Explore resilience evi

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Prepare data

```
# Read data
raw_evires <- read.csv(file=paste(di, "/data/resilience/resilience_evi.csv", sep=""), header = TRUE, sep

# add data of pop
anomalias <- read.csv(file=paste(di, "/data/anomalies/anomalias_evimean.csv", sep=""), header = TRUE, se

attr_iv_malla_modis_id <- anomalias %>% dplyr::select(iv_malla_modi_id,long,lat,pop) %>% unique()


raw_evires <- raw_evires %>% inner_join(attr_iv_malla_modis_id, by='iv_malla_modi_id')

# filter by pop and add new variable

evires <- raw_evires %>%
  mutate(
    clu_pop = as.factor(case_when(
      pop == 1 ~ "Camarate",
      pop %in% c(2,3,4,5) ~ 'Northern slope',
      pop %in% c(6,7,8) ~ 'Southern slope',
      pop == 9 ~ 'out')),
    clu_pop2 = as.factor(case_when(
      pop %in% c(1,2,3,4,5) ~ 'N',
      pop %in% c(6,7,8) ~ 'S',
      pop == 9 ~ 'out'))) %>%
  filter(clu_pop != 'out')

# Change name of clu_pop2 and disturb_year para los analisis anovas
evires <- evires %>% dplyr::rename(site = clu_pop2) %>%
  mutate(disturb_year = as.factor(disturb_year))
```

ANOVAS

Recovery

Table 1: ANOVA table: rc

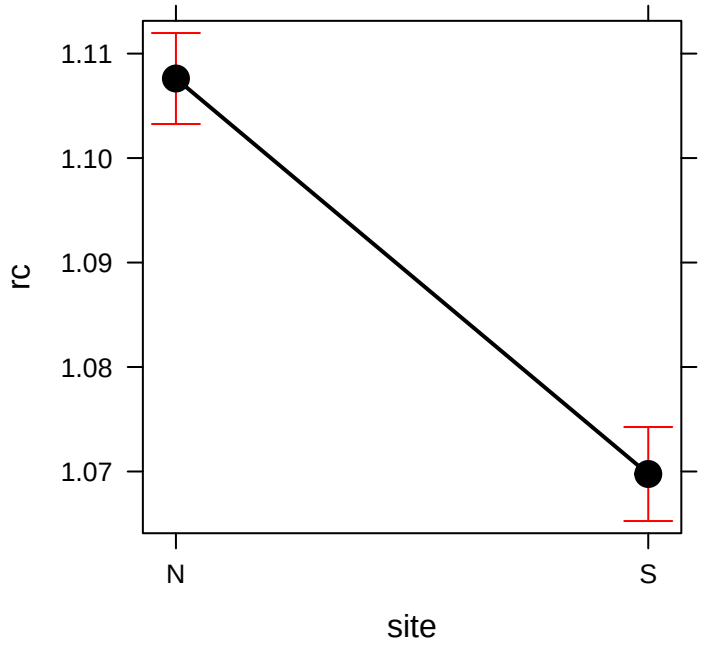
term	df	sumsq	meansq	statistic	p.value
disturb_year	1	1.951	1.951	420.3	**0**
site	1	0.6528	0.6528	140.6	**0**
disturb_year:site	1	1.969	1.969	424.1	**0**
Residuals	1820	8.45	0.00464		

	Statistic
R^2	0.35
adjR^2	0.35
σ_e	0.07
F	328.31
p	0.00
df_m	4.00
logLik	2313.52
AIC	-4617.05
BIC	-4589.50
dev	8.45
df_e	1820.00

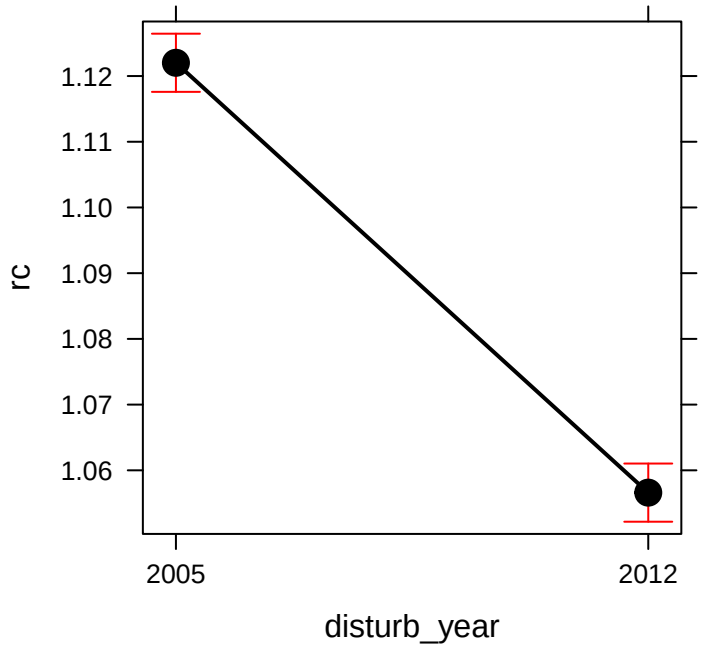
```
# Post hoc Define model
mymodel <- aov_rc$mymodel
postH_rc <- phc(mymodel = mymodel, resp_var = resp_var)
```

```
##
## ### Event ###
## $lsmeans
##  disturb_year   lsmean          SE   df lower.CL upper.CL
##  2005         1.120312 0.002257496 1820 1.115885 1.124740
##  2012         1.057062 0.002257496 1820 1.052634 1.061489
##
## Results are averaged over the levels of: site
## Confidence level used: 0.95
##
## $contrasts
##  contrast      estimate          SE   df t.ratio p.value
##  2005 - 2012 0.06325071 0.003192582 1820  19.812  <.0001
##
## Results are averaged over the levels of: site
##
##  disturb_year   lsmean          SE   df lower.CL upper.CL .group
##  2012         1.057062 0.002257496 1820 1.051998 1.062126  a
##  2005         1.120312 0.002257496 1820 1.115248 1.125377   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
##  N    1.107615 0.002220056 1820 1.103261 1.111969
##  S    1.069759 0.002294326 1820 1.065259 1.074259
##
## Results are averaged over the levels of: disturb_year
## Confidence level used: 0.95
##
## $contrasts
```

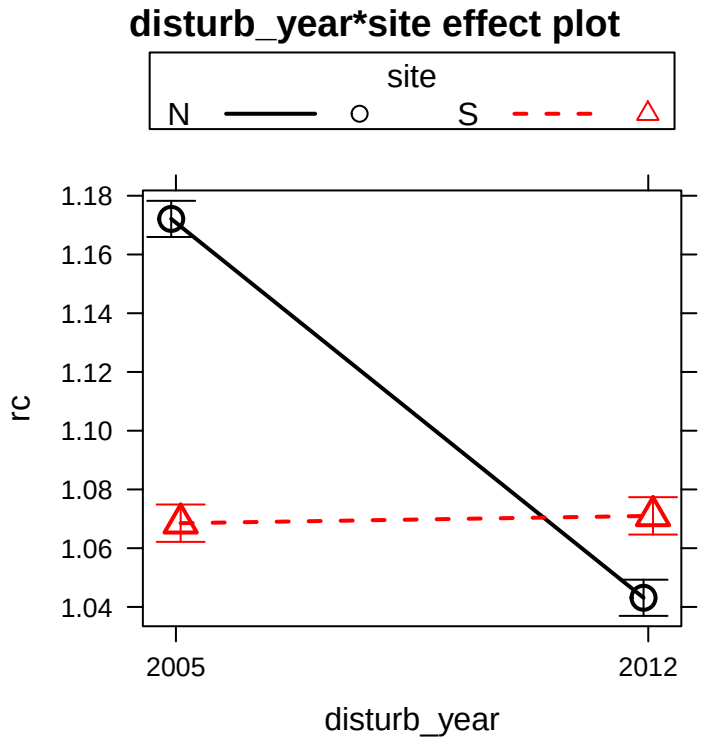
```
##  contrast   estimate          SE   df t.ratio p.value
##  N - S    0.03785579 0.003192582 1820  11.857  <.0001
##
## Results are averaged over the levels of: disturb_year
##
##  site   lsmean          SE   df lower.CL upper.CL .group
##  S    1.069759 0.002294326 1820 1.064612 1.074906  a
##  N    1.107615 0.002220056 1820 1.102635 1.112595   b
##
## Results are averaged over the levels of: disturb_year
## Confidence level used: 0.95
## Conf-level adjustment: bonferroni method for 2 estimates
## significance level used: alpha = 0.01
##
## ### Event:Clu pop ###
## $lsmeans
##  disturb_year site   lsmean          SE   df lower.CL upper.CL
##  2005         N    1.172113 0.003139633 1820 1.165955 1.178271
##  2012         N    1.043117 0.003139633 1820 1.036959 1.049275
##  2005         S    1.068512 0.003244666 1820 1.062148 1.074876
##  2012         S    1.071007 0.003244666 1820 1.064643 1.077370
##
## Confidence level used: 0.95
##
## $contrasts
##  contrast            estimate          SE   df t.ratio p.value
##  2005,N - 2012,N  0.128996090 0.004440112 1820  29.052  <.0001
##  2005,N - 2005,S  0.103601172 0.004514992 1820  22.946  <.0001
##  2005,N - 2012,S  0.101106495 0.004514992 1820  22.394  <.0001
##  2012,N - 2005,S -0.025394918 0.004514992 1820  -5.625  <.0001
##  2012,N - 2012,S -0.027889595 0.004514992 1820  -6.177  <.0001
##  2005,S - 2012,S -0.002494677 0.004588651 1820  -0.544  1.0000
##
## P value adjustment: bonferroni method for 6 tests
ps
```



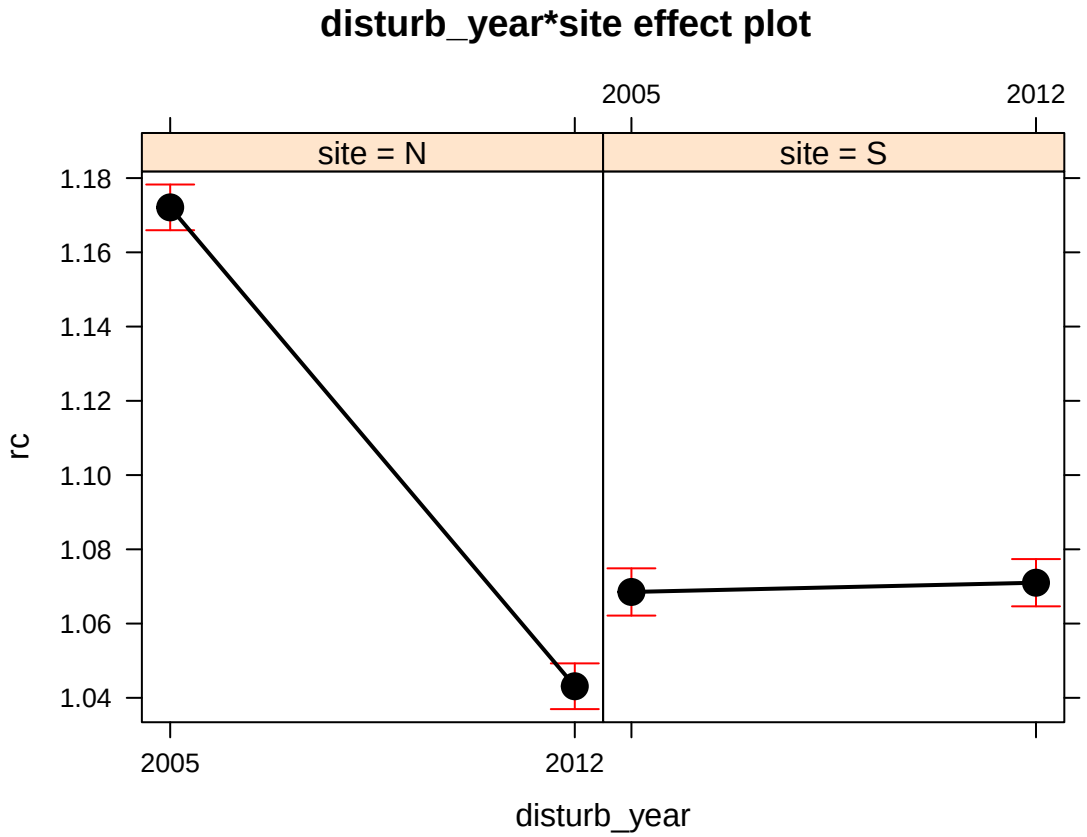

```
pd
```




```
picollapse
```


disturb_year*site effect plot
site
N
S
1.18
1.16
1.14
1.12
1.10
1.08
1.06
1.04
rc
2005
2012
disturb_year

```
pi
```


disturb_year*site effect plot
2005
2012
site = N
site = S
1.18
1.16
1.14
1.12
1.10
1.08
1.06
1.04
rc
2005
2012
disturb_year

Resistance

Table 3: ANOVA table: rt

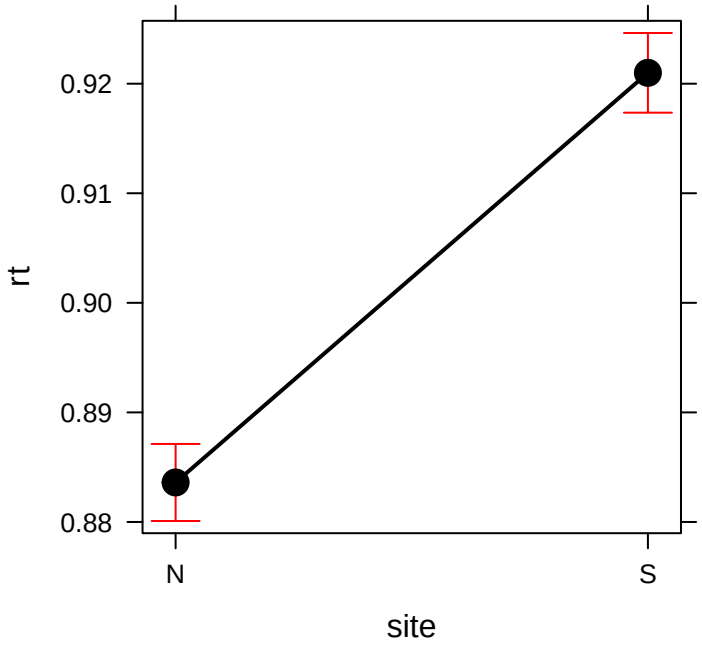
term	df	sumsq	meansq	statistic	p.value
disturb_year	1	3.266	3.266	1079	**0**
site	1	0.6366	0.6366	210.2	**0**
disturb_year:site	1	0.9736	0.9736	321.5	**0**
Residuals	1820	5.511	0.00303		

	Statistic
R^2	0.47
adjR^2	0.47
σ_e	0.06
F	536.85
p	0.00
df_m	4.00
logLik	2703.33
AIC	-5396.66
BIC	-5369.12
dev	5.51
df_e	1820.00

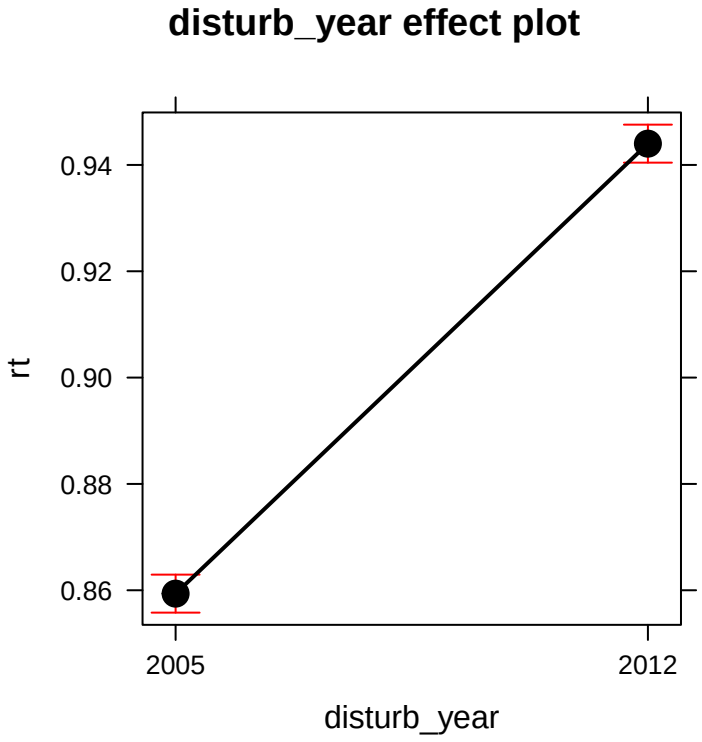
```
# Post hoc Define model
mymodel <- aov_rt$mymodel
postH_rt <- phc(mymodel = mymodel, resp_var = resp_var)
```

```
##
## ### Event ###
## $lsmeans
##  disturb_year    lsmean          SE   df  lower.CL  upper.CL
##  2005         0.8607403 0.001823114 1820 0.8571647 0.8643159
##  2012         0.9438559 0.001823114 1820 0.9402803 0.9474315
##
## Results are averaged over the levels of: site
## Confidence level used: 0.95
##
## $contrasts
##  contrast       estimate          SE   df t.ratio p.value
##  2005 - 2012 -0.08311557 0.002578272 1820 -32.237  <.0001
##
## Results are averaged over the levels of: site
##
##  disturb_year    lsmean          SE   df  lower.CL  upper.CL .group
##  2005         0.8607403 0.001823114 1820 0.8566506 0.8648300  a
##  2012         0.9438559 0.001823114 1820 0.9397662 0.9479456   b
##
## Results are averaged over the levels of: site
## Confidence level used: 0.95
## Conf-level adjustment: bonferroni method for 2 estimates
```

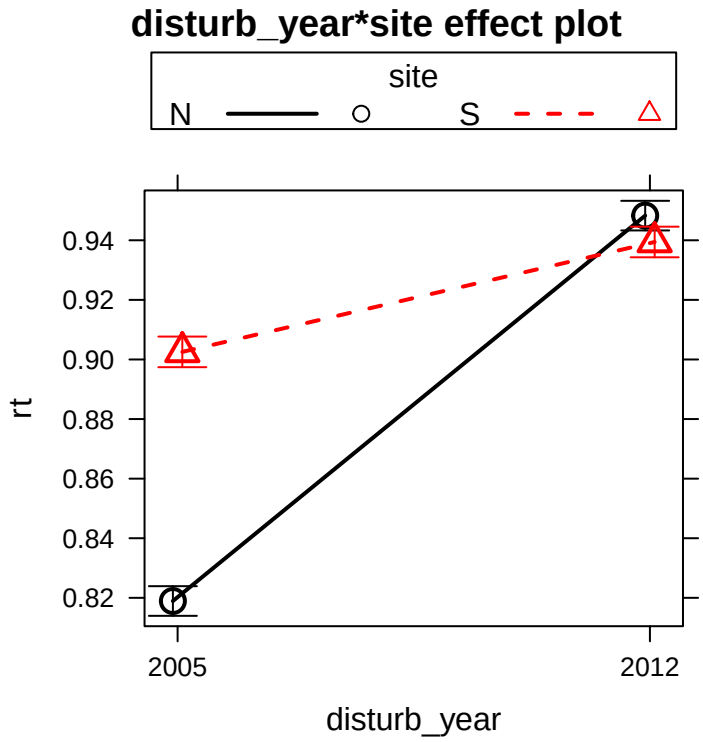
```
## significance level used: alpha = 0.01
##
## ### Clu pop ###
## $lsmeans
##  site    lsmean          SE   df  lower.CL  upper.CL
##  N    0.8836057 0.001792878 1820 0.8800894 0.8871220
##  S    0.9209905 0.001852856 1820 0.9173566 0.9246245
##
## Results are averaged over the levels of: disturb_year
## Confidence level used: 0.95
##
## $contrasts
##  contrast    estimate          SE   df t.ratio p.value
##  N - S    -0.03738486 0.002578272 1820   -14.5  <.0001
##
## Results are averaged over the levels of: disturb_year
##
##  site    lsmean          SE   df  lower.CL  upper.CL .group
##  N    0.8836057 0.001792878 1820 0.8795838 0.8876276  a
##  S    0.9209905 0.001852856 1820 0.9168341 0.9251470   b
##
## Results are averaged over the levels of: disturb_year
## Confidence level used: 0.95
## Conf-level adjustment: bonferroni method for 2 estimates
## significance level used: alpha = 0.01
##
## ### Event:Clu pop ###
## $lsmeans
##  disturb_year site    lsmean          SE   df  lower.CL  upper.CL
##  2005         N    0.8189321 0.002535512 1820 0.8139593 0.8239049
##  2012         N    0.9482792 0.002535512 1820 0.9433064 0.9532521
##  2005         S    0.9025485 0.002620335 1820 0.8974093 0.9076877
##  2012         S    0.9394325 0.002620335 1820 0.9342934 0.9445717
##
## Confidence level used: 0.95
##
## $contrasts
##  contrast           estimate          SE   df t.ratio p.value
##  2005,N - 2012,N -0.12934712 0.003585755 1820 -36.072  <.0001
##  2005,N - 2005,S -0.08361641 0.003646227 1820 -22.932  <.0001
##  2005,N - 2012,S -0.12050043 0.003646227 1820 -33.048  <.0001
##  2012,N - 2005,S  0.04573071 0.003646227 1820  12.542  <.0001
##  2012,N - 2012,S  0.00884669 0.003646227 1820   2.426  0.0921
##  2005,S - 2012,S -0.03688402 0.003705713 1820  -9.953  <.0001
##
## P value adjustment: bonferroni method for 6 tests
ps
```



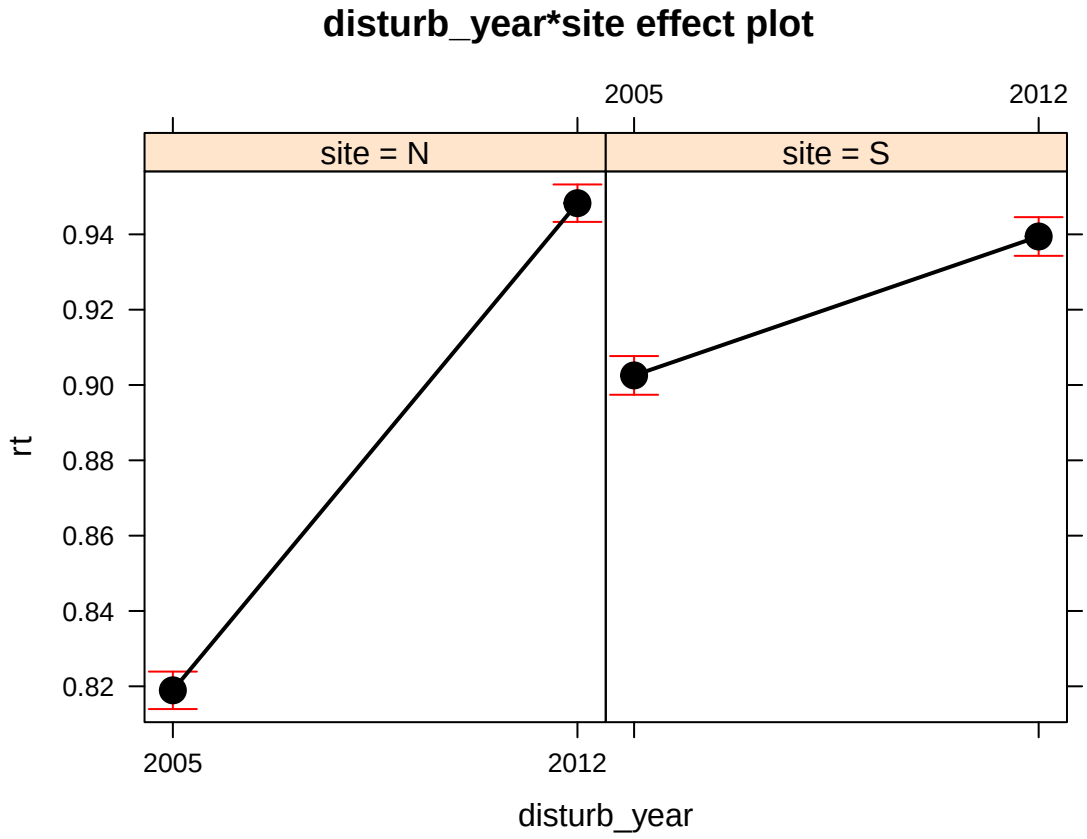

```
pd
```




```
picollapse
```


disturb_year*site effect plot
site
N
S
0.94
0.92
0.90
0.88
0.86
0.84
0.82
rt
2005
2012
disturb_year

```
pi
```


disturb_year*site effect plot
2005
2012
site = N
site = S
0.94
0.92
0.90
0.88
0.86
0.84
0.82
rt
2005
2012
disturb_year

Resilience

Table 5: ANOVA table: rs

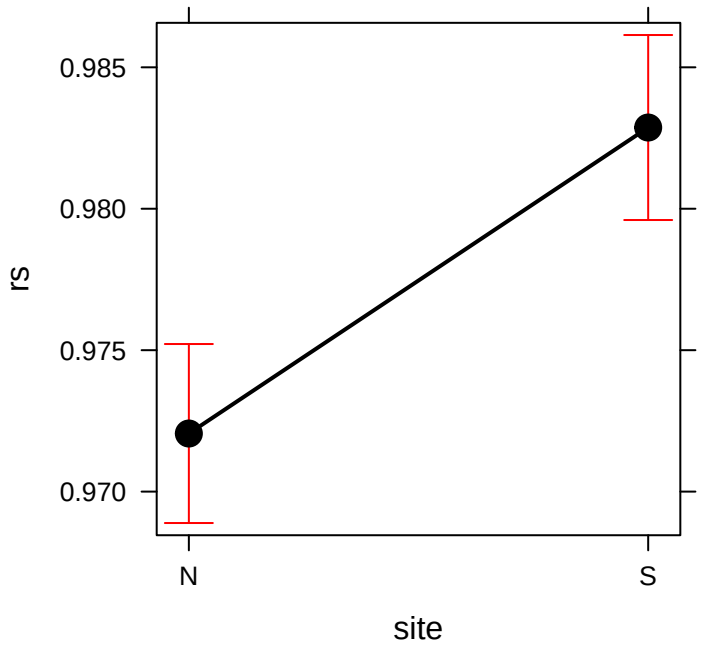
term	df	sumsq	meansq	statistic	p.value
disturb_year	1	0.6334	0.6334	258.4	**0**
site	1	0.0533	0.0533	21.74	**0**
disturb_year:site	1	0.01931	0.01931	7.875	**0.00507**
Residuals	1820	4.462	0.00245		

	Statistic
R^2	0.14
adjR^2	0.14
σ_e	0.05
F	96.00
p	0.00
df_m	4.00
logLik	2895.92
AIC	-5781.83
BIC	-5754.29
dev	4.46
df_e	1820.00

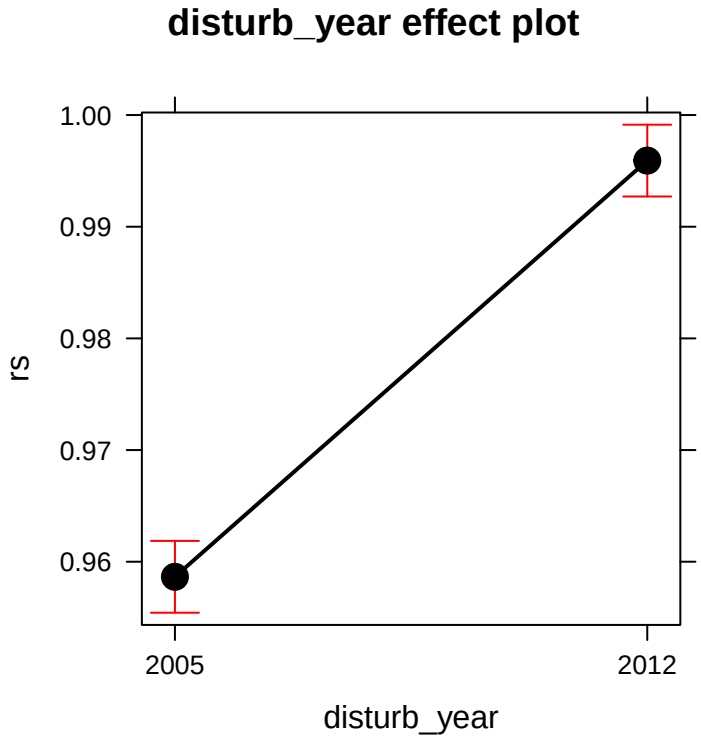
```
# Post hoc Define model
mymodel <- aov_rs$mymodel
postH_rs <- phc(mymodel = mymodel, resp_var = resp_var)
```

```
##
## ### Event ###
## $lsmeans
##  disturb_year    lsmean          SE   df  lower.CL  upper.CL
##  2005         0.9587200 0.001640436 1820 0.9555027 0.9619373
##  2012         0.9962045 0.001640436 1820 0.9929872 0.9994219
##
## Results are averaged over the levels of: site
## Confidence level used: 0.95
##
## $contrasts
##  contrast       estimate          SE   df t.ratio p.value
##  2005 - 2012 -0.03748452 0.002319926 1820 -16.158  <.0001
##
## Results are averaged over the levels of: site
##
##  disturb_year    lsmean          SE   df  lower.CL  upper.CL .group
##  2005         0.9587200 0.001640436 1820 0.9550401 0.9623999  a
##  2012         0.9962045 0.001640436 1820 0.9925246 0.9998844   b
##
## Results are averaged over the levels of: site
## Confidence level used: 0.95
## Conf-level adjustment: bonferroni method for 2 estimates
```

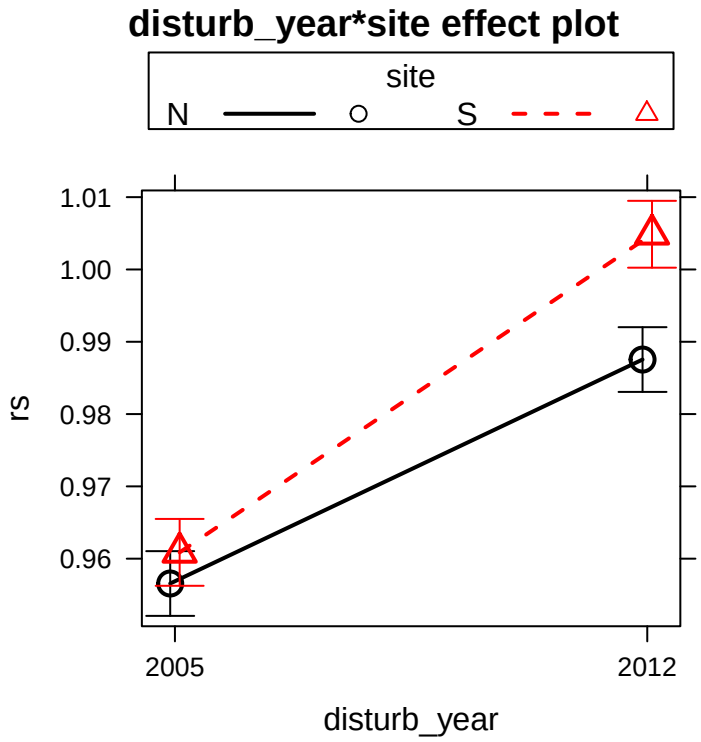
```
## significance level used: alpha = 0.01
##
## ### Clu pop ###
## $lsmeans
##  site    lsmean          SE   df  lower.CL  upper.CL
##  N    0.9720535 0.001613229 1820 0.9688896 0.9752175
##  S    0.9828710 0.001667198 1820 0.9796012 0.9861408
##
## Results are averaged over the levels of: disturb_year
## Confidence level used: 0.95
##
## $contrasts
##  contrast    estimate          SE   df t.ratio p.value
##  N - S    -0.01081743 0.002319926 1820  -4.663  <.0001
##
## Results are averaged over the levels of: disturb_year
##
##  site    lsmean          SE   df  lower.CL  upper.CL .group
##  N    0.9720535 0.001613229 1820 0.9684347 0.9756724  a
##  S    0.9828710 0.001667198 1820 0.9791310 0.9866109   b
##
## Results are averaged over the levels of: disturb_year
## Confidence level used: 0.95
## Conf-level adjustment: bonferroni method for 2 estimates
## significance level used: alpha = 0.01
##
## ### Event:Clu pop ###
## $lsmeans
##  disturb_year site    lsmean          SE   df  lower.CL  upper.CL
##  2005         N    0.9565664 0.002281451 1820 0.9520919 0.9610410
##  2012         N    0.9875407 0.002281451 1820 0.9830661 0.9920152
##  2005         S    0.9608736 0.002357774 1820 0.9562493 0.9654978
##  2012         S    1.0048684 0.002357774 1820 1.0002442 1.0094926
##
## Confidence level used: 0.95
##
## $contrasts
##  contrast            estimate          SE   df t.ratio p.value
##  2005,N - 2012,N -0.030974221 0.003226458 1820  -9.600  <.0001
##  2005,N - 2005,S -0.004307134 0.003280871 1820  -1.313  1.0000
##  2005,N - 2012,S -0.048301950 0.003280871 1820 -14.722  <.0001
##  2012,N - 2005,S  0.026667087 0.003280871 1820   8.128  <.0001
##  2012,N - 2012,S -0.017327728 0.003280871 1820  -5.281  <.0001
##  2005,S - 2012,S -0.043994816 0.003334396 1820 -13.194  <.0001
##
## P value adjustment: bonferroni method for 6 tests
ps
```



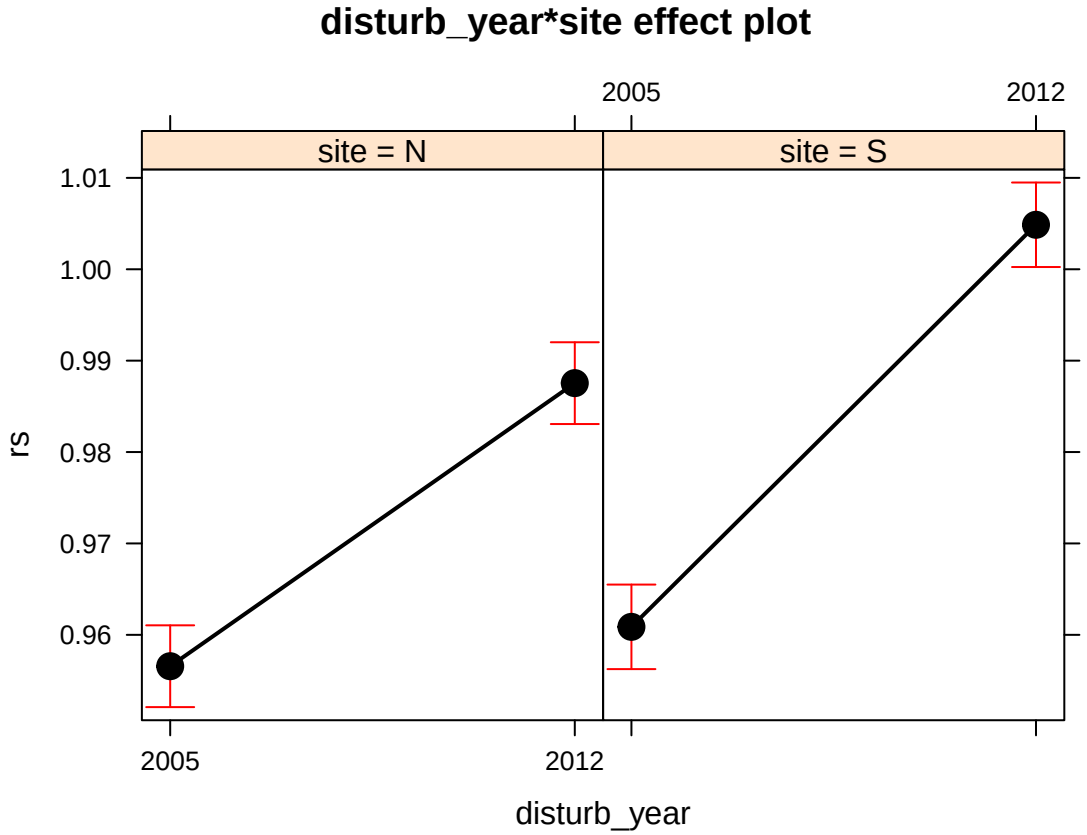

```
pd
```




```
picollapse
```


disturb_year*site effect plot
site
N
S
1.01
1.00
0.99
0.98
0.97
0.96
rs
2005
2012
disturb_year

```
pi
```


disturb_year*site effect plot
2005
2012
site = N
site = S
1.01
1.00
0.99
0.98
0.97
0.96
rs
2005
2012
disturb_year

Relative Resilience

Table 7: ANOVA table: rrs

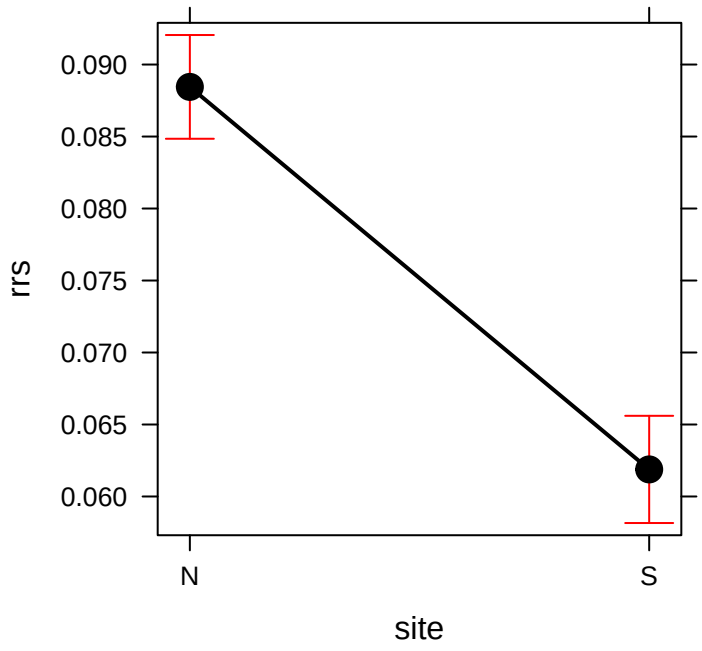
term	df	sumsq	meansq	statistic	p.value
disturb_year	1	1.023	1.023	321.9	**0**
site	1	0.3215	0.3215	101.2	**0**
disturb_year:site	1	1.267	1.267	398.7	**0**
Residuals	1820	5.783	0.00318		

	Statistic
R^2	0.31
adjR^2	0.31
σ_e	0.06
F	273.95
p	0.00
df_m	4.00
logLik	2659.30
AIC	-5308.61
BIC	-5281.06
dev	5.78
df_e	1820.00

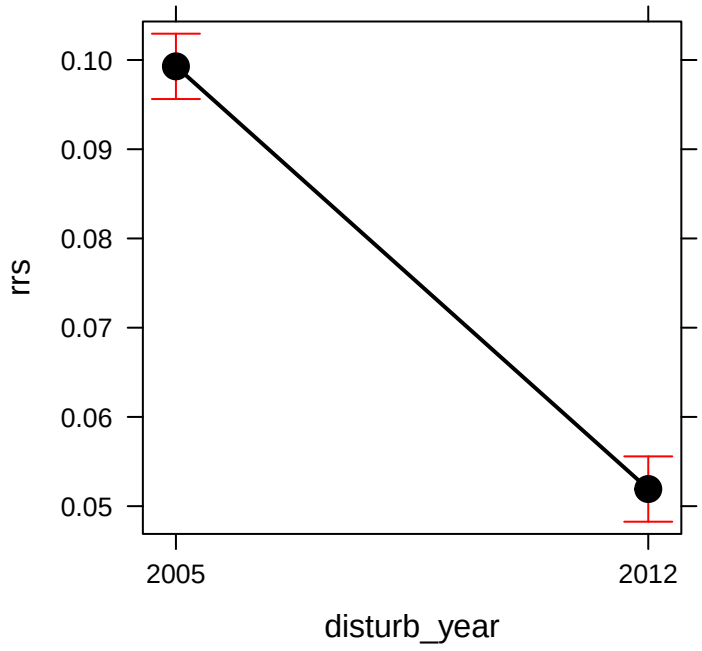
```
# Post hoc Define model
mymodel <- aov_rrs$mymodel
postH_rrs <- phc(mymodel = mymodel, resp_var = resp_var)
```

```
##
## ### Event ###
## $lsmeans
##  disturb_year     lsmean          SE   df   lower.CL  upper.CL
##  2005         0.09797968 0.001867656 1820 0.09431670 0.1016427
##  2012         0.05234863 0.001867656 1820 0.04868565 0.0560116
##
## Results are averaged over the levels of: site
## Confidence level used: 0.95
##
## $contrasts
##  contrast      estimate          SE   df t.ratio p.value
##  2005 - 2012 0.04563105 0.002641264 1820  17.276  <.0001
##
## Results are averaged over the levels of: site
##
##  disturb_year     lsmean          SE   df   lower.CL   upper.CL .group
##  2012         0.05234863 0.001867656 1820 0.04815899 0.05653826  a
##  2005         0.09797968 0.001867656 1820 0.09379004 0.10216931   b
##
## Results are averaged over the levels of: site
## Confidence level used: 0.95
## Conf-level adjustment: bonferroni method for 2 estimates
```

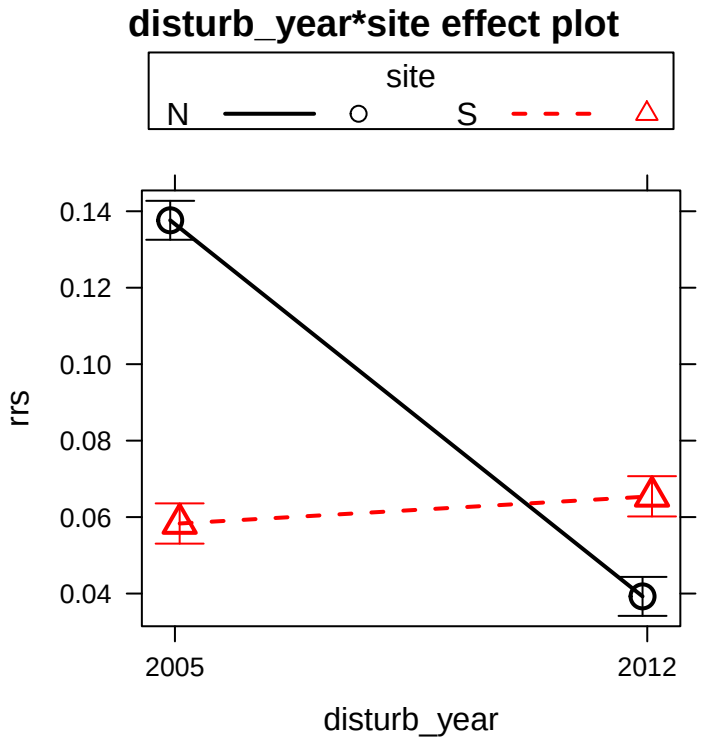
```
## significance level used: alpha = 0.01
##
## ### Clu pop ###
## $lsmeans
##  site     lsmean          SE   df   lower.CL   upper.CL
##  N    0.08844787 0.001836681 1820 0.08484564 0.09205009
##  S    0.06188044 0.001898125 1820 0.05815770 0.06560317
##
## Results are averaged over the levels of: disturb_year
## Confidence level used: 0.95
##
## $contrasts
##  contrast   estimate          SE   df t.ratio p.value
##  N - S    0.02656743 0.002641264 1820  10.059  <.0001
##
## Results are averaged over the levels of: disturb_year
##
##  site     lsmean          SE   df   lower.CL   upper.CL .group
##  S    0.06188044 0.001898125 1820 0.05762245 0.06613842  a
##  N    0.08844787 0.001836681 1820 0.08432772 0.09256802   b
##
## Results are averaged over the levels of: disturb_year
## Confidence level used: 0.95
## Conf-level adjustment: bonferroni method for 2 estimates
## significance level used: alpha = 0.01
##
## ### Event:Clu pop ###
## $lsmeans
##  disturb_year site     lsmean          SE   df  lower.CL   upper.CL
##  2005         N    0.13763432 0.002597459 1820 0.1325400 0.14272863
##  2012         N    0.03926142 0.002597459 1820 0.0341671 0.04435573
##  2005         S    0.05832504 0.002684355 1820 0.0530603 0.06358978
##  2012         S    0.06543584 0.002684355 1820 0.0601711 0.07070057
##
## Confidence level used: 0.95
##
## $contrasts
##  contrast            estimate          SE   df t.ratio p.value
##  2005,N - 2012,N  0.098372900 0.003673362 1820  26.780  <.0001
##  2005,N - 2005,S  0.079309278 0.003735312 1820  21.232  <.0001
##  2005,N - 2012,S  0.072198481 0.003735312 1820  19.329  <.0001
##  2012,N - 2005,S -0.019063621 0.003735312 1820  -5.104  <.0001
##  2012,N - 2012,S -0.026174419 0.003735312 1820  -7.007  <.0001
##  2005,S - 2012,S -0.007110797 0.003796251 1820  -1.873  0.3673
##
## P value adjustment: bonferroni method for 6 tests
ps
```



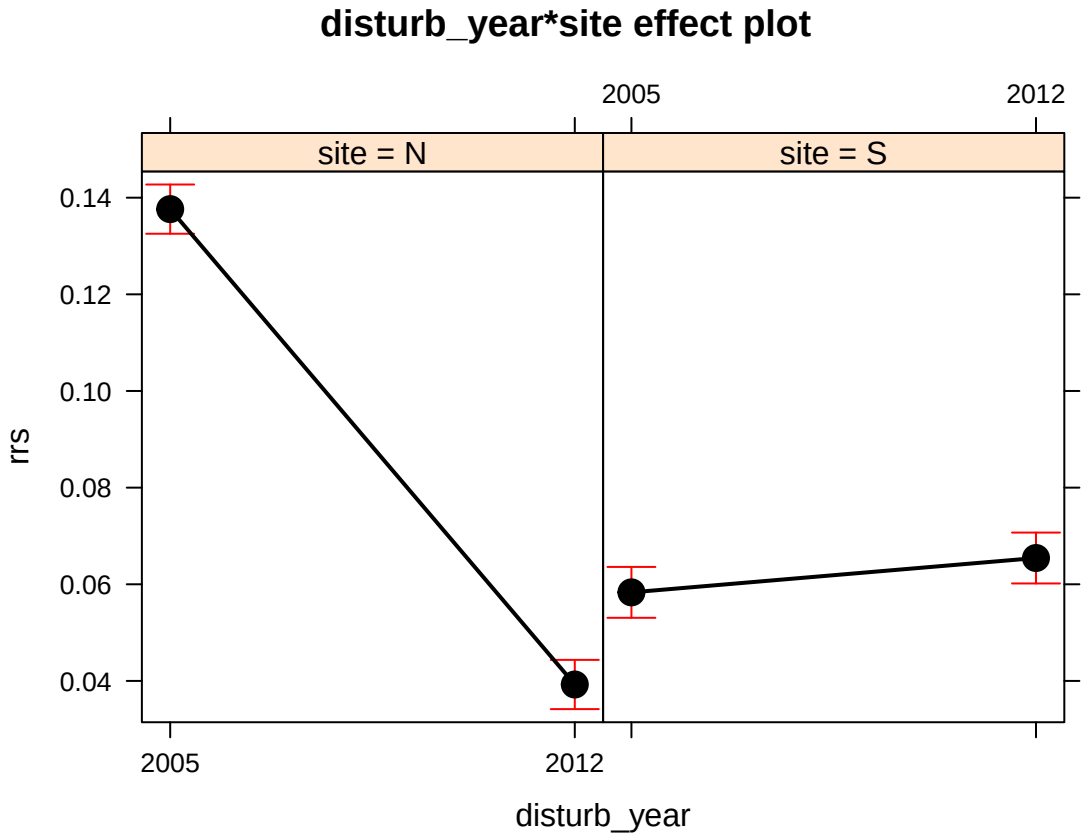

```
pd
```




```
picollapse
```

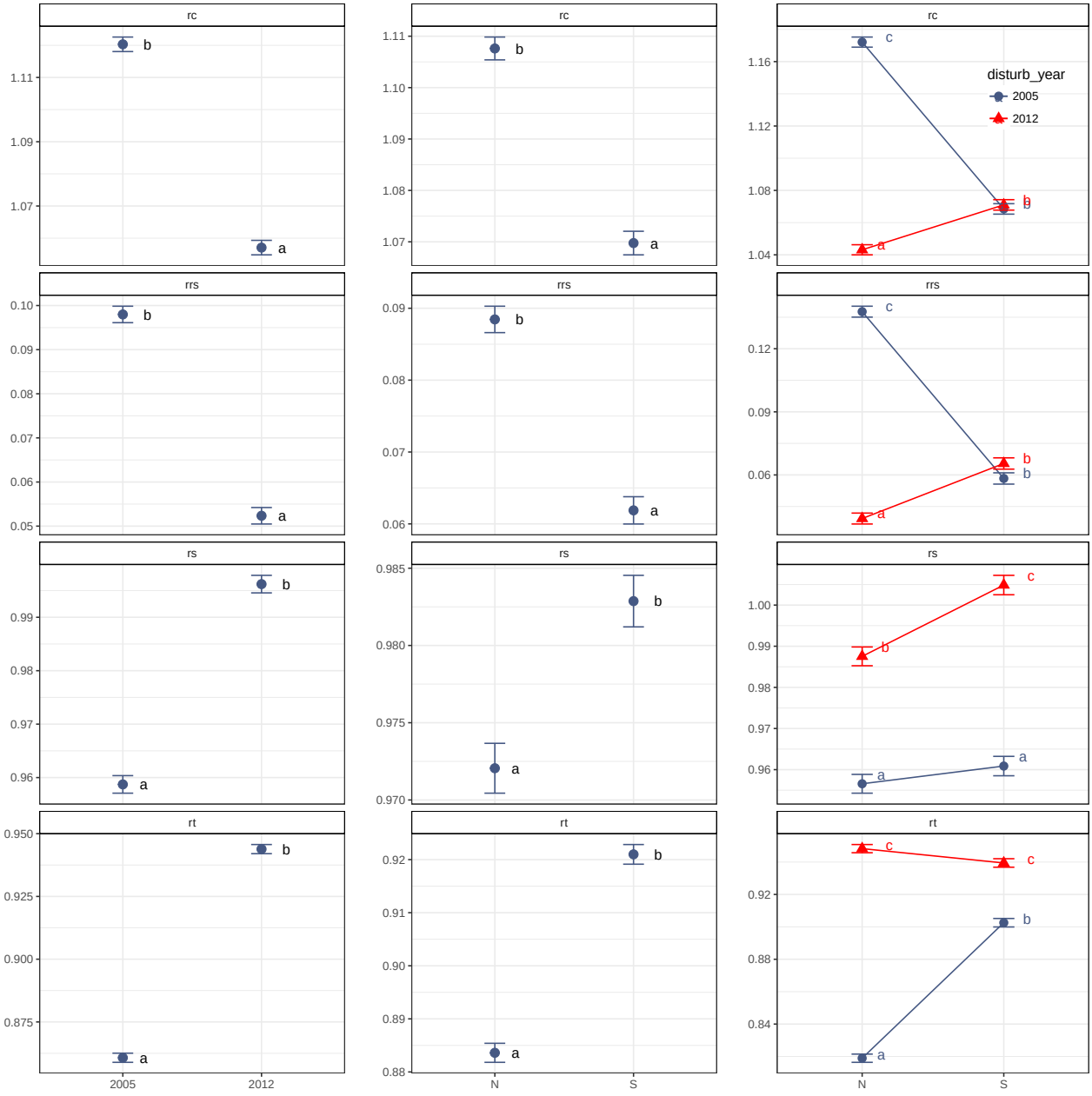

disturb_year*site effect plot
site
N
S
0.14
0.12
0.10
0.08
0.06
0.04
rrs
2005
2012
disturb_year

```
pi
```


disturb_year*site effect plot
2005
2012
site = N
site = S
0.14
0.12
0.10
0.08
0.06
0.04
rrs
2005
2012
disturb_year

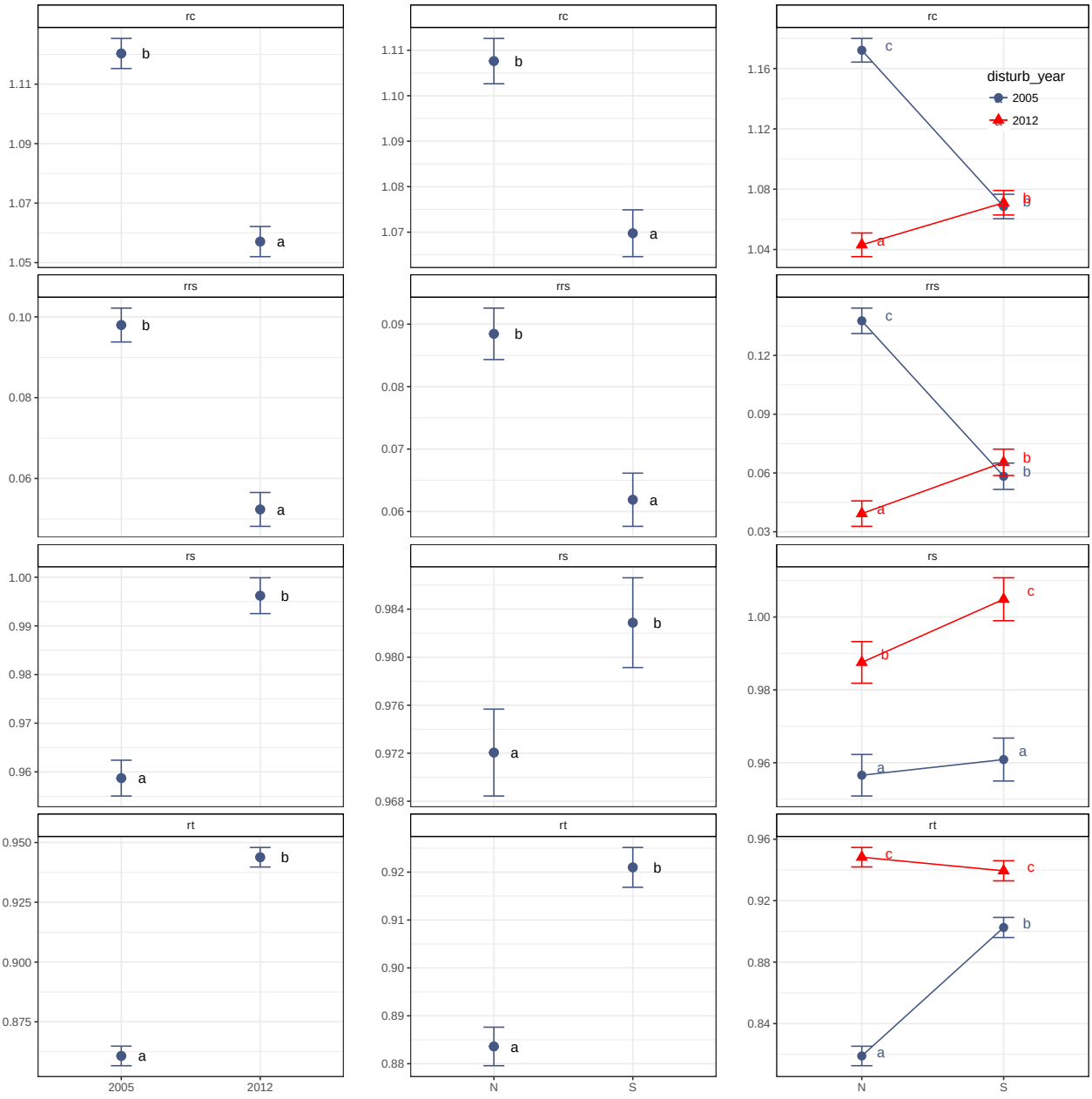
mean + sd

```
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	1.951	1.951	420.3	3.368e-84	rc
site	1	0.6528	0.6528	140.6	2.706e-31	rc
disturb_year:site	1	1.969	1.969	424.1	7.127e-85	rc
Residuals	1820	8.45	0.004643	NA	NA	rc
disturb_year	1	3.266	3.266	1079	3.446e-186	rt
site	1	0.6366	0.6366	210.2	3.608e-45	rt
disturb_year:site	1	0.9736	0.9736	321.5	2.446e-66	rt

term	df	sumsq	meansq	statistic	p.value	var
Residuals	1820	5.511	0.003028	NA	NA	rt
disturb_year	1	0.6334	0.6334	258.4	1.817e-54	rs
site	1	0.0533	0.0533	21.74	3.346e-06	rs
disturb_year:site	1	0.01931	0.01931	7.875	0.005066	rs
Residuals	1820	4.462	0.002452	NA	NA	rs
disturb_year	1	1.023	1.023	321.9	2.05e-66	rrs
site	1	0.3215	0.3215	101.2	3.356e-23	rrs
disturb_year:site	1	1.267	1.267	398.7	2.249e-80	rrs
Residuals	1820	5.783	0.003178	NA	NA	rrs

	rc	rt	rs	rrs
R^2	0.3511444	0.4694715	0.1366188	0.3110905
adjR^2	0.3500749	0.4685970	0.1351956	0.3099549
σ_e	0.06813799	0.05502703	0.04951326	0.05637145
F	328.31282	536.84720	95.99708	273.95212
p	2.291209e-170	7.130860e-250	1.111125e-57	1.015581e-146
df_m	4	4	4	4
logLik	2313.524	2703.332	2895.917	2659.304
AIC	-4617.048	-5396.664	-5781.835	-5308.608
BIC	-4589.504	-5369.120	-5754.291	-5281.064
dev	8.449871	5.510913	4.461844	5.783487
df_e	1820	1820	1820	1820
variable	rc	rt	rs	rrs

Asumptions

```
shapirosNormal <- function(df, resp_var, factor_vars) {
  rv <- enquo(resp_var)
  out <- df %>%
    dplyr::group_by_(.dots=factor_vars) %>%
    dplyr::summarise(statistic = round(shapiro.test(!!rv)$statistic,5),
              p_value = round(shapiro.test(!!rv)$p.value,5)) %>%
    data.frame()

  return(out)
}

homogetest <- function(resp_var, factores, df){

  out_factores <- c()

  for (f in factores){
    hv <- c()
    myformula <- as.formula(paste0(resp_var, "~", f))
    #tests
    fk <- fligner.test(myformula, data = df)
    lv <- leveneTest(myformula, data = df)
    # out
```

```
    hv$fk_stat <- fk$statistic
    hv$fk_pvalue <- fk$p.value
    hv$lev_stat <- lv$`F value`[1]
    hv$lev_pvalue <- lv$`Pr(>F)`[1]
    hv$factor <- f
    hv <- as.data.frame(hv)
    row.names(hv) <- NULL

    out_factores <- rbind(out_factores, hv)}
  return(out_factores)

}
```

- Explorar si se cumplen los supuestos de normalidad y homocedasticidad. Tenemos que comprobar que cada uno de los grupos son normales (2005 vs 2012; N vs S; e interactions)

Normalidad

```
# See auxiliar::shapirosNormal
### Resilience
nrsA<- shapirosNormal(evires, resp_var = rs, 'disturb_year')
nrsA$var <- 'rs'
nrsB <- shapirosNormal(evires, resp_var = rs, 'site')
nrsB$var <- 'rs'
nrsAB <- shapirosNormal(evires, resp_var = rs, c('disturb_year','site'))
nrsAB$var <- 'rs'

### Recovery
nrcA <- shapirosNormal(evires, resp_var = rc, 'disturb_year')
nrcA$var <- 'rc'
nrcB <- shapirosNormal(evires, resp_var = rc, 'site')
nrcB$var <- 'rc'
nrcAB <- shapirosNormal(evires, resp_var = rc, c('disturb_year','site'))
nrcAB$var <- 'rc'

### Resistance
nrtA <- shapirosNormal(evires, resp_var = rt, 'disturb_year')
nrtA$var <- 'rt'
nrtB <- shapirosNormal(evires, resp_var = rt, 'site')
nrtB$var <- 'rt'
nrtAB <- shapirosNormal(evires, resp_var = rt, c('disturb_year','site'))
nrtAB$var <- 'rt'


### Relative Resilience
nrrsA <- shapirosNormal(evires, resp_var = rrs, 'disturb_year')
nrrsA$var <- 'rrs'
nrrsB <- shapirosNormal(evires, resp_var = rrs, 'site')
nrrsB$var <- 'rrs'
nrrsAB <- shapirosNormal(evires, resp_var = rrs, c('disturb_year','site'))
nrrsAB$var <- 'rrs'
```

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

disturb_year	statistic	p_value	var
2005	0.9937	0.00069	rc
2012	0.9952	0.00573	rc
2005	0.9962	0.0248	rt
2012	0.9976	0.2164	rt
2005	0.9989	0.8793	rs
2012	0.9938	8e-04	rs
2005	0.9977	0.2435	rrs
2012	0.9916	5e-05	rrs

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

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

site	statistic	p_value	var
N	0.9768	0	rc
S	0.9889	0	rc
N	0.9909	1e-05	rt
S	0.9981	0.4341	rt
N	0.9901	1e-05	rs
S	0.9968	0.0752	rs
N	0.9942	0.00113	rrs
S	0.9905	2e-05	rrs

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

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

disturb_year	site	statistic	p_value	var
2005	N	0.9873	0.00041	rc
2005	S	0.9922	0.02101	rc
2012	N	0.9907	0.0045	rc
2012	S	0.9905	0.00597	rc
2005	N	0.9932	0.03304	rt
2005	S	0.994	0.07917	rt
2012	N	0.9959	0.2602	rt
2012	S	0.9964	0.4178	rt
2005	N	0.9949	0.1252	rs
2005	S	0.9959	0.3181	rs
2012	N	0.9832	3e-05	rs
2012	S	0.9916	0.01349	rs
2005	N	0.994	0.05822	rrs
2005	S	0.9962	0.3659	rrs

disturb_year	site	statistic	p_value	var
2012	N	0.9961	0.3059	rrs
2012	S	0.9843	0.00011	rrs

```
write.csv(normtestAB,
          file=paste0(di, '/out/anovas_resilience/evi/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

```
## See auxiliar::homogetest

factores <- c('disturb_year', 'site', 'interaction(disturb_year, site)')
responses <- c('rs', 'rc', 'rt', 'rrs')
homo <- c()


for (i in responses){
  ht <- homogetest(resp_var = i, factores = factores, df = evires)
  ht <- ht %>% mutate(response = i)
  homo <- rbind(homo, ht)
}

homo %>% pander()
```

fk_stat	fk_pvalue	lev_stat	lev_pvalue	factor	response
2.525	0.1121	2.648	0.1039	disturb_year	rs
3.839	0.05008	3.789	0.05174	site	rs
17.51	0.0005562	5.914	0.0005166	interaction(disturb_year, site)	rs
211.9	5.368e-48	246.3	3.656e-52	disturb_year	rc
141.3	1.413e-32	150.6	2.554e-33	site	rc
190.7	4.314e-41	70.07	6.952e-43	interaction(disturb_year, site)	rc
63.89	1.317e-15	66.3	7.115e-16	disturb_year	rt
125.1	4.959e-29	131.9	1.555e-29	site	rt
12.28	0.006492	4.056	0.006951	interaction(disturb_year, site)	rt
130.1	3.979e-30	146.9	1.419e-32	disturb_year	rrs
99.79	1.69e-23	105.6	4.123e-24	site	rrs
140.8	2.564e-30	50.69	1.832e-31	interaction(disturb_year, site)	rrs

```
write.csv(homo,
          file=paste0(di, '/out/anovas_resilience/evi/homocedasticidad.csv'), row.names = F)
```

- 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

```
factores <- c('disturb_year', 'site', 'interaction(disturb_year, site)')
responses <- c('logrs', 'logrc', 'logrt', 'logrrs')
homo_log <- c()

evires <- evires %>%
  mutate(
    logrs = log(rs),
    logrc = log(rc),
    logrt = log(rc),
    logrrs = log(rrs)
)

for (i in responses){
  ht <- homogetest(resp_var = i, factores = factores, df = evires)
  ht <- ht %>% mutate(response = i)
  homo_log <- rbind(homo_log, ht)
}

homo_log %>% pander()
```

fk_stat	fk_pvalue	lev_stat	lev_pvalue	factor	response
0.2861	0.5927	0.2493	0.6176	disturb_year	logrs
4.653	0.031	4.631	0.03153	site	logrs
18.81	0.0002987	6.272	0.0003116	interaction(disturb_year, site)	logrs
181.4	2.449e-41	208.7	7.253e-45	disturb_year	logrc
127.8	1.217e-29	136.2	2.146e-30	site	logrc
165.2	1.367e-35	60.48	2.844e-37	interaction(disturb_year, site)	logrc
181.4	2.449e-41	208.7	7.253e-45	disturb_year	logrt
127.8	1.217e-29	136.2	2.146e-30	site	logrt
165.2	1.367e-35	60.48	2.844e-37	interaction(disturb_year, site)	logrt
2.26	0.1328	2.944	0.0864	disturb_year	logrrs
19.95	7.953e-06	16.68	4.642e-05	site	logrrs
116.2	5.156e-25	32.45	2.308e-20	interaction(disturb_year, site)	logrrs

```
write.csv(homo_log,
          file=paste0(di, '/out/anovas_resilience/evi/homocedasticidad_log.csv'), row.names = F)
```

- Tampoco se cumplen

Log + 1

```
factores <- c('disturb_year', 'site', 'interaction(disturb_year, site)')
responses <- c('log1rs', 'log1rc', 'log1rt', 'log1rrs')
homo_log1 <- c()

evires <- evires %>%
  mutate(
    log1rs = log(rs + 1),
    log1rc = log(rc + 1),
    log1rt = log(rc + 1),
    log1rrs = log(rrs +1 )
)

for (i in responses){
  ht <- homogetest(resp_var = i, factores = factores, df = evires)
  ht <- ht %>% mutate(response = i)
  homo_log1 <- rbind(homo_log1, ht)
}

homo_log1 %>% pander()
```

fk_stat	fk_pvalue	lev_stat	lev_pvalue	factor	response
1.128	0.2883	1.152	0.2833	disturb_year	log1rs
4.259	0.03905	4.202	0.04052	site	log1rs
17.94	0.0004531	6.002	0.0004567	interaction(disturb_year, site)	log1rs
196.2	1.4e-44	227.4	1.624e-48	disturb_year	log1rc
134.3	4.666e-31	143.7	6.465e-32	site	log1rc
176.4	5.39e-38	64.66	1.001e-39	interaction(disturb_year, site)	log1rc
196.2	1.4e-44	227.4	1.624e-48	disturb_year	log1rt
134.3	4.666e-31	143.7	6.465e-32	site	log1rt
176.4	5.39e-38	64.66	1.001e-39	interaction(disturb_year, site)	log1rt
107.1	4.152e-25	119.2	6.458e-27	disturb_year	log1rrs
86.45	1.431e-20	91.37	3.696e-21	site	log1rrs
136.2	2.493e-29	49.05	1.747e-30	interaction(disturb_year, site)	log1rrs

```
write.csv(homo_log,
          file=paste0(di, '/out/anovas_resilience/evi/homocedasticidad_log_plus_1.csv'), row.names = F)
```

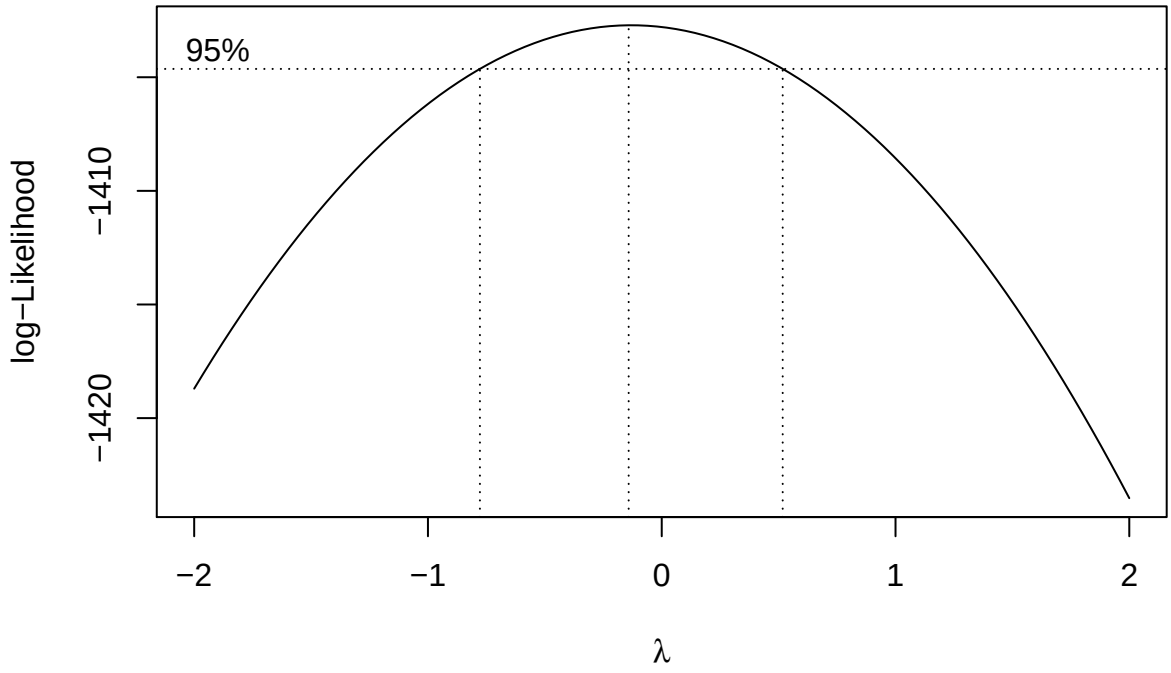
- Tampoco se cumplen

Buscar mejor transformación de Box-Cox

- Buscamos el mejor lambda para cada variable para estudiar posibles transformaciones

Lambda Resilience

```
m  <- lm(rs ~ disturb_year*site, evires)
b <- boxcox(m)
```

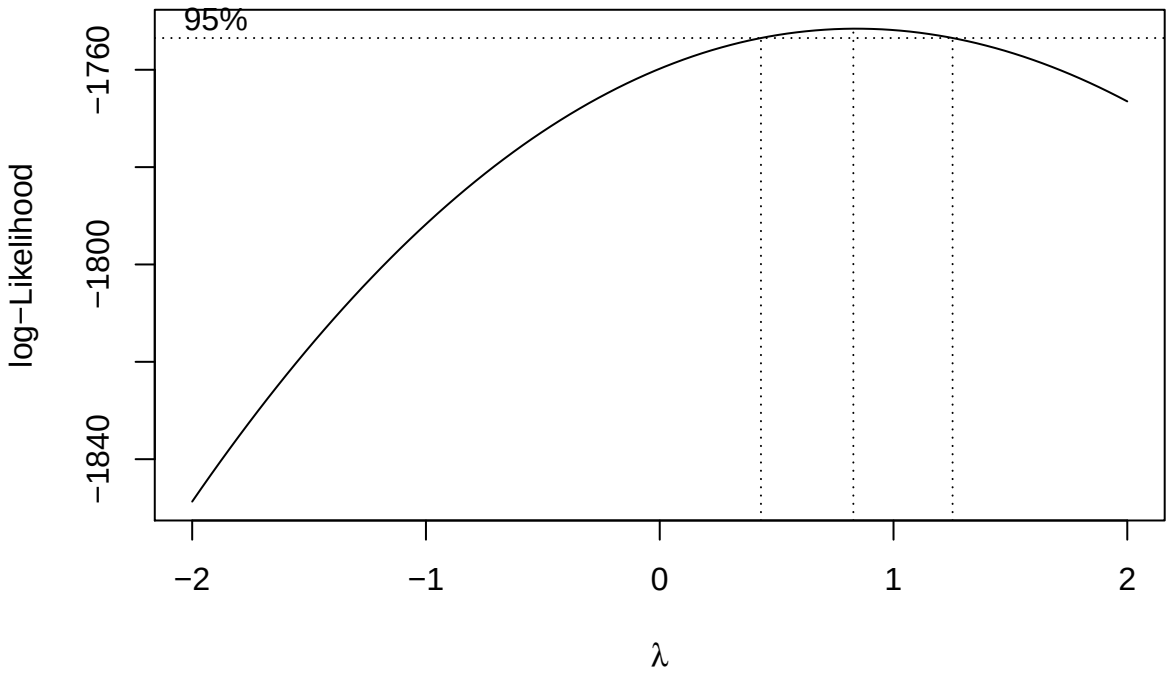



```
b$x[which.max(b$y)]
```

```
## [1] -0.1414141
```

Lambda Resistance

```
m  <- lm(rt ~ disturb_year*site, evires)
b <- boxcox(m)
```

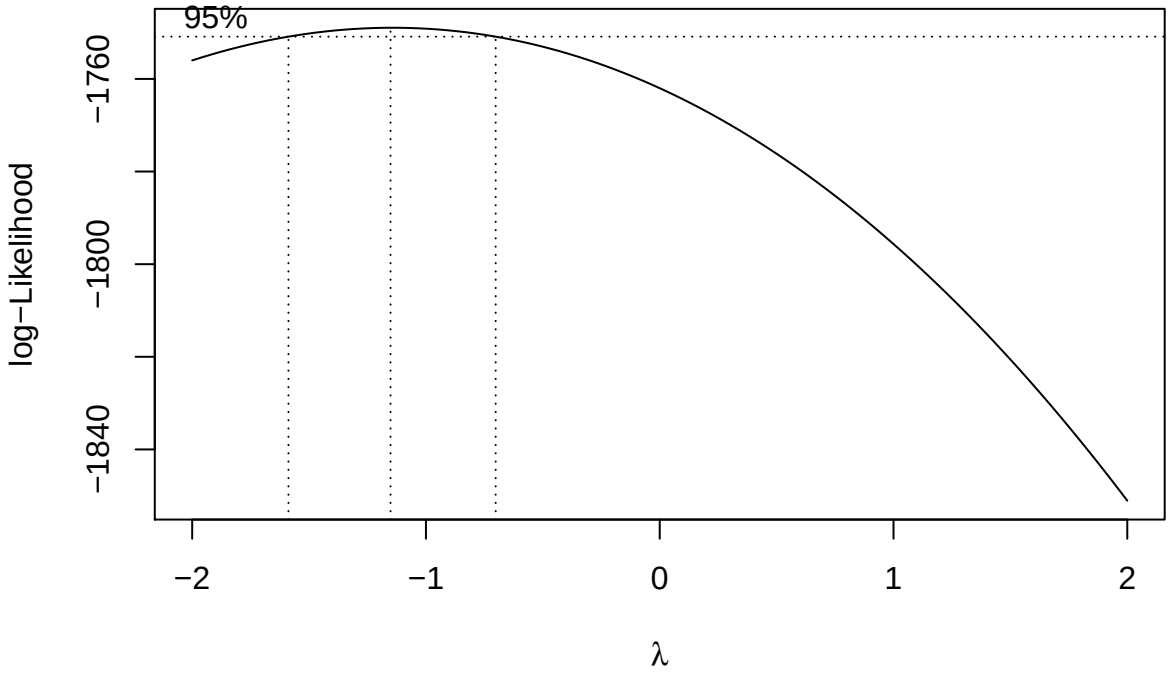



```
b$x[which.max(b$y)]
```

```
## [1] 0.8282828
```

Lambda Recovery

```
m  <- lm(rc ~ disturb_year*site, evires)
b <- boxcox(m)
```




```
b$x[which.max(b$y)]
```

```
## [1] -1.151515
```

Lambda Relative Resilience

```
m  <- lm(rrs ~ disturb_year*site, evires)
b <- boxcox(m)
b$x[which.max(b$y)]
```

Obtengo diferentes lambdas, lo cual complica las transformaciones. Por lo que opto por ROBUST ANOVA

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

```
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


  # 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))

  # 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)

  out <- list()
  out$mest <- mest # Huber M-estimators and Confidence Intervals
  out$mest_a <- mest_a
  out$mest_b <- mest_b
  out$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(out_ra)
  print(phRWS2)

  return(out)
}
```

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

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

```
## [1] "comparison 1 ..."
##
##
## [1] "comparison 1 ..."
##
##
## [1] "comparison 1 ..."
## [1] "comparison 2 ..."
## [1] "comparison 3 ..."
## [1] "comparison 4 ..."
## [1] "comparison 5 ..."
## [1] "comparison 6 ..."
##
##
##                term p_value
## 1      disturb_year   0.000
## 2              site   0.000
## 3 disturb_year:site   0.041
## Call:
```

```
## mcp2a(formula = formulaFull, data = df, est = "mom", nboot = nboot)
##
##                       psihat ci.lower ci.upper p-value
## disturb_year1       -0.07125 -0.08020 -0.06301 0.00000
## site1               -0.02635 -0.03503 -0.01766 0.00000
## disturb_year1:site1  0.01036  0.00292  0.01943 0.01567
```

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
letraBrs
```

```
##   Group Letter MonoLetter var
## 1     N      a         a   rs
## 2     S      b          b  rs
```

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

```
##   Group Letter MonoLetter var
## 1  25.N      a        a    rs
## 2 212.N      b         b   rs
## 3  25.S      a        a    rs
## 4 212.S      c          c  rs
```

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

```
## [1] "comparison 1 ..."
##
##
## [1] "comparison 1 ..."
##
##
## [1] "comparison 1 ..."
## [1] "comparison 2 ..."
## [1] "comparison 3 ..."
## [1] "comparison 4 ..."
## [1] "comparison 5 ..."
## [1] "comparison 6 ..."
##
##
##                term p_value
## 1      disturb_year       0
## 2              site       0
## 3 disturb_year:site       0
## Call:
## mcp2a(formula = formulaFull, data = df, est = "mom", nboot = nboot)
```

```
##
##                       psihat ci.lower ci.upper p-value
## disturb_year1       0.12129  0.11083  0.13372       0
## site1               0.07067  0.05851  0.08113       0
## disturb_year1:site1 0.13400  0.12189  0.14551       0
```

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     N      a         a   rc
## 2     S      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.N      a        a    rc
## 2 212.N      b         b   rc
## 3  25.S      c          c  rc
## 4 212.S      c          c  rc
```

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

```
## [1] "comparison 1 ..."
##
##
## [1] "comparison 1 ..."
##
##
## [1] "comparison 1 ..."
## [1] "comparison 2 ..."
## [1] "comparison 3 ..."
## [1] "comparison 4 ..."
## [1] "comparison 5 ..."
## [1] "comparison 6 ..."
##
##
##                term p_value
## 1      disturb_year       0
## 2              site       0
## 3 disturb_year:site       0
## Call:
## mcp2a(formula = formulaFull, data = df, est = "mom", nboot = nboot)
##
```

```
##                         psihat ci.lower ci.upper p-value
## disturb_year1       -0.16567 -0.17504 -0.15672       0
## site1               -0.07410 -0.08271 -0.06395       0
## disturb_year1:site1 -0.09022 -0.09967 -0.08074       0
```

Rt Letters

```
x <-rart

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

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

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

```
##   Group Letter MonoLetter var
## 1     N      a         a   rt
## 2     S      b          b  rt
```

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

```
##   Group Letter MonoLetter var
## 1  25.N      a        a    rt
## 2 212.N      b         b   rt
## 3  25.S      c          c  rt
## 4 212.S      b         b   rt
```

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

```
## [1] "comparison 1 ..."
##
##
## [1] "comparison 1 ..."
##
##
## [1] "comparison 1 ..."
## [1] "comparison 2 ..."
## [1] "comparison 3 ..."
## [1] "comparison 4 ..."
## [1] "comparison 5 ..."
## [1] "comparison 6 ..."
##
##
##                term p_value
## 1      disturb_year       0
## 2              site       0
## 3 disturb_year:site       0
## Call:
## mcp2a(formula = formulaFull, data = df, est = "mom", nboot = nboot)
##
##                      psihat ci.lower ci.upper p-value
```

```
## disturb_year1       0.09017  0.08039  0.09934       0
## site1               0.04760  0.03845  0.05692       0
## disturb_year1:site1 0.10647  0.09719  0.11625       0
```

```
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     N      a          a  rrs
## 2     S      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.N      a         a   rrs
## 2 212.N      b          b  rrs
## 3  25.S      c           c rrs
## 4 212.S      c           c 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	N	471	1.169	(1.161,1.1768)	a
rc	2005	S	441	1.066	(1.0584,1.0741)	c
rc	2012	N	471	1.042	(1.0364,1.047)	b
rc	2012	S	441	1.071	(1.0674,1.0748)	c
rt	2005	N	471	0.819	(0.8137,0.8243)	a
rt	2005	S	441	0.9016	(0.8958,0.9074)	c
rt	2012	N	471	0.9472	(0.9423,0.9521)	b
rt	2012	S	441	0.9387	(0.9336,0.9438)	b
rs	2005	N	471	0.9553	(0.9507,0.9599)	a
rs	2005	S	441	0.9618	(0.9573,0.9663)	a
rs	2012	N	471	0.9855	(0.9805,0.9905)	b
rs	2012	S	441	1.004	(0.9996,1.0081)	c
rrs	2005	N	471	0.1362	(0.1304,0.142)	a
rrs	2005	S	441	0.0582	(0.0514,0.065)	c
rrs	2012	N	471	0.0388	(0.034,0.0437)	b
rrs	2012	S	441	0.0662	(0.0629,0.0695)	c

```
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	912	1.12	(1.1131,1.1262)	a
rc	2012	912	1.057	(1.0537,1.0604)	b

var	disturb_year	n	M.Huber	ci	Letter
rt	2005	912	0.8584	(0.8535,0.8633)	a
rt	2012	912	0.9431	(0.9396,0.9466)	b
rs	2005	912	0.9585	(0.9553,0.9617)	a
rs	2012	912	0.9947	(0.9913,0.998)	b
rrs	2005	912	0.0999	(0.0948,0.1051)	a
rrs	2012	912	0.0533	(0.0502,0.0563)	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	N	942	1.102	(1.0958,1.1084)	a
rc	S	882	1.069	(1.0652,1.0729)	b
rt	N	942	0.8835	(0.8777,0.8893)	a
rt	S	882	0.9207	(0.9167,0.9246)	b
rs	N	942	0.9701	(0.9666,0.9737)	a
rs	S	882	0.983	(0.9797,0.9864)	b
rrs	N	942	0.0866	(0.0816,0.0917)	a
rrs	S	882	0.063	(0.0596,0.0664)	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	0.05994	0	0	rc
N - S = 0	0.03308	0	0	rc

Comparison	Statistic	p.value	p.adjust	var
2005.N - 2012.N = 0	0.1276	0	0	rc
2005.N - 2005.S = 0	0.1023	0	0	rc
2005.N - 2012.S = 0	0.09598	0	0	rc
2012.N - 2005.S = 0	-0.02531	0	0	rc
2012.N - 2012.S = 0	-0.03167	0	0	rc
2005.S - 2012.S = 0	-0.006357	0.2047	1	rc
2005 - 2012 = 0	-0.0853	0	0	rt
N - S = 0	-0.03784	0	0	rt
2005.N - 2012.N = 0	-0.1279	0	0	rt
2005.N - 2005.S = 0	-0.08216	0	0	rt
2005.N - 2012.S = 0	-0.1199	0	0	rt
2012.N - 2005.S = 0	0.04579	0	0	rt
2012.N - 2012.S = 0	0.008059	0.03267	0.196	rt
2005.S - 2012.S = 0	-0.03773	0	0	rt
2005 - 2012 = 0	-0.03583	0	0	rs
N - S = 0	-0.01344	0	0	rs
2005.N - 2012.N = 0	-0.03045	0	0	rs
2005.N - 2005.S = 0	-0.007997	0.01933	0.116	rs
2005.N - 2012.S = 0	-0.0488	0	0	rs
2012.N - 2005.S = 0	0.02245	0	0	rs
2012.N - 2012.S = 0	-0.01835	0	0	rs
2005.S - 2012.S = 0	-0.0408	0	0	rs
2005 - 2012 = 0	0.04601	0	0	rrs
N - S = 0	0.02191	0	0	rrs
2005.N - 2012.N = 0	0.09832	0	0	rrs
2005.N - 2005.S = 0	0.07703	0	0	rrs
2005.N - 2012.S = 0	0.06889	0	0	rrs
2012.N - 2005.S = 0	-0.02129	0	0	rrs
2012.N - 2012.S = 0	-0.02943	0	0	rrs
2005.S - 2012.S = 0	-0.008148	0.03267	0.196	rrs

Interaction plot

Response ~ (x=Drought)

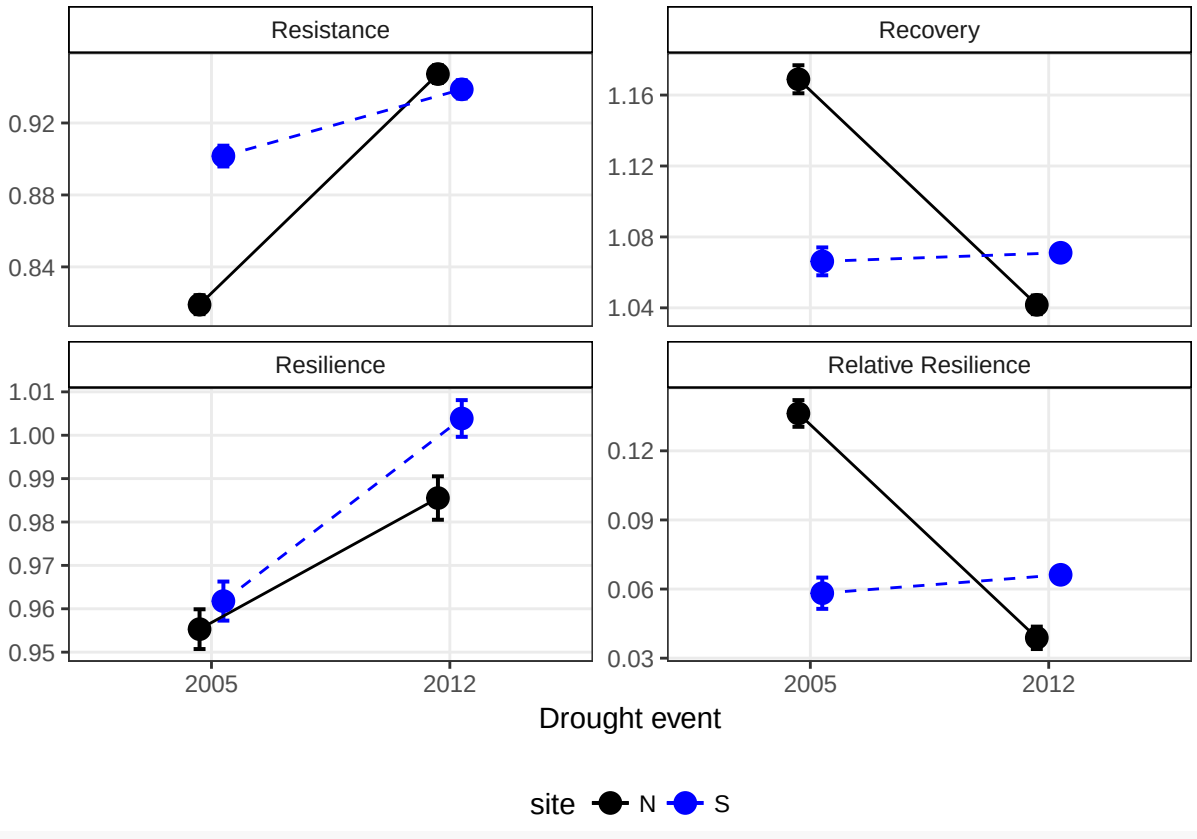
```
mhuber<- mhuber %>%
  mutate(var_sorted = case_when(var == "rc" ~ "1_rc",
                                var == "rt" ~ "0_rt",
                                var == "rs" ~ "2_rs",
                                var == "rrs" ~ "3_rrs"))

pd <- position_dodge(.2)

robust_plot_evi_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')) +
  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_evi_drought
```




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

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

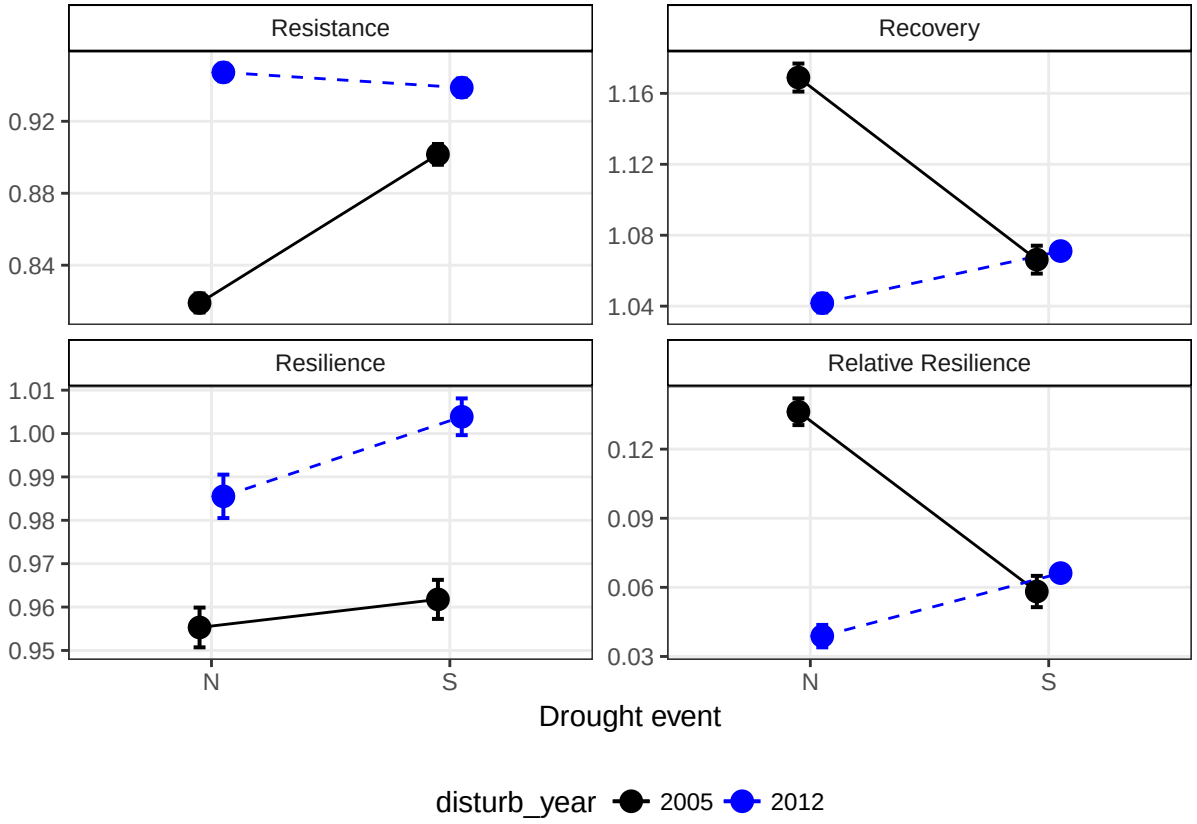
Response ~ (x=site)

```
pd <- position_dodge(.2)

robust_plot_evi_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_evi_site
```




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

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

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

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