuber(formula_A, data = df, ci.type = 'wald', conf.level = alpha)
  mest_b <- groupwiseHuber(formula_B, data = df, ci.type = 'wald', conf.level = alpha)

  # Two-way robust analysis
  x <- pbad2way(formulaFull, data = df, est = "mom", nboot = nboot)


  out_ra <- data.frame(
    term = c(x$varnames[2],
             x$varnames[3],
             paste0(x$varnames[2], ':', x$varnames[3])),
    p_value = c(x$A.p.value, x$B.p.value, x$AB.p.value))

  out_raTrimmed <- t2way(formulaFull, data = df)

  out_ratr_df <- data.frame(fact = c(out_raTrimmed$varnames[2],
                                     out_raTrimmed$varnames[3],
                                     paste0(out_raTrimmed$varnames[2], ':', out_raTrimmed$varnames[3])),
              statistic = c(out_raTrimmed$Qa, out_raTrimmed$Qb, out_raTrimmed$Qab),
              pvalue = c(out_raTrimmed$A.p.value, out_raTrimmed$B.p.value, out_raTrimmed$AB.p.value))

  # post-hoc
  ## factor A
  pha <- pairwiseRobustTest(formula_A, data = df, est = "mom",
                            nboot = nboot, method="bonferroni")

  ## factor B
  phb <- pairwiseRobustTest(formula_B, data = df, est = "mom",
                            nboot = nboot, method="bonferroni")
  ## interaction effect (AB)
```

```
  phab <- pairwiseRobustTest(formula_AB, data = df, est = "mom",
                             nboot = nboot, method="bonferroni")

  ph <- rbind(pha, phb, phab)

  phRWS2 <- mcp2a(formulaFull, data=df, est = "mom", nboot = nboot)

  phtrimmed <- mcp2atm(formulaFull, data=df)

  out <- list()
  out$mest <- mest # Huber M-estimators and Confidence Intervals
  out$mest_a <- mest_a
  out$mest_b <- mest_b
  out$raTrimmed <- out_raTrimmed
  out$out_ratr_df <- out_ratr_df
  out$ra <- out_ra # Output for Two-way robust analysis (M-estimators)
  out$ph <- ph # posthoc comparison usinng pairwiseRobustTest
  out$pha <- pha
  out$phb <- phb
  out$phab <- phab

  print(cat('\n Robust M-Anova \n'))
  print(out_ra)
  print(cat('\n Robust Trimmed \n'))
  print(out_raTrimmed)
  print(cat('\n post hoc Mhuber \n'))
  print(phRWS2)
  print(cat('\n post hoc Trimmed means \n'))
  print(phtrimmed)

  return(out)
}

  # if (exists('letters_phb')) {
  # letters_phb <- letters_phb} else {
  # myerror <- evaluate('cldList(comparison = phb$Comparison,
  #                     p.value = phb$p.adjust, threshold  = treshold)')
  # letters_phb <- as.character(myerror[[2]]$message)}
  #
  # if (exists('letters_pha')) {
  # letters_pha <- letters_pha} else {
  # myerror <- evaluate('cldList(comparison = pha$Comparison,
  #                     p.value = pha$p.adjust, threshold  = treshold)')
  # letters_pha <- as.character(myerror[[2]]$message)}
  #
  # if (exists('letters_phab')) {
  # letters_phab <- letters_phab} else {
  # myerror <- evaluate('cldList(comparison = phab$Comparison,
  #                     p.value = phab$p.adjust, threshold  = treshold)')
  # letters_phab <- as.character(myerror[[2]]$message)}
```

```
factores = c('disturb_year', 'site', 'disturb_year:site')
```

Resilience

```
rars <- robustANOVA(df=re, resp_var='rs', factores=factores,
             alpha = 0.95, nboot = 3000, treshold = 0.01)
```

```
## [1] "comparison 1 ..."
##
##
## [1] "comparison 1 ..."
## [1] "comparison 2 ..."
## [1] "comparison 3 ..."
##
##
## [1] "comparison 1 ..."
## [1] "comparison 2 ..."
## [1] "comparison 3 ..."
## [1] "comparison 4 ..."
## [1] "comparison 5 ..."
## [1] "comparison 6 ..."
## [1] "comparison 7 ..."
## [1] "comparison 8 ..."
## [1] "comparison 9 ..."
## [1] "comparison 10 ..."
## [1] "comparison 11 ..."
## [1] "comparison 12 ..."
## [1] "comparison 13 ..."
## [1] "comparison 14 ..."
## [1] "comparison 15 ..."
##
##
##
##  Robust M-Anova
## NULL
##                term   p_value
## 1      disturb_year 0.0000000
## 2              site 0.5486667
## 3 disturb_year:site 0.0000000
##
##  Robust Trimmed
## NULL
## Call:
## t2way(formula = formulaFull, data = df)
##
##                      value p.value
## disturb_year      71.0246   0.001
## site               2.8626   0.260
## disturb_year:site 48.0500   0.001
##
##
##  post hoc Mhuber
## NULL
## Call:
## mcp2a(formula = formulaFull, data = df, est = "mom", nboot = nboot)
##
```

```
##                       psihat ci.lower ci.upper p-value
## disturb_year1       -0.72943 -0.96421 -0.53688 0.00000
## site1               -0.10092 -0.30895  0.09093 0.11167
## site2               -0.08768 -0.28296  0.09801 0.15067
## site3                0.01323 -0.15329  0.18857 0.41400
## disturb_year1:site1 -0.47788 -0.69430 -0.30359 0.00000
## disturb_year1:site2 -0.41825 -0.61764 -0.22357 0.00000
## disturb_year1:site3  0.05963 -0.09717  0.26854 0.18767
##
##
##  post hoc Trimmed means
## NULL
## Call:
## mcp2atm(formula = formulaFull, data = df)
##
##                       psihat ci.lower ci.upper p-value
## disturb_year1       -0.75207 -0.93138 -0.57277 0.00000
## site1               -0.12597 -0.31506  0.06311 0.10456
## site2               -0.09108 -0.27777  0.09562 0.22978
## site3                0.03490 -0.13760  0.20740 0.61296
## disturb_year1:site1 -0.50137 -0.69045 -0.31229 0.00000
## disturb_year1:site2 -0.41264 -0.59933 -0.22595 0.00000
## disturb_year1:site3  0.08873 -0.08377  0.26123 0.20384
```

Rs Letters

```
x <-rars

letraArs <- cldList(comparison = x$pha$Comparison, p.value = x$pha$p.adjust, threshold  = 0.01) %>% muta
letraArs
```

```
##   Group Letter MonoLetter var
## 1    25      a         a   rs
## 2   212      b          b  rs
```

```
letraBrs <- cldList(comparison = x$phb$Comparison, p.value = x$phb$p.adjust, threshold  = 0.01) %>% muta
```

```
## Error: No significant differences.
```

```
letraBrs # Manual (IMPROVE IT)
```

```
## Error in eval(expr, envir, enclos): object 'letraBrs' not found
```

```
letraBrs <- data.frame(Group = c('SJ', 'caH', 'caL'),
                       Letter = c('a','a','a'),
                       MonoLetter = c('a','a','a')) %>% mutate(var ='rs')
letraBrs
```

```
##   Group Letter MonoLetter var
## 1    SJ      a          a  rs
## 2   caH      a          a  rs
## 3   caL      a          a  rs
```

```
letraABrs  <- cldList(comparison = x$phab$Comparison, p.value = x$phab$p.adjust, threshold  = 0.01) %>%
letraABrs
```

```
##     Group Letter MonoLetter var
## 1   25.SJ      a        a    rs
```

```
## 2  212.SJ      b         b   rs
## 3  25.caH      c          c  rs
## 4 212.caH     bc         bc  rs
## 5  25.caL     ac        a c  rs
## 6 212.caL     bc         bc  rs
```

Recovery

```
rarc <- robustANOVA(df=re, resp_var='rc', factores=factores,
              alpha = 0.95, nboot = 3000, treshold = 0.01)
```

```
## [1] "comparison 1 ..."
##
##
## [1] "comparison 1 ..."
## [1] "comparison 2 ..."
## [1] "comparison 3 ..."
##
##
## [1] "comparison 1 ..."
## [1] "comparison 2 ..."
## [1] "comparison 3 ..."
## [1] "comparison 4 ..."
## [1] "comparison 5 ..."
## [1] "comparison 6 ..."
## [1] "comparison 7 ..."
## [1] "comparison 8 ..."
## [1] "comparison 9 ..."
## [1] "comparison 10 ..."
## [1] "comparison 11 ..."
## [1] "comparison 12 ..."
## [1] "comparison 13 ..."
## [1] "comparison 14 ..."
## [1] "comparison 15 ..."
##
##
##
##  Robust M-Anova
## NULL
##                term p_value
## 1      disturb_year   0.000
## 2              site   0.000
## 3 disturb_year:site   0.118
##
##  Robust Trimmed
## NULL
## Call:
## t2way(formula = formulaFull, data = df)
##
##                     value p.value
## disturb_year      32.1553   0.001
## site              54.0514   0.001
## disturb_year:site  3.7283   0.178
```

```
##
##
##  post hoc Mhuber
## NULL
## Call:
## mcp2a(formula = formulaFull, data = df, est = "mom", nboot = nboot)
##
##                       psihat ci.lower ci.upper p-value
## disturb_year1       -0.65218 -0.90500 -0.41425 0.00000
## site1                0.52444  0.26297  0.74729 0.00000
## site2                0.77070  0.50882  0.95238 0.00000
## site3                0.24626  0.04499  0.41107 0.00433
## disturb_year1:site1 -0.05684 -0.31167  0.15217 0.22533
## disturb_year1:site2 -0.19242 -0.42138  0.03381 0.03233
## disturb_year1:site3 -0.13557 -0.29443  0.07265 0.09767
##
##
##  post hoc Trimmed means
## NULL
## Call:
## mcp2atm(formula = formulaFull, data = df)
##
##                       psihat ci.lower ci.upper p-value
## disturb_year1       -0.66153 -0.89687 -0.42619 0.00000
## site1                0.50457  0.24373  0.76541 0.00003
## site2                0.73950  0.48520  0.99380 0.00000
## site3                0.23493  0.03334  0.43652 0.00636
## disturb_year1:site1 -0.08655 -0.34739  0.17428 0.41020
## disturb_year1:site2 -0.18429 -0.43859  0.07001 0.07753
## disturb_year1:site3 -0.09774 -0.29933  0.10386 0.22961
```

Rc Letters

```
x <-rarc

letraArc <- cldList(comparison = x$pha$Comparison, p.value = x$pha$p.adjust, threshold  = 0.01) %>% muta
letraArc
```

```
##   Group Letter MonoLetter var
## 1    25      a         a   rc
## 2   212      b          b  rc
```

```
letraBrc <- cldList(comparison = x$phb$Comparison, p.value = x$phb$p.adjust, threshold  = 0.01) %>% muta
letraBrc
```

```
##   Group Letter MonoLetter var
## 1    SJ      a         a   rc
## 2   caH      b          b  rc
## 3   caL      b          b  rc
```

```
letraABrc <- cldList(comparison = x$phab$Comparison, p.value = x$phab$p.adjust, threshold  = 0.01) %>% m
letraABrc
```

```
##     Group Letter MonoLetter var
## 1   25.SJ     ab        ab   rc
## 2  212.SJ      a        a    rc
```

```
## 3  25.caH     bc         bc  rc
## 4 212.caH     ab        ab   rc
## 5  25.caL      c          c  rc
## 6 212.caL     bc         bc  rc
```

Resistance

```
rart <- robustANOVA(df=re, resp_var='rt', factores=factores,
              alpha = 0.95, nboot = 3000, treshold = 0.01)
```

```
## [1] "comparison 1 ..."
##
##
## [1] "comparison 1 ..."
## [1] "comparison 2 ..."
## [1] "comparison 3 ..."
##
##
## [1] "comparison 1 ..."
## [1] "comparison 2 ..."
## [1] "comparison 3 ..."
## [1] "comparison 4 ..."
## [1] "comparison 5 ..."
## [1] "comparison 6 ..."
## [1] "comparison 7 ..."
## [1] "comparison 8 ..."
## [1] "comparison 9 ..."
## [1] "comparison 10 ..."
## [1] "comparison 11 ..."
## [1] "comparison 12 ..."
## [1] "comparison 13 ..."
## [1] "comparison 14 ..."
## [1] "comparison 15 ..."
##
##
##
##  Robust M-Anova
## NULL
##                term    p_value
## 1      disturb_year 0.01533333
## 2              site 0.00000000
## 3 disturb_year:site 0.00000000
##
##  Robust Trimmed
## NULL
## Call:
## t2way(formula = formulaFull, data = df)
##
##                      value p.value
## disturb_year       8.3202   0.006
## site              73.6290   0.001
## disturb_year:site 39.0757   0.001
##
```

```
##
##  post hoc Mhuber
## NULL
## Call:
## mcp2a(formula = formulaFull, data = df, est = "mom", nboot = nboot)
##
##                        psihat ci.lower ci.upper p-value
## disturb_year1       -0.23926 -0.43184 -0.04996 0.00733
## site1               -0.40017 -0.61001 -0.24605 0.00000
## site2               -0.57438 -0.77436 -0.42001 0.00000
## site3               -0.17421 -0.31943 -0.01647 0.00967
## disturb_year1:site1 -0.47057 -0.63523 -0.28334 0.00000
## disturb_year1:site2 -0.29946 -0.47947 -0.11566 0.00000
## disturb_year1:site3  0.17111  0.00938  0.30162 0.01167
##
##
##  post hoc Trimmed means
## NULL
## Call:
## mcp2atm(formula = formulaFull, data = df)
##
##                        psihat ci.lower ci.upper p-value
## disturb_year1       -0.24537 -0.41675 -0.07400 0.00602
## site1               -0.43524 -0.61967 -0.25082 0.00000
## site2               -0.59627 -0.77172 -0.42083 0.00000
## site3               -0.16103 -0.32670  0.00464 0.02021
## disturb_year1:site1 -0.45473 -0.63915 -0.27030 0.00000
## disturb_year1:site2 -0.30662 -0.48206 -0.13118 0.00011
## disturb_year1:site3  0.14811 -0.01756  0.31377 0.03122
```

Rt Letters

```
x <-rart

letraArt <- cldList(comparison = x$pha$Comparison, p.value = x$pha$p.adjust, threshold  = 0.01) %>% muta
```

```
## Error: No significant differences.
```

```
letraArt #Manual (IMPROVE IT)
```

```
## Error in eval(expr, envir, enclos): object 'letraArt' not found
```

```
letraArt <- data.frame(Group = as.factor(c('25', '212')),
                       Letter = as.factor(c('a','a')),
                       MonoLetter = as.factor(c('a','a'))) %>% mutate(var ='rt')
letraArt
```

```
##   Group Letter MonoLetter var
## 1    25      a          a  rt
## 2   212      a          a  rt
```

```
letraBrt <- cldList(comparison = x$phb$Comparison, p.value = x$phb$p.adjust, threshold  = 0.01) %>% muta
letraBrt
```

```
##   Group Letter MonoLetter var
## 1    SJ      a         a   rt
## 2   caH      b          b  rt
```

```
## 3   caL      b          b  rt
```

```
letraABrt <- cldList(comparison = x$phab$Comparison, p.value = x$phab$p.adjust, threshold  = 0.01) %>% r
letraABrt
```

```
##     Group Letter MonoLetter var
## 1   25.SJ      a         a    rt
## 2  212.SJ     bc          bc  rt
## 3  25.caH     bc          bc  rt
## 4 212.caH      b          b   rt
## 5  25.caL     bc          bc  rt
## 6 212.caL      c           c  rt
```

Relative Resilience

```
rarrs <- robustANOVA(df=re, resp_var='rrs', factores=factores,
              alpha = 0.95, nboot = 3000, treshold = 0.01)
```

```
## [1] "comparison 1 ..."
##
##
## [1] "comparison 1 ..."
## [1] "comparison 2 ..."
## [1] "comparison 3 ..."
##
##
## [1] "comparison 1 ..."
## [1] "comparison 2 ..."
## [1] "comparison 3 ..."
## [1] "comparison 4 ..."
## [1] "comparison 5 ..."
## [1] "comparison 6 ..."
## [1] "comparison 7 ..."
## [1] "comparison 8 ..."
## [1] "comparison 9 ..."
## [1] "comparison 10 ..."
## [1] "comparison 11 ..."
## [1] "comparison 12 ..."
## [1] "comparison 13 ..."
## [1] "comparison 14 ..."
## [1] "comparison 15 ..."
##
##
##
##  Robust M-Anova
## NULL
##                 term p_value
## 1      disturb_year   0.000
## 2              site   0.000
## 3 disturb_year:site   0.158
##
##  Robust Trimmed
## NULL
## Call:
```

```
## t2way(formula = formulaFull, data = df)
##
##                      value p.value
## disturb_year      42.1386   0.001
## site              67.9379   0.001
## disturb_year:site  4.9425   0.107
##
##
##  post hoc Mhuber
## NULL
## Call:
## mcp2a(formula = formulaFull, data = df, est = "mom", nboot = nboot)
##
##                        psihat ci.lower ci.upper p-value
## disturb_year1       -0.53354 -0.70514 -0.34390 0.00000
## site1                0.35391  0.17105  0.50666 0.00000
## site2                0.53311  0.37908  0.67140 0.00000
## site3                0.17920  0.02233  0.35082 0.00833
## disturb_year1:site1 -0.02498 -0.21497  0.09894 0.25433
## disturb_year1:site2 -0.12823 -0.29656  0.00236 0.01967
## disturb_year1:site3 -0.10325 -0.24207  0.07439 0.12300
##
##
##  post hoc Trimmed means
## NULL
## Call:
## mcp2atm(formula = formulaFull, data = df)
##
##                        psihat ci.lower ci.upper p-value
## disturb_year1       -0.53220 -0.69774 -0.36666 0.00000
## site1                0.34608  0.17192  0.52024 0.00003
## site2                0.53397  0.36848  0.69946 0.00000
## site3                0.18789  0.01871  0.35707 0.00892
## disturb_year1:site1 -0.06830 -0.24246  0.10586 0.32938
## disturb_year1:site2 -0.14482 -0.31031  0.02067 0.03500
## disturb_year1:site3 -0.07652 -0.24569  0.09266 0.26117
```

RRs Letters

```
x <-rarrs

letraArrs <- cldList(comparison = x$pha$Comparison, p.value = x$pha$p.adjust, threshold  = 0.01) %>% mu
letraArrs
```

```
##   Group Letter MonoLetter var
## 1    25      a         a  rrs
## 2   212      b          b rrs
```

```
letraBrrs <- cldList(comparison = x$phb$Comparison, p.value = x$phb$p.adjust, threshold  = 0.01) %>% mu
letraBrrs
```

```
##   Group Letter MonoLetter var
## 1    SJ      a         a  rrs
## 2   caH     ab         ab rrs
## 3   caL      b          b rrs
```

```
letraABrrs <- cldList(comparison = x$phab$Comparison, p.value = x$phab$p.adjust, threshold  = 0.01) %>%
letraABrrs
```

```
##     Group Letter MonoLetter var
## 1   25.SJ     ab         ab  rrs
## 2  212.SJ      c          c rrs
## 3  25.caH     ab         ab  rrs
## 4 212.caH      a         a   rrs
## 5  25.caL      b          b  rrs
## 6 212.caL     ab         ab  rrs
```

```
letrasA <- rbind(letraArs, letraArc, letraArt, letraArrs) %>%
  mutate(disturb_year =
           case_when(Group == "25" ~ "2005",
                     Group == "212" ~ "2012")) %>%
  dplyr::select(-Group)

letrasB <- rbind(letraBrs, letraBrc, letraBrt, letraBrrs) %>% rename(site = Group)

letrasAB <- rbind(letraABrs, letraABrc, letraABrt, letraABrrs) %>%
  separate(Group, into=c('disturb_year', 'site')) %>%
  mutate(disturb_year =
           case_when(disturb_year == "25" ~ "2005",
                     disturb_year == "212" ~ "2012"))
```

Estimadores de huber

```
rars$mest$var <- 'rs'
rarc$mest$var <- 'rc'
rart$mest$var <- 'rt'
rarrs$mest$var <- 'rrs'

mhuber <- rbind(rarc$mest, rart$mest, rars$mest, rarrs$mest)

# add letras
mhuber <- mhuber %>% inner_join(letrasAB, by=c('var','disturb_year', 'site'))

mhuber_agg <- mhuber %>%
  mutate(M.Huber = round(M.Huber, 4),
         lower.ci = round(lower.ci, 4),
         upper.ci = round(upper.ci, 4)) %>%
  unite_("ci", c("lower.ci", "upper.ci"), sep=",") %>%
  mutate(ci = paste0('(', ci, ')')) %>%
  dplyr::select(-MonoLetter) %>%
  dplyr::select(var, disturb_year:ci, Letter) %>% as.data.frame()

mhuber_agg %>% pander()
```

var	disturb_year	site	n	M.Huber	ci	Letter
rc	2005	SJ	20	1.075	(0.9688,1.1806)	ab
rc	2005	caH	15	0.8689	(0.7875,0.9504)	bc
rc	2005	caL	15	0.8104	(0.7432,0.8775)	c

var	disturb_year	site	n	M.Huber	ci	Letter
rc	2012	SJ	20	1.394	(1.257,1.5315)	a
rc	2012	caH	15	1.094	(1.0301,1.158)	ab
rc	2012	caL	15	0.9293	(0.8738,0.9847)	bc
rt	2005	SJ	20	0.4331	(0.3616,0.5047)	a
rt	2005	caH	15	0.8649	(0.7834,0.9464)	bc
rt	2005	caL	15	0.8716	(0.7894,0.9538)	bc
rt	2012	SJ	20	0.7475	(0.6692,0.8258)	bc
rt	2012	caH	15	0.7438	(0.6846,0.803)	b
rt	2012	caL	15	0.903	(0.8636,0.9425)	c
rs	2005	SJ	20	0.4506	(0.3854,0.5158)	a
rs	2005	caH	15	0.7413	(0.6669,0.8157)	c
rs	2005	caL	15	0.6928	(0.605,0.7805)	ac
rs	2012	SJ	20	0.9983	(0.9213,1.0752)	b
rs	2012	caH	15	0.8052	(0.7509,0.8595)	bc
rs	2012	caL	15	0.8314	(0.7796,0.8831)	bc
rrs	2005	SJ	20	0.0256	(-0.0158,0.067)	ab
rrs	2005	caH	15	-0.1225	(-0.1997,-0.0452)	ab
rrs	2005	caL	15	-0.164	(-0.2254,-0.1025)	b
rrs	2012	SJ	20	0.2727	(0.1959,0.3494)	c
rrs	2012	caH	15	0.0683	(0.0239,0.1128)	a
rrs	2012	caL	15	-0.0632	(-0.1148,-0.0115)	ab

```
rars$mest_a$var <- 'rs'
rarc$mest_a$var <- 'rc'
rart$mest_a$var <- 'rt'
rarrs$mest_a$var <- 'rrs'

mhuber_a <- rbind(rarc$mest_a, rart$mest_a, rars$mest_a, rarrs$mest_a)
mhuber_a <- mhuber_a %>% inner_join(letrasA, by=c('var','disturb_year'))


mhuber_agg_a <- mhuber_a %>%
  mutate(M.Huber = round(M.Huber, 4),
         lower.ci = round(lower.ci, 4),
         upper.ci = round(upper.ci, 4)) %>%
  unite_("ci", c("lower.ci", "upper.ci"), sep=",") %>%
  mutate(ci = paste0('(', ci, ')')) %>%
  dplyr::select(-MonoLetter) %>%
  dplyr::select(var, disturb_year:ci, Letter) %>% as.data.frame()

mhuber_agg_a %>% pander()
```

var	disturb_year	n	M.Huber	ci	Letter
rc	2005	50	0.9218	(0.8624,0.9813)	a
rc	2012	50	1.137	(1.064,1.2098)	b
rt	2005	50	0.7033	(0.6282,0.7784)	a
rt	2012	50	0.7993	(0.7594,0.8392)	a
rs	2005	50	0.6173	(0.5593,0.6753)	a
rs	2012	50	0.8767	(0.8352,0.9182)	b
rrs	2005	50	-0.0755	(-0.1165,-0.0344)	a
rrs	2012	50	0.0977	(0.04,0.1553)	b

```
rars$mest_b$var <- 'rs'
rarc$mest_b$var <- 'rc'
rart$mest_b$var <- 'rt'
rarrs$mest_b$var <- 'rrs'

mhuber_b <- rbind(rarc$mest_b, rart$mest_b, rars$mest_b, rarrs$mest_b)
mhuber_b <- mhuber_b %>% inner_join(letrasB, by=c('var','site'))

mhuber_agg_b <- mhuber_b %>%
  mutate(M.Huber = round(M.Huber, 4),
         lower.ci = round(lower.ci, 4),
         upper.ci = round(upper.ci, 4)) %>%
  unite_("ci", c("lower.ci", "upper.ci"), sep=",") %>%
  mutate(ci = paste0('(', ci, ')')) %>%
  dplyr::select(-MonoLetter) %>%
  dplyr::select(var, site:ci, Letter) %>% as.data.frame()

mhuber_agg_b %>% pander()
```

var	site	n	M.Huber	ci	Letter
rc	SJ	40	1.23	(1.1329,1.3276)	a
rc	caH	30	0.9789	(0.9103,1.0476)	b
rc	caL	30	0.8702	(0.817,0.9234)	b
rt	SJ	40	0.5975	(0.525,0.67)	a
rt	caH	30	0.7987	(0.7388,0.8586)	b
rt	caL	30	0.8891	(0.8482,0.93)	b
rs	SJ	40	0.7361	(0.6304,0.8418)	a
rs	caH	30	0.776	(0.7335,0.8185)	a
rs	caL	30	0.7734	(0.715,0.8318)	a
rrs	SJ	40	0.1313	(0.0711,0.1915)	a
rrs	caH	30	-0.0243	(-0.0832,0.0346)	ab
rrs	caL	30	-0.1136	(-0.1601,-0.0671)	b

Pairwise comparison

```
rars$ph$var <- 'rs'
rarc$ph$var <- 'rc'
rart$ph$var <- 'rt'
rarrs$ph$var <- 'rrs'

pairwise <- rbind(rarc$ph, rart$ph, rars$ph, rarrs$ph)
pairwise %>% pander()
```

Comparison	Statistic	p.value	p.adjust	var
2005 - 2012 = 0	-0.1687	0.0006667	0.0006667	rc
SJ - caH = 0	0.2434	0.0006667	0.002	rc
SJ - caL = 0	0.3558	0	0	rc
caH - caL = 0	0.1124	0.02	0.06	rc
2005.SJ - 2012.SJ = 0	-0.3005	0.002667	0.04	rc
2005.SJ - 2005.caH = 0	0.2338	0.007333	0.11	rc
2005.SJ - 2012.caH = 0	-0.009841	0.7667	1	rc

Comparison	Statistic	p.value	p.adjust	var
2005.SJ - 2005.caL = 0	0.2891	0	0	rc
2005.SJ - 2012.caL = 0	0.1811	0.02267	0.34	rc
2012.SJ - 2005.caH = 0	0.5343	0	0	rc
2012.SJ - 2012.caH = 0	0.2906	0.0006667	0.01	rc
2012.SJ - 2005.caL = 0	0.5896	0	0	rc
2012.SJ - 2012.caL = 0	0.4816	0	0	rc
2005.caH - 2012.caH = 0	-0.2436	0.0006667	0.01	rc
2005.caH - 2005.caL = 0	0.05534	0.314	1	rc
2005.caH - 2012.caL = 0	-0.05272	0.3607	1	rc
2012.caH - 2005.caL = 0	0.299	0	0	rc
2012.caH - 2012.caL = 0	0.1909	0.0006667	0.01	rc
2005.caL - 2012.caL = 0	-0.1081	0.03933	0.59	rc
2005 - 2012 = 0	-0.1002	0.1607	0.1607	rt
SJ - caH = 0	-0.1956	0	0	rt
SJ - caL = 0	-0.3014	0	0	rt
caH - caL = 0	-0.1059	0.01	0.03	rt
2005.SJ - 2012.SJ = 0	-0.3364	0	0	rt
2005.SJ - 2005.caH = 0	-0.4354	0	0	rt
2005.SJ - 2012.caH = 0	-0.3012	0	0	rt
2005.SJ - 2005.caL = 0	-0.4369	0	0	rt
2005.SJ - 2012.caL = 0	-0.4739	0	0	rt
2012.SJ - 2005.caH = 0	-0.09894	0.06867	1	rt
2012.SJ - 2012.caH = 0	0.0352	0.8033	1	rt
2012.SJ - 2005.caL = 0	-0.1005	0.07133	1	rt
2012.SJ - 2012.caL = 0	-0.1375	0.004667	0.07	rt
2005.caH - 2012.caH = 0	0.1341	0.01133	0.17	rt
2005.caH - 2005.caL = 0	-0.001546	0.9387	1	rt
2005.caH - 2012.caL = 0	-0.03852	0.4613	1	rt
2012.caH - 2005.caL = 0	-0.1357	0.008	0.12	rt
2012.caH - 2012.caL = 0	-0.1727	0	0	rt
2005.caL - 2012.caL = 0	-0.03697	0.57	1	rt
2005 - 2012 = 0	-0.2354	0	0	rs
SJ - caH = 0	-0.03897	0.5433	1	rs
SJ - caL = 0	-0.03078	0.5393	1	rs
caH - caL = 0	0.008188	0.998	1	rs
2005.SJ - 2012.SJ = 0	-0.5419	0	0	rs
2005.SJ - 2005.caH = 0	-0.2894	0	0	rs
2005.SJ - 2012.caH = 0	-0.3534	0	0	rs
2005.SJ - 2005.caL = 0	-0.253	0.001333	0.02	rs
2005.SJ - 2012.caL = 0	-0.3766	0	0	rs
2012.SJ - 2005.caH = 0	0.2525	0	0	rs
2012.SJ - 2012.caH = 0	0.1885	0.003333	0.05	rs
2012.SJ - 2005.caL = 0	0.2889	0	0	rs
2012.SJ - 2012.caL = 0	0.1653	0.003333	0.05	rs
2005.caH - 2012.caH = 0	-0.06397	0.3167	1	rs
2005.caH - 2005.caL = 0	0.03643	0.4947	1	rs
2005.caH - 2012.caL = 0	-0.08717	0.09733	1	rs
2012.caH - 2005.caL = 0	0.1004	0.09733	1	rs
2012.caH - 2012.caL = 0	-0.0232	0.5567	1	rs
2005.caL - 2012.caL = 0	-0.1236	0.01533	0.23	rs
2005 - 2012 = 0	-0.1726	0	0	rrs
SJ - caH = 0	0.1265	0.01667	0.05001	rrs

Comparison	Statistic	p.value	p.adjust	var
SJ - caL = 0	0.2161	0	0	rrs
caH - caL = 0	0.0896	0.03333	0.09999	rrs
2005.SJ - 2012.SJ = 0	-0.2289	0	0	rrs
2005.SJ - 2005.caH = 0	0.1645	0.016	0.24	rrs
2005.SJ - 2012.caH = 0	-0.03947	0.1767	1	rrs
2005.SJ - 2005.caL = 0	0.2024	0.0006667	0.01	rrs
2005.SJ - 2012.caL = 0	0.1018	0.02867	0.43	rrs
2012.SJ - 2005.caH = 0	0.3934	0	0	rrs
2012.SJ - 2012.caH = 0	0.1894	0	0	rrs
2012.SJ - 2005.caL = 0	0.4314	0	0	rrs
2012.SJ - 2012.caL = 0	0.3307	0	0	rrs
2005.caH - 2012.caH = 0	-0.2039	0.0006667	0.01	rrs
2005.caH - 2005.caL = 0	0.03798	0.424	1	rrs
2005.caH - 2012.caL = 0	-0.06271	0.452	1	rrs
2012.caH - 2005.caL = 0	0.2419	0	0	rrs
2012.caH - 2012.caL = 0	0.1412	0.001333	0.02	rrs
2005.caL - 2012.caL = 0	-0.1007	0.048	0.72	rrs

Interaction plot

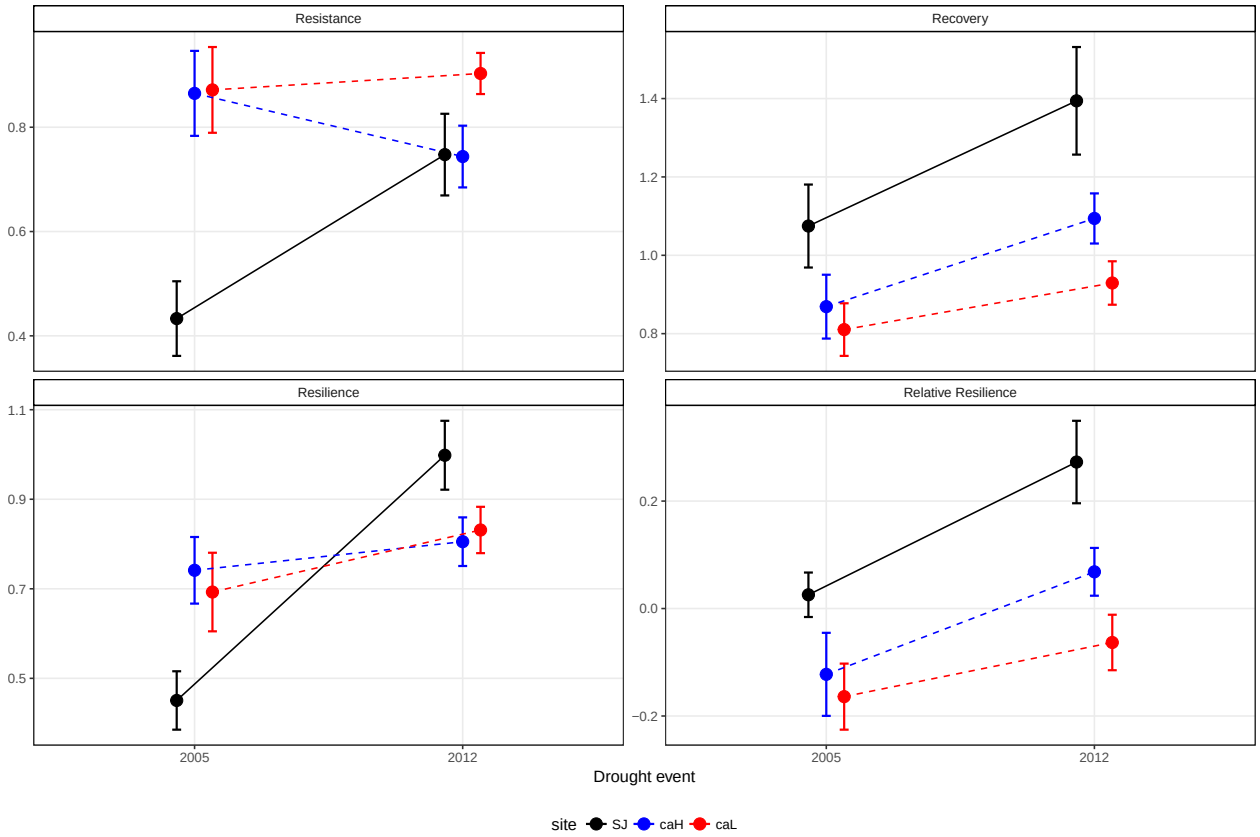
Response ~ (x=Drought)

```
mhuber<- mhuber %>%
  mutate(var_sorted = case_when(var == "rc" ~ "1_rc",
                                var == "rt" ~ "0_rt",
                                var == "rs" ~ "2_rs",
                                var == "rrs" ~ "3_rrs"))

pd <- position_dodge(.2)

robust_plot_rwi_drought <- ggplot(mhuber, aes(x=disturb_year, y=M.Huber, color = site, group=site, fill=
  geom_errorbar(aes(ymin=lower.ci, ymax=upper.ci),
                width=.1, size=0.7, position=pd) +
  geom_line(aes(group=site,color=site, linetype=site), position=pd) +
  geom_point(shape=21, size=3.5, position=pd) +
  facet_wrap(~var_sorted, nrow = 2, scales = 'free_y',
             labeller=as_labeller(c('0_rt' = 'Resistance',
                                    '1_rc' = 'Recovery',
                                    '2_rs' = 'Resilience',
                                    '3_rrs' = 'Relative Resilience'))) +
  scale_color_manual(values=c('black','blue','red')) +
  scale_fill_manual(values=c('black','blue','red')) + theme_bw() +
  scale_linetype_manual(values=c("solid", "dashed", 'dashed')) +
  theme(panel.grid.minor = element_blank(),
        strip.background = element_rect(colour='black',
                                        fill='white'),
        legend.position="bottom") +
  ylab('') + xlab('Drought event')

robust_plot_rwi_drought
```




```
pdf(paste0(di, 'out/resilience_robust/rwi/robust_plot_rwi_drought.pdf'), width=9, height = 9)
robust_plot_rwi_drought
dev.off()
```

```
## pdf
##   2
```

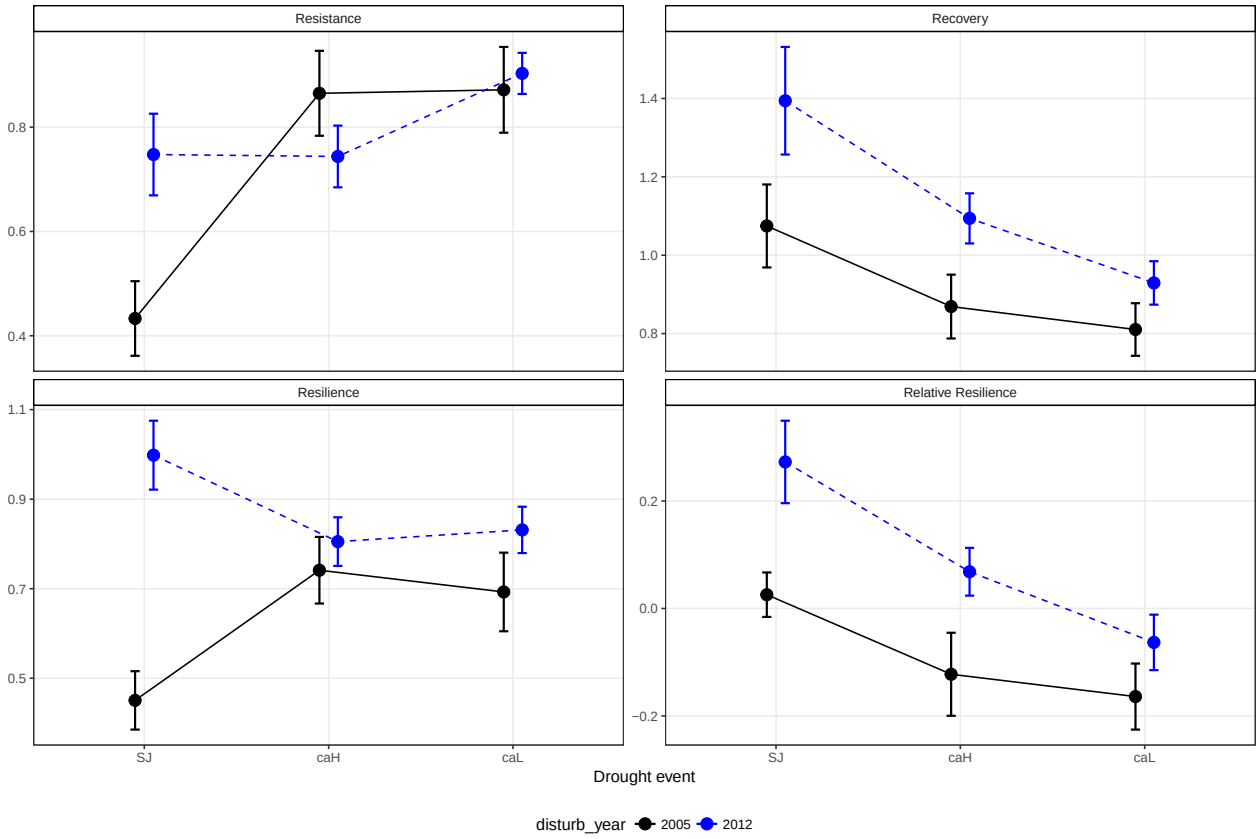
Response ~ (x=site)

```
pd <- position_dodge(.2)

robust_plot_rwi_site <- ggplot(mhuber, aes(x=site, y=M.Huber, color = disturb_year, group=disturb_year,
  geom_errorbar(aes(ymin=lower.ci, ymax=upper.ci),
                width=.1, size=0.7, position=pd) +
  geom_line(aes(group=disturb_year,color=disturb_year, linetype=disturb_year), position=pd) +
  geom_point(shape=21, size=3.5, position=pd) +
  facet_wrap(~var_sorted, nrow = 2, scales = 'free_y',
             labeller=as_labeller(c('0_rt' = 'Resistance',
                                    '1_rc' = 'Recovery',
                                    '2_rs' = 'Resilience',
                                    '3_rrs' = 'Relative Resilience'))) +
  scale_color_manual(values=c('black','blue')) +
  scale_fill_manual(values=c('black','blue')) + theme_bw() +
  scale_linetype_manual(values=c("solid", "dashed")) +
  theme(panel.grid.minor = element_blank(),
        strip.background = element_rect(colour='black',
```

```
                                    fill='white'),
       legend.position="bottom") +
  ylab('') + xlab('Drought event')


robust_plot_rwi_site
```




```
pdf(paste0(di, 'out/resilience_robust/rwi/robust_plot_rwi_site.pdf'), width=9, height = 9)
robust_plot_rwi_site
dev.off()
```

```
## pdf
##   2
```

```
rars$out_ratr_df$var <- 'rs'
rarc$out_ratr_df$var <- 'rc'
rart$out_ratr_df$var <- 'rt'
rarrs$out_ratr_df$var <- 'rrs'


trimmedanovas <- rbind(rarc$out_ratr_df, rart$out_ratr_df, rars$out_ratr_df, rarrs$out_ratr_df)
trimmedanovas %>% pander()
```

fact	statistic	pvalue	var
disturb_year	32.16	0.001	rc
site	54.05	0.001	rc
disturb_year:site	3.728	0.178	rc
disturb_year	8.32	0.006	rt

fact	statistic	pvalue	var
site	73.63	0.001	rt
disturb_year:site	39.08	0.001	rt
disturb_year	71.02	0.001	rs
site	2.863	0.26	rs
disturb_year:site	48.05	0.001	rs
disturb_year	42.14	0.001	rrs
site	67.94	0.001	rrs
disturb_year:site	4.942	0.107	rrs

```
# Export data
write.csv(mhuber, file=paste0(di, '/out/anovas_resilience/huber_rwi/robust_mhuber.csv'), row.names = F)
write.csv(mhuber_agg, file=paste0(di, '/out/anovas_resilience/huber_rwi/robust_mhuber_agg.csv'), row.nar
write.csv(mhuber_a, file=paste0(di, '/out/anovas_resilience/huber_rwi/robust_mhuber_a.csv'), row.names =
write.csv(mhuber_agg_a, file=paste0(di, '/out/anovas_resilience/huber_rwi/robust_mhuber_agg_a.csv'), rou
write.csv(mhuber_b, file=paste0(di, '/out/anovas_resilience/huber_rwi/robust_mhuber_b.csv'), row.names =
write.csv(mhuber_agg_b, file=paste0(di, '/out/anovas_resilience/huber_rwi/robust_mhuber_agg_b.csv'), rou

write.csv(pairwise, file=paste0(di, '/out/anovas_resilience/huber_rwi/robust_pairwise.csv'), row.names =

write.csv(trimmedanovas, file=paste0(di, '/out/anovas_resilience/huber_rwi/trimmed_anovas.csv'), row.nar
```

References