Sunset Crater Rock Lichen Community Composition

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1 Questions for Co-Authors

1. Were all measurments a part of the same quadrat?

2. I.E., are lichen/bryophyte measurements ablsolute or a proportion of available habitat?

3. Rikke and Cameron, how were the lichen/bryophyte measurements done?

4. Richard, how were the plant and light measurements done?

2 Things to Do

- Check Resistance vs Susceptible in barplots

- Chekc on bird preference

- Compile trait data from database

- Check on co-occurrence

- Do indicator species sems or summed species sems

- multiple resgresion for variables on community

3 Do rock lichen communities respond to phenotypic variation in a foundation species?

3.1 Load and Pre-Process Data

```
> key <- read.csv('/Users/Aeolus/Documents/Active_Projects/Sunset_Crater_Lichens/dat
> x <- read.csv('/Users/Aeolus/Documents/Active_Projects/Sunset_Crater_Lichens/data/
>                                              #remove dead
> x <- x[x$Live.Dead == 1,]
> com <- x[,((1:ncol(x))[colnames(x) == 'Acacon']):((1:ncol(x))[colnames(x) == 'Xanel
> env <- x[,1:12]
>                                              #remove N and S light
> env <- env[,-10:-11]
>                                              #flip R and
> ## env$Moth[env$Moth==0] <- 2
> ## env$Moth[env$Moth==1] <- 0
> ## env$Moth[env$Moth==2] <- 1
>                                              #fix colnames
> colnames(env) <- sub('\\.\\.','',colnames(env))
> colnames(env)
```

```
[1] "Tree.pairs"    "Moth"          "Live.Dead"     "Litter"
[5] "Big.rocks"     "Small.rocks"   "Shrubs"        "Grass"
[9] "Branches"      "Light.average"
```

>

3.2 Analysis of Moth Affects on "Env" Variables
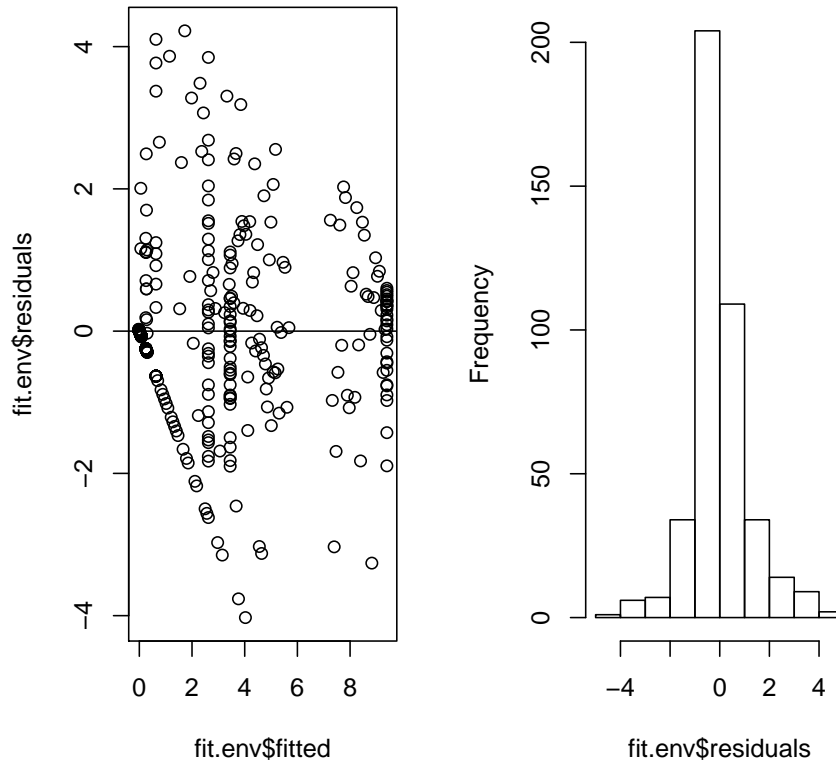
> *shapiro.test(fit.env$residuals)*

```
        Shapiro-Wilk normality test

data:  fit.env$residuals
W = 0.9019, p-value = 8.339e-16
```

> *par(mfrow=c(1,2))*

> *plot(fit.env$residuals~fit.env$fitted)*

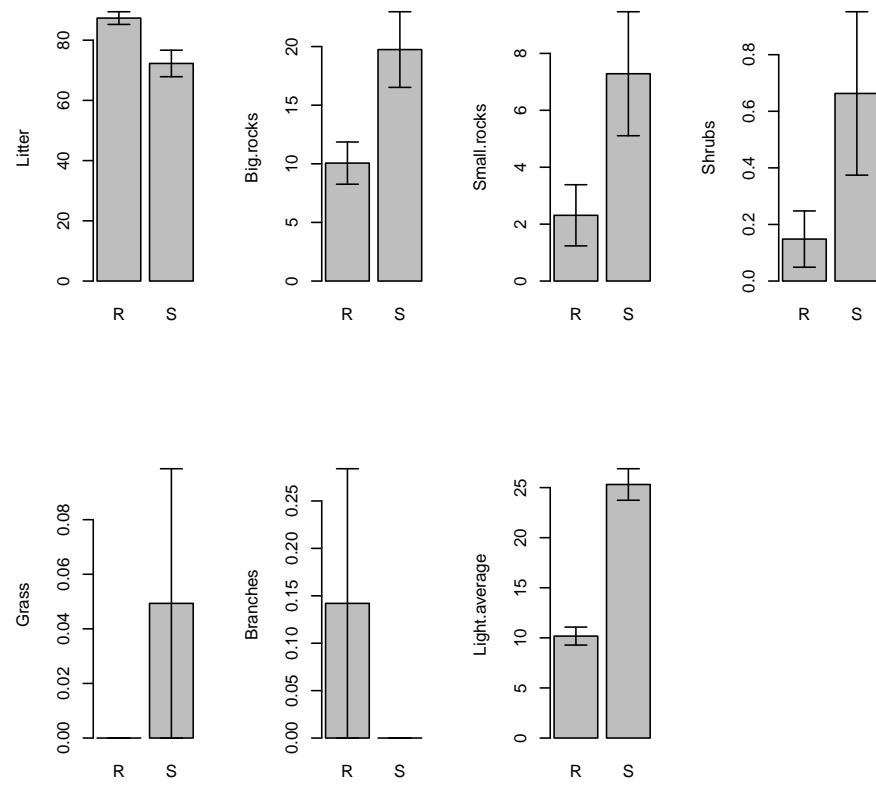> *abline(h=0)*

> *hist(fit.env$residuals)*

>

Histogram of fit.env$residual


```
> library(gplots)

> par(mfrow=c(2,4))

> for (i in 4:ncol(env)){

+    mu <- tapply(env[,i],env$Moth,mean)

+    se <- tapply(env[,i],env$Moth,function(x)sd(x)/sqrt(length(x)))

+    x.names <- unique(env$Moth)

+    x.names[x.names==1] <- 'R'

+    x.names[x.names==0] <- 'S'

+    barplot2(mu,plot.ci=TRUE,ci.l=mu-se,ci.u=mu+se,ylab=colnames(env)[i],names=x.na
```
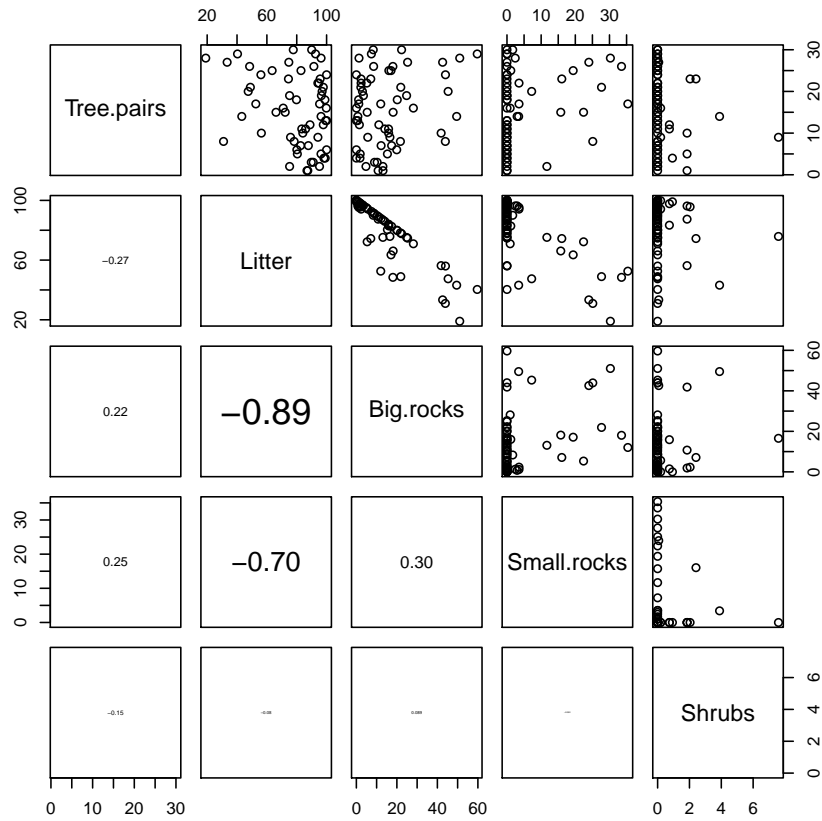
```
+ }

>
```



```
>    pairs(env[,c(-2:-3,-8:-11)],lower.panel=panel.cor)

>
```

4 Community Response to Moth

4.1 Sampling

```
> library(vegan)
> spac <- specaccum(com)
> plot(spac,xlab='Number of Trees',ylab='Number of Lichen Species')
>
```

4.2 Abundance, Richness and Diversity

```
>                                       #abundance
> A <- apply(com,1,sum)
> A.fit <- glm(log(A+1)~Moth:Tree.pairs,data=env)
>                                       #richness
> R <- apply(com,1,function(x) length(x[x!=0]))
> R.fit <- glm(R~Moth:Tree.pairs,data=env,family='poisson')
>                                       #Shannon's diversity
> H <- apply(com,1,diversity)
> H.fit <- glm(H~Moth:Tree.pairs,data=env)
>

> library(xtable)
> xtable(summary(A.fit))
```

	Estimate	Std. Error	t value	Pr($>$|t|)
(Intercept)	0.6388	0.1172	5.45	0.0000
Moth:Tree.pairs	0.0182	0.0093	1.95	0.0555

```
> xtable(summary(R.fit))


> xtable(summary(H.fit))


>
```

	Estimate	Std. Error	z value	Pr($>$|z|)
(Intercept)	1.3234	0.0832	15.91	0.0000
Moth:Tree.pairs	0.0209	0.0057	3.66	0.0002

	Estimate	Std. Error	t value	Pr($>$|t|)
(Intercept)	0.7461	0.1074	6.94	0.0000
Moth:Tree.pairs	0.0205	0.0086	2.40	0.0197

4.3   Composition

```
>                                        #paired test of composition
> ds <- rep(min(com[com!=0]),nrow(com))
> com. <- cbind(com,ds)
> adonis(com.~env$Moth:env$Tree.pairs)

Call:
adonis(formula = com. ~ env$Moth:env$Tree.pairs)


Terms added sequentially (first to last)


                        Df SumsOfSqs MeanSqs F.Model      R2 Pr(>F)
env$Moth:env$Tree.pairs  1    0.8211 0.82114  2.5772 0.04254  0.037 *
Residuals               58   18.4799 0.31862         0.95746
Total                   59   19.3010                 1.00000
---
Signif. codes:  0 âĂŸ***âĂŹ 0.001 âĂŸ**âĂŹ 0.01 âĂŸ*âĂŹ 0.05 âĂŸ.âĂŹ 0.1 âĂŸ âĂŹ 1
```

```
> ##                                              #mvabund
> ## attach(env)
> ## mva.com <- com[,apply(com,2,sum)!=0]
> ##                                              #many glm with gaussian distribution
> ## mva.com <- apply(mva.com,2,sqrt)
> ## mva.com <- mvabund(mva.com)
> ## glm.fit <- manyglm(mva.com~Moth:Tree.pairs,family='gaussian')
> ## detach(env)
> ## anova(glm.fit)
>

>                                              #paired distance based
> d. <- as.matrix(vegdist(com.))
> pd <- 0
> for (i in 1:(nrow(d.)-1)){
+    pd[i] <- d.[(i+1),i]
+ }
> pd. <- pd[(1:length(pd)) %% 2 == 1]
> wilcox.test(pd.,exact=FALSE)

        Wilcoxon signed rank test with continuity correction


data:  pd.
V = 406, p-value = 4.003e-06
alternative hypothesis: true location is not equal to 0

> env.. <- env[(1:nrow(env)) %% 2 == 1,]
> library(tweedie)
```

```
> glm. <- glm(pd.~Light.average*Litter*Big.rocks,data=env..,family=tweedie(2))
>

> xtable(summary(glm.))
```

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-0.8025	3.4980	-0.23	0.8207
Light.average	0.1093	0.1556	0.70	0.4897
Litter	0.0339	0.0395	0.86	0.4001
Big.rocks	0.0378	0.0733	0.51	0.6117
Light.average:Litter	-0.0016	0.0017	-0.91	0.3724
Light.average:Big.rocks	-0.0023	0.0031	-0.76	0.4529
Litter:Big.rocks	-0.0007	0.0011	-0.68	0.5009
Light.average:Litter:Big.rocks	0.0000	0.0000	0.95	0.3503

```
>
```

4.4   Indicator Species Analysis

```
>                                          #indicator species
> ## library(labdsv)
> ## ind.spp <- indval(com,env$Moth)
> ## summary(ind.spp)
> ## detach(package:labdsv)
>
```

Indicator Species Analysis Results using Moth as the grouping factor

species cluster indicator.value probability

Canros 2 0.6397 0.006

Acasup 2 0.6295 0.002

Acacon 2 0.4769 0.001

Acaobp 2 0.4241 0.008

Phydub 2 0.4125 0.018

Calare 2 0.2966 0.036

```
>                                              #NMDS
> library(ecodist)
> d <- vegdist(com.)
> if (any(ls()=='my.nmds')){}else{my.nmds <- nmds(d,3,3,100)}

NULL

> env.nms <- env.[,-c(3,4,5,6)]
> par(mfrow=c(3,3))
> for (i in 1:3){
+   for (j in 1:3){
+     if (i!=j){
+       par(mar=c(5.1, 4.1, 4.1, 2.1)-0.75)
+       vectors <- envfit(nmds.min(my.nmds)[,c(i,j)]~env.nms)
```

```
+        plot(nmds.min(my.nmds)[,c(j,i)],pch=19,col=grey(c(0.75,0))[(env$Moth+1)],xl
+        plot(vectors,col='black')
+      }else{
+        par(mar=c(5.1, 4.1, 4.1, 2.1)-2)
+        plot(1,1,axes=FALSE,xlab='',ylab='',type='n')
+        text(1,1,labels=paste('X',i,sep=''),cex=10)
+      }
+    }
+ }
```

Minimum stress for given dimensionality: 0.1487555

r^2 for minimum stress configuration: 0.8666012

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Minimum stress for given dimensionality:  0.1487555
r^2 for minimum stress configuration:  0.8666012

>
```
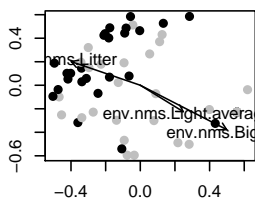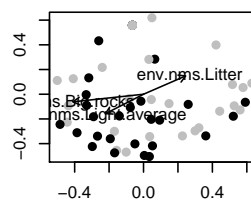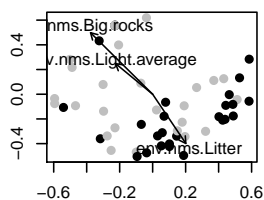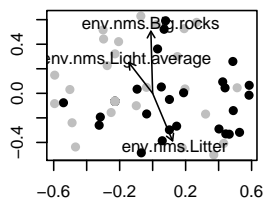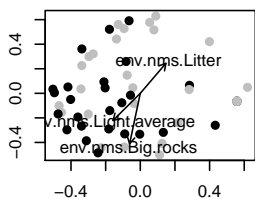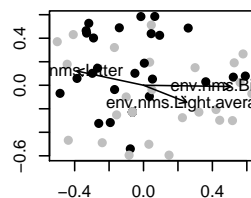
4.5 SEM

```
Model Chisquare =  5.0513   Df =  4 Pr(>Chisq) = 0.28207

Chisquare (null model) =  158.65   Df =  10

Goodness-of-fit index =  0.96765

Adjusted goodness-of-fit index =  0.87868

RMSEA index =  0.066744   90% CI: (NA, 0.21702)

Bentler-Bonnett NFI =  0.96816

Tucker-Lewis NNFI =  0.98232

Bentler CFI =  0.99293

SRMR =  0.039061

AIC =  27.051

AICc =  10.551

BIC =  50.089

CAIC =  -15.326


Normalized Residuals
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
-0.9340  0.0000  0.0000 -0.0639  0.0297  0.3070


 R-square for Endogenous Variables
Light.average         Litter    Abundance    Big.rocks
      0.5583         0.1442       0.3360       0.7041


 Parameter Estimates
     Estimate Std Error z value   Pr(>|z|)
```

```
g.1.2  1.86246 0.215650    8.63652 5.7952e-18 Light.average <--- Moth

g.1.3 -0.96225 0.305240   -3.15244 1.6191e-03 Litter <--- Moth

b.2.5  0.26986 0.226461    1.19165 2.3340e-01 Abundance <--- Light.average

b.3.4 -1.32422 0.111764  -11.84832 2.1954e-32 Big.rocks <--- Litter

b.3.5  0.11105 0.397655    0.27926 7.8004e-01 Abundance <--- Litter

b.4.5  0.74057 0.248775    2.97687 2.9121e-03 Abundance <--- Big.rocks

e.1    0.25424 0.046809    5.43139 5.5917e-08 Moth <--> Moth

e.2    0.69757 0.128434    5.43139 5.5917e-08 Light.average <--> Light.average

e.3    1.39757 0.257314    5.43139 5.5917e-08 Litter <--> Litter

e.4    1.20348 0.221579    5.43139 5.5917e-08 Big.rocks <--> Big.rocks

e.5    4.39445 0.809084    5.43139 5.5917e-08 Abundance <--> Abundance


 Iterations =  0

 5 largest modification indices, A matrix:
   Litter<-Light.average    Light.average<-Litter         Abundance<-Moth
             2.494770                 2.494770                 1.254584
   Big.rocks<-Abundance Big.rocks<-Light.average
             1.137006                 1.137006


  5 largest modification indices, P matrix:
   Light.average<->Litter          Abundance<->Moth Abundance<->Light.average
             2.4947699                 1.2545837                 1.2545837
       Abundance<->Litter          Big.rocks<->Moth
             1.2545837                 0.8392215

Running  dot -Tpng -o semPathA.png  semPathA.dot
```
15
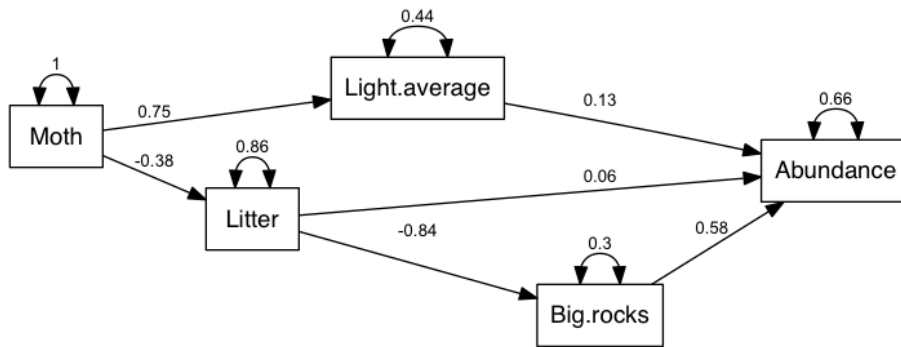
```
Model Chisquare =  4.2927   Df =  4 Pr(>Chisq) = 0.36785

Chisquare (null model) =  198.77   Df =  10

Goodness-of-fit index =  0.9727

Adjusted goodness-of-fit index =  0.89762

RMSEA index =  0.035215   90% CI: (NA, 0.20261)

Bentler-Bonnett NFI =  0.9784

Tucker-Lewis NNFI =  0.99612

Bentler CFI =  0.99845

SRMR =  0.04022

AIC =  26.293

AICc =  9.7927

BIC =  49.33

CAIC =  -16.085


Normalized Residuals
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
 -0.934  -0.216   0.000  -0.141   0.000   0.252


 R-square for Endogenous Variables
Light.average        Litter       Richness      Big.rocks
       0.5583        0.1442         0.6740         0.7041


 Parameter Estimates
      Estimate Std Error z value  Pr(>|z|)
g.1.2  1.86246 0.215650     8.6365 5.7952e-18 Light.average <--- Moth
g.1.3 -0.96225 0.305240    -3.1524 1.6191e-03 Litter <--- Moth
```

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```
b.2.5   0.83401 0.200015     4.1697 3.0497e-05 Richness <--- Light.average

b.3.4 -1.32422 0.111764   -11.8483 2.1954e-32 Big.rocks <--- Litter

b.3.5   1.17773 0.351217     3.3533 7.9862e-04 Richness <--- Litter

b.4.5   1.68066 0.219723     7.6490 2.0257e-14 Richness <--- Big.rocks

e.1     0.25424 0.046809     5.4314 5.5917e-08 Moth <--> Moth

e.2     0.69757 0.128434     5.4314 5.5917e-08 Light.average <--> Light.average

e.3     1.39757 0.257314     5.4314 5.5917e-08 Litter <--> Litter

e.4     1.20348 0.221579     5.4314 5.5917e-08 Big.rocks <--> Big.rocks

e.5     3.42801 0.631147     5.4314 5.5917e-08 Richness <--> Richness


 Iterations =  0

 5 largest modification indices, A matrix:
   Litter<-Light.average    Light.average<-Litter         Litter<-Richness
             2.494770                 2.494770                 1.639637
     Big.rocks<-Richness Big.rocks<-Light.average
             1.137006                 1.137006


  5 largest modification indices, P matrix:
  Light.average<->Litter          Big.rocks<->Moth         Big.rocks<->Litter
            2.4947699                 0.8392215                 0.8392215
        Richness<->Moth Richness<->Light.average
            0.4628788                 0.4628788

Running  dot -Tpng -o semPathR.png   semPathR.dot
```
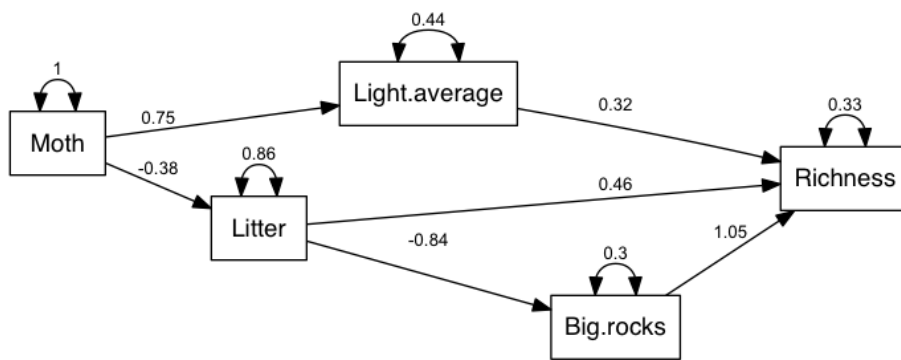
```
Model Chisquare =  3.8579   Df =  4 Pr(>Chisq) = 0.42557

Chisquare (null model) =  183.64   Df =  10

Goodness-of-fit index =  0.97565

Adjusted goodness-of-fit index =  0.90868

RMSEA index =  0   90% CI: (NA, 0.19348)

Bentler-Bonnett NFI =  0.97899

Tucker-Lewis NNFI =  1.002

Bentler CFI =  1

SRMR =  0.042232

AIC =  25.858

AICc =  9.3579

BIC =  48.896

CAIC =  -16.519


Normalized Residuals
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
 -0.934  -0.271   0.000  -0.156   0.000   0.252


 R-square for Endogenous Variables
Light.average        Litter    Diversity    Big.rocks
      0.5583         0.1442       0.5808       0.7041


 Parameter Estimates
      Estimate Std Error z value  Pr(>|z|)
g.1.2  1.86246 0.215650    8.6365 5.7952e-18 Light.average <--- Moth
g.1.3 -0.96225 0.305240   -3.1524 1.6191e-03 Litter <--- Moth
```

```
b.2.5   0.16786 0.047902      3.5042 4.5794e-04 Diversity <--- Light.average

b.3.4  -1.32422 0.111764    -11.8483 2.1954e-32 Big.rocks <--- Litter

b.3.5   0.22462 0.084115      2.6704 7.5763e-03 Diversity <--- Litter

b.4.5   0.32511 0.052622      6.1782 6.4842e-10 Diversity <--- Big.rocks

e.1     0.25424 0.046809      5.4314 5.5917e-08 Moth <--> Moth

e.2     0.69757 0.128434      5.4314 5.5917e-08 Light.average <--> Light.average

e.3     1.39757 0.257314      5.4314 5.5917e-08 Litter <--> Litter

e.4     1.20348 0.221579      5.4314 5.5917e-08 Big.rocks <--> Big.rocks

e.5     0.19662 0.036201      5.4314 5.5917e-08 Diversity <--> Diversity


 Iterations =  0

 5 largest modification indices, A matrix:
   Light.average<-Litter      Litter<-Light.average       Litter<-Diversity
             2.494770                   2.494770                  2.420293
 Big.rocks<-Light.average     Big.rocks<-Diversity
             1.137006                   1.137006


  5 largest modification indices, P matrix:
   Light.average<->Litter        Big.rocks<->Moth         Big.rocks<->Litter
           2.49476987                   0.83922155                 0.83922155
 Light.average<->Big.rocks       Diversity<->Litter
           0.34301774                   0.00461226


Running  dot -Tpng -o semPathD.png  semPathD.dot
```
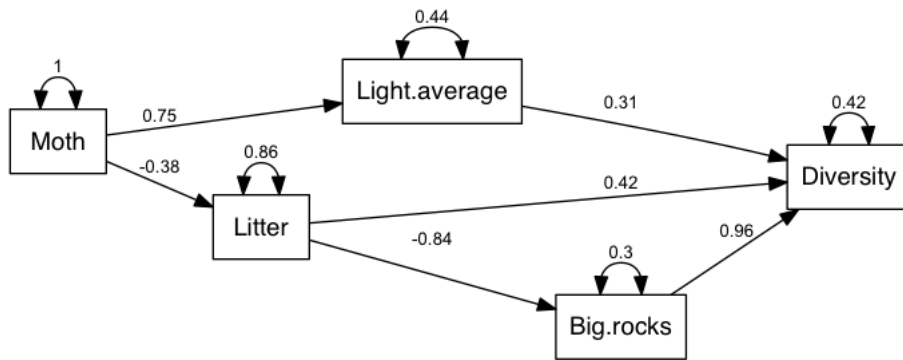
```
Minimum stress for given dimensionality:  0.1487555

r^2 for minimum stress configuration:  0.8666012


 Model Chisquare =  8.4011   Df =  9 Pr(>Chisq) = 0.49428

 Chisquare (null model) =  203.09   Df =  21

 Goodness-of-fit index =  0.95968

 Adjusted goodness-of-fit index =  0.87455

 RMSEA index =  0   90% CI: (NA, 0.13967)

 Bentler-Bonnett NFI =  0.95863

 Tucker-Lewis NNFI =  1.0077

 Bentler CFI =  1

 SRMR =  0.047869

 AIC =  46.401

 AICc =  27.401

 BIC =  86.194

 CAIC =  -37.448


 Normalized Residuals
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
-0.9340 -0.1790  0.0000 -0.0171  0.1080  0.8890


 R-square for Endogenous Variables
Light.average        Litter           X1           X2           X3
      0.5583         0.1442       0.4217       0.4097       0.0521
    Big.rocks
      0.7041
```

```
 Parameter Estimates
       Estimate  Std Error z value   Pr(>|z|)
g.1.2  1.862463 0.215650    8.63652 5.7952e-18 Light.average <--- Moth

g.1.3 -0.962252 0.305240   -3.15244 1.6191e-03 Litter <--- Moth

b.2.5 -0.080703 0.029471   -2.73840 6.1739e-03 X1 <--- Light.average

b.2.6  0.054260 0.027169    1.99716 4.5808e-02 X2 <--- Light.average

b.2.7 -0.026432 0.031000   -0.85264 3.9386e-01 X3 <--- Light.average

b.3.4 -1.324220 0.111764  -11.84832 2.1954e-32 Big.rocks <--- Litter

b.3.5 -0.160718 0.051750   -3.10569 1.8984e-03 X1 <--- Litter

b.3.6  0.067605 0.047707    1.41709 1.5646e-01 X2 <--- Litter

b.3.7  0.074578 0.054434    1.37007 1.7067e-01 X3 <--- Litter

b.4.5 -0.167030 0.032375   -5.15927 2.4791e-07 X1 <--- Big.rocks

b.4.6  0.124920 0.029846    4.18552 2.8451e-05 X2 <--- Big.rocks

b.4.7  0.035507 0.034054    1.04266 2.9711e-01 X3 <--- Big.rocks

e.1    0.254237 0.046809    5.43139 5.5917e-08 Moth <--> Moth

e.2    0.697573 0.128434    5.43139 5.5917e-08 Light.average <--> Light.average

e.3    1.397574 0.257314    5.43139 5.5917e-08 Litter <--> Litter

e.4    1.203481 0.221579    5.43139 5.5917e-08 Big.rocks <--> Big.rocks

e.5    0.074423 0.013702    5.43139 5.5917e-08 X1 <--> X1

e.6    0.063249 0.011645    5.43139 5.5917e-08 X2 <--> X2

e.7    0.082344 0.015161    5.43139 5.5917e-08 X3 <--> X3


 Iterations =  0
```

```
5 largest modification indices, A matrix:
        Litter<-X1 Litter<-Light.average Light.average<-Litter
        3.438300              2.494770              2.494770
            X1<-X2                X2<-X1
          2.245427              2.245427


 5 largest modification indices, P matrix:
Light.average<->Litter                X2<->X1                X2<->Moth
            2.494770              2.245427              1.144694
    X2<->Light.average            X2<->Litter
            1.144694              1.144694

Running  dot -Tpng -o semPath1.png  semPath1.dot
```
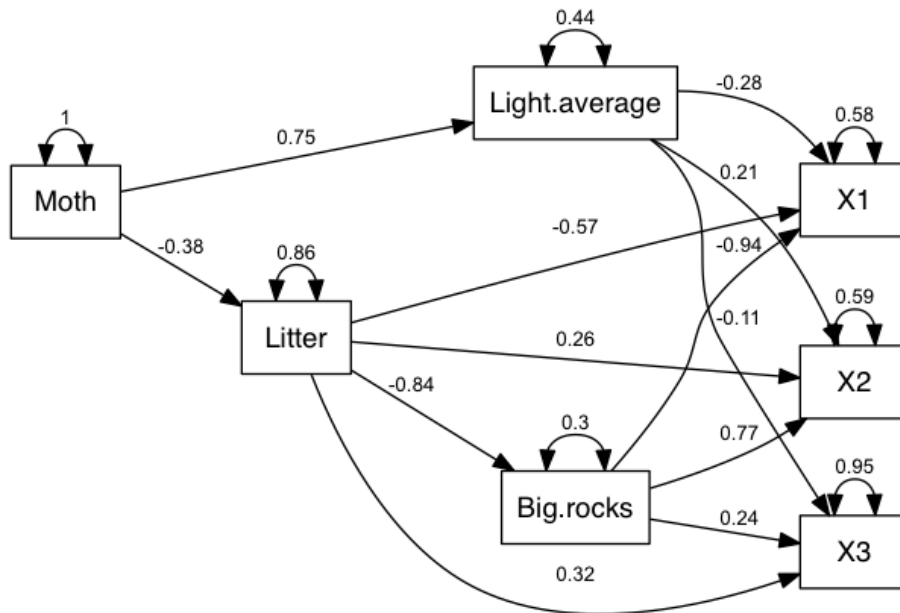


```
Model Chisquare =  3.9132   Df =  4 Pr(>Chisq) = 0.41787
Chisquare (null model) =  166.87   Df =  10
```

```
 Goodness-of-fit index =  0.97527

 Adjusted goodness-of-fit index =  0.90726

 RMSEA index =  0    90% CI: (NA, 0.19468)

 Bentler-Bonnett NFI =  0.97655

 Tucker-Lewis NNFI =  1.0014

 Bentler CFI =  1

 SRMR =  0.04181

 AIC =  25.913

 AICc =  9.4132

 BIC =  48.951

 CAIC =  -16.464


 Normalized Residuals
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
-0.9340  0.0000  0.0000 -0.0575  0.0736  0.4100


 R-square for Endogenous Variables
Light.average          Litter          Acacon      Big.rocks
       0.5583          0.1442          0.4175         0.7041


 Parameter Estimates
      Estimate   Std Error z value    Pr(>|z|)
g.1.2  1.8624634 0.2156498    8.63652 5.7952e-18
g.1.3 -0.9622521 0.3052403   -3.15244 1.6191e-03
b.2.5  0.0119617 0.0045513    2.62819 8.5840e-03
b.3.4 -1.3242197 0.1117643  -11.84832 2.1954e-32
```

```
b.3.5 -0.0186545 0.0079919  -2.33419 1.9586e-02

b.4.5  0.0025973 0.0049998   0.51949 6.0342e-01

e.1    0.2542373 0.0468089   5.43139 5.5917e-08

e.2    0.6975726 0.1284335   5.43139 5.5917e-08

e.3    1.3975744 0.2573143   5.43139 5.5917e-08

e.4    1.2034807 0.2215787   5.43139 5.5917e-08

e.5    0.0017750 0.0003268   5.43139 5.5917e-08


g.1.2 Light.average <--- Moth

g.1.3 Litter <--- Moth

b.2.5 Acacon <--- Light.average

b.3.4 Big.rocks <--- Litter

b.3.5 Acacon <--- Litter

b.4.5 Acacon <--- Big.rocks

e.1   Moth <--> Moth

e.2   Light.average <--> Light.average

e.3   Litter <--> Litter

e.4   Big.rocks <--> Big.rocks

e.5   Acacon <--> Acacon


 Iterations =  0

 5 largest modification indices, A matrix:

  Litter<-Light.average    Light.average<-Litter Big.rocks<-Light.average

           2.4947699               2.4947699                1.1370060

      Big.rocks<-Acacon Light.average<-Big.rocks
```
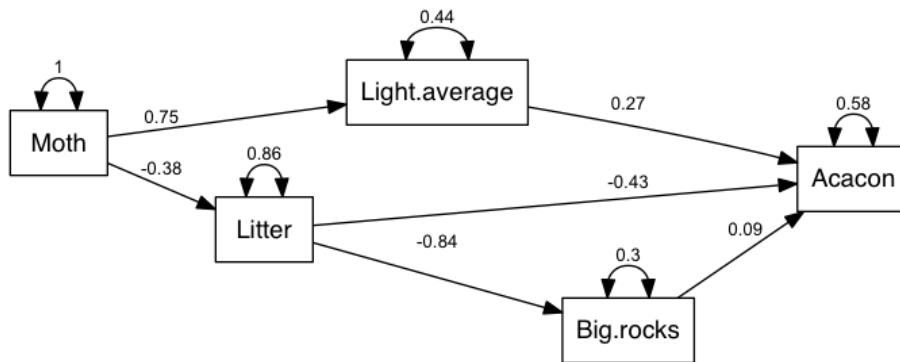
```
        1.1370060                        0.9165941


    5 largest modification indices, P matrix:
      Light.average<->Litter          Big.rocks<->Litter          Big.rocks<->Moth
                2.49476987                      0.83922155                      0.83922155
    Light.average<->Big.rocks          Acacon<->Litter
                0.34301774                      0.06310573


    Running  dot -Tpng -o semPathAcacon.png  semPathAcacon.dot
```

```
Model Chisquare =  3.9045   Df =  4 Pr(>Chisq) = 0.41908

Chisquare (null model) =  185.53   Df =  10

Goodness-of-fit index =  0.97533

Adjusted goodness-of-fit index =  0.90749

RMSEA index =  0   90% CI: (NA, 0.19449)

Bentler-Bonnett NFI =  0.97896

Tucker-Lewis NNFI =  1.0014

Bentler CFI =  1

SRMR =  0.04161

AIC =  25.905

AICc =  9.4045

BIC =  48.942

CAIC =  -16.473


Normalized Residuals
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
-0.9340 -0.1620  0.0000 -0.0840  0.0431  0.3860


 R-square for Endogenous Variables
Light.average         Litter         Acasup     Big.rocks
      0.5583         0.1442         0.5794        0.7041


 Parameter Estimates
      Estimate  Std Error z value  Pr(>|z|)
g.1.2  1.862463 0.2156498   8.6365 5.7952e-18 Light.average <--- Moth
g.1.3 -0.962252 0.3052403  -3.1524 1.6191e-03 Litter <--- Moth
```

```
b.2.5   0.036276 0.0156584    2.3167 2.0521e-02 Acasup <--- Light.average

b.3.4 -1.324220 0.1117643  -11.8483 2.1954e-32 Big.rocks <--- Litter

b.3.5 -0.056637 0.0274954   -2.0599 3.9411e-02 Acasup <--- Litter

b.4.5   0.042716 0.0172013    2.4833 1.3017e-02 Acasup <--- Big.rocks

e.1     0.254237 0.0468089    5.4314 5.5917e-08 Moth <--> Moth

e.2     0.697573 0.1284335    5.4314 5.5917e-08 Light.average <--> Light.average

e.3     1.397574 0.2573143    5.4314 5.5917e-08 Litter <--> Litter

e.4     1.203481 0.2215787    5.4314 5.5917e-08 Big.rocks <--> Big.rocks

e.5     0.021009 0.0038681    5.4314 5.5917e-08 Acasup <--> Acasup


 Iterations =   0

 5 largest modification indices, A matrix:
   Light.average<-Litter     Litter<-Light.average          Litter<-Acasup
              2.494770                  2.494770                1.982069
   Light.average<-Acasup Big.rocks<-Light.average
              1.397081                  1.137006


  5 largest modification indices, P matrix:
   Light.average<->Litter          Big.rocks<->Moth          Big.rocks<->Litter
            2.49476987                0.83922155                  0.83922155
Light.average<->Big.rocks          Acasup<->Litter
            0.34301774                0.05389307

Running  dot -Tpng -o semPathAcasup.png  semPathAcasup.dot
```
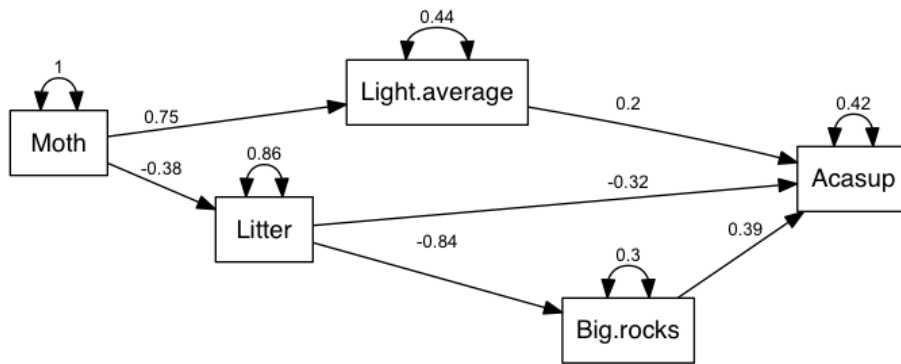
```
 Model Chisquare =  3.8536    Df =  3 Pr(>Chisq) = 0.27772

 Chisquare (null model) =  142.14    Df =  10

 Goodness-of-fit index =  0.97568

 Adjusted goodness-of-fit index =  0.87839

 RMSEA index =  0.069444    90% CI: (NA, 0.24056)

 Bentler-Bonnett NFI =  0.97289

 Tucker-Lewis NNFI =  0.97847

 Bentler CFI =  0.99354

 SRMR =  0.042811

 AIC =  27.854

 AICc =  10.492

 BIC =  52.986

 CAIC =  -11.429


 Normalized Residuals
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
-0.9340 -0.0505  0.0000 -0.0853  0.0000  0.5020


 R-square for Endogenous Variables
Light.average         Litter         Acaobp      Big.rocks
       0.5583         0.1442         0.1465         0.7041


 Parameter Estimates
     Estimate  Std Error z value   Pr(>|z|)
g.1.2  1.862463 0.215650    8.63652 5.7952e-18 Light.average <--- Moth
g.1.3 -0.962252 0.305240   -3.15244 1.6191e-03 Litter <--- Moth
```

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```
g.1.5  1.056837 0.384638    2.74761 6.0030e-03 Acaobp <--- Moth

b.2.5 -0.427636 0.148880   -2.87236 4.0742e-03 Acaobp <--- Light.average

b.3.4 -1.324220 0.111764  -11.84832 2.1954e-32 Big.rocks <--- Litter

b.3.5  0.034415 0.183282    0.18777 8.5106e-01 Acaobp <--- Litter

b.4.5  0.056794 0.113347    0.50106 6.1633e-01 Acaobp <--- Big.rocks

e.1    0.254237 0.046809    5.43139 5.5917e-08 Moth <--> Moth

e.2    0.697573 0.128434    5.43139 5.5917e-08 Light.average <--> Light.average

e.3    1.397574 0.257314    5.43139 5.5917e-08 Litter <--> Litter

e.4    1.203481 0.221579    5.43139 5.5917e-08 Big.rocks <--> Big.rocks

e.5    0.912248 0.167958    5.43139 5.5917e-08 Acaobp <--> Acaobp


 Iterations =  0

 5 largest modification indices, A matrix:
   Light.average<-Litter    Litter<-Light.average          Litter<-Acaobp
             2.4947699                 2.4947699                 2.2967054
Big.rocks<-Light.average Light.average<-Big.rocks
             1.1370060                 0.9165941


  5 largest modification indices, P matrix:
   Light.average<->Litter          Big.rocks<->Moth        Big.rocks<->Litter
             2.4947699                 0.8392215                 0.8392215
Light.average<->Big.rocks                      <NA>
             0.3430177                        NA


Running  dot -Tpng -o semPathAcaobp.png  semPathAcaobp.dot
```
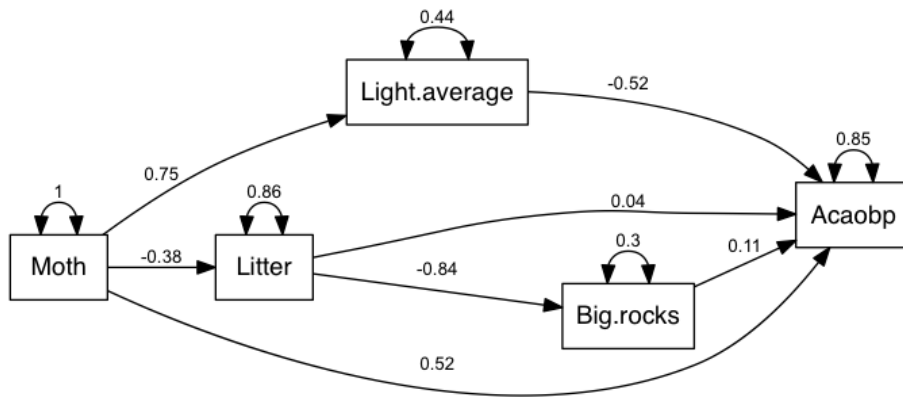
```
Model Chisquare =  3.8661    Df =  4 Pr(>Chisq) = 0.42443

Chisquare (null model) =  191.38    Df =  10

Goodness-of-fit index =  0.97559

Adjusted goodness-of-fit index =  0.90847

RMSEA index =  0    90% CI: (NA, 0.19366)

Bentler-Bonnett NFI =  0.9798

Tucker-Lewis NNFI =  1.0018

Bentler CFI =  1

SRMR =  0.040632

AIC =  25.866

AICc =  9.3661

BIC =  48.904

CAIC =  -16.511


Normalized Residuals
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
-0.9340 -0.2020  0.0000 -0.1080  0.0802  0.2520


 R-square for Endogenous Variables
Light.average         Litter        Canros      Big.rocks
       0.5583         0.1442        0.6211         0.7041


 Parameter Estimates
     Estimate  Std Error z value   Pr(>|z|)
g.1.2  1.8624634 0.215650    8.63652 5.7952e-18
g.1.3 -0.9622521 0.305240   -3.15244 1.6191e-03
```

```
b.2.5  0.1295623 0.028641     4.52371 6.0765e-06

b.3.4 -1.3242197 0.111764   -11.84832 2.1954e-32

b.3.5 -0.0083869 0.050292    -0.16676 8.6756e-01

b.4.5  0.1249703 0.031463     3.97200 7.1271e-05

e.1    0.2542373 0.046809     5.43139 5.5917e-08

e.2    0.6975726 0.128434     5.43139 5.5917e-08

e.3    1.3975744 0.257314     5.43139 5.5917e-08

e.4    1.2034807 0.221579     5.43139 5.5917e-08

e.5    0.0702887 0.012941     5.43139 5.5917e-08


g.1.2 Light.average <--- Moth

g.1.3 Litter <--- Moth

b.2.5 Canros <--- Light.average

b.3.4 Big.rocks <--- Litter

b.3.5 Canros <--- Litter

b.4.5 Canros <--- Big.rocks

e.1   Moth <--> Moth

e.2   Light.average <--> Light.average

e.3   Litter <--> Litter

e.4   Big.rocks <--> Big.rocks

e.5   Canros <--> Canros


 Iterations =  0

 5 largest modification indices, A matrix:
   Light.average<-Litter    Litter<-Light.average         Litter<-Canros
```

```
                  2.494770                        2.494770                        2.299203
Big.rocks<-Light.average          Big.rocks<-Canros
                  1.137006                        1.137006


  5 largest modification indices, P matrix:
    Light.average<->Litter            Big.rocks<->Moth           Big.rocks<->Litter
                2.49476987                    0.83922155                    0.83922155
Light.average<->Big.rocks            Canros<->Moth
                0.34301774                    0.01323831


Running  dot -Tpng -o semPathCanros.png  semPathCanros.dot
```
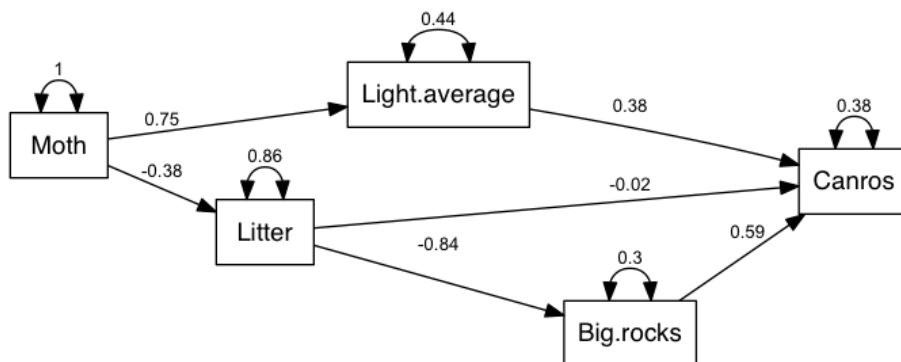
```
Model Chisquare =  5.0461   Df =  4 Pr(>Chisq) = 0.2826

Chisquare (null model) =  138.66   Df =  10

Goodness-of-fit index =  0.96768

Adjusted goodness-of-fit index =  0.87881

RMSEA index =  0.066579   90% CI: (NA, 0.21693)

Bentler-Bonnett NFI =  0.96361

Tucker-Lewis NNFI =  0.97967

Bentler CFI =  0.99187

SRMR =  0.042323

AIC =  27.046

AICc =  10.546

BIC =  50.084

CAIC =  -15.331


Normalized Residuals
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
-0.9340 -0.1910  0.0000 -0.0819  0.0000  0.5010


 R-square for Endogenous Variables
Light.average         Litter         Calare      Big.rocks
      0.5583         0.1442         0.0825         0.7041


 Parameter Estimates
     Estimate   Std Error  z value  Pr(>|z|)
g.1.2  1.8624634 0.21564981    8.6365 5.7952e-18
g.1.3 -0.9622521 0.30524028   -3.1524 1.6191e-03
```

```
b.2.5   0.0117248 0.00774787    1.5133 1.3021e-01

b.3.4 -1.3242197 0.11176430  -11.8483 2.1954e-32

b.3.5   0.0202336 0.01360492    1.4872 1.3696e-01

b.4.5   0.0145328 0.00851130    1.7075 8.7735e-02

e.1     0.2542373 0.04680888    5.4314 5.5917e-08

e.2     0.6975726 0.12843352    5.4314 5.5917e-08

e.3     1.3975744 0.25731430    5.4314 5.5917e-08

e.4     1.2034807 0.22157875    5.4314 5.5917e-08

e.5     0.0051438 0.00094705    5.4314 5.5917e-08


g.1.2 Light.average <--- Moth

g.1.3 Litter <--- Moth

b.2.5 Calare <--- Light.average

b.3.4 Big.rocks <--- Litter

b.3.5 Calare <--- Litter

b.4.5 Calare <--- Big.rocks

e.1   Moth <--> Moth

e.2   Light.average <--> Light.average

e.3   Litter <--> Litter

e.4   Big.rocks <--> Big.rocks

e.5   Calare <--> Calare


 Iterations =  0

 5 largest modification indices, A matrix:
Light.average<-Litter Litter<-Light.average Light.average<-Calare
```

```
         2.494770                2.494770                    1.624254
        Calare<-Moth      Big.rocks<-Calare
           1.249195                1.137006


   5 largest modification indices, P matrix:
Light.average<->Litter          Calare<->Litter Calare<->Light.average
              2.4947699                1.2491953                  1.2491953
        Calare<->Moth      Big.rocks<->Moth
              1.2491953                0.8392215


Running  dot -Tpng -o semPathCalare.png  semPathCalare.dot
```
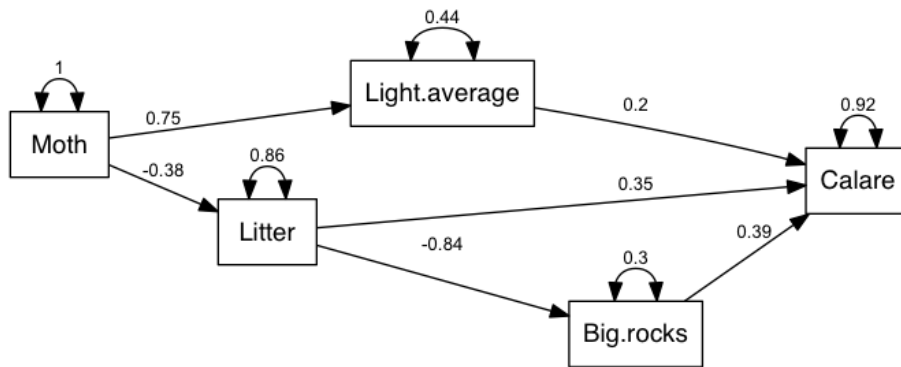
```
Model Chisquare =   4.5   Df =   4 Pr(>Chisq) = 0.34255

Chisquare (null model) =   146.05    Df =   10

Goodness-of-fit index =   0.97131

Adjusted goodness-of-fit index =   0.8924

RMSEA index =   0.046028    90% CI: (NA, 0.20672)

Bentler-Bonnett NFI =   0.96919

Tucker-Lewis NNFI =   0.99081

Bentler CFI =   0.99633

SRMR =   0.039249

AIC =   26.5

AICc =   10

BIC =   49.538

CAIC =   -15.877


Normalized Residuals
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
 -0.934  -0.189   0.000  -0.105   0.000   0.252


 R-square for Endogenous Variables
Light.average         Litter        Phydub      Big.rocks
       0.5583         0.1442        0.1979         0.7041


 Parameter Estimates
      Estimate  Std Error z value  Pr(>|z|)
g.1.2  1.862463 0.2156498    8.6365 5.7952e-18 Light.average <--- Moth
g.1.3 -0.962252 0.3052403   -3.1524 1.6191e-03 Litter <--- Moth
```

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```
b.2.5   0.038712 0.0204195    1.8959 5.7979e-02 Phydub <--- Light.average

b.3.4 -1.324220 0.1117643  -11.8483 2.1954e-32 Big.rocks <--- Litter

b.3.5   0.059666 0.0358558    1.6640 9.6103e-02 Phydub <--- Litter

b.4.5   0.062696 0.0224315    2.7950 5.1903e-03 Phydub <--- Big.rocks

e.1     0.254237 0.0468089    5.4314 5.5917e-08 Moth <--> Moth

e.2     0.697573 0.1284335    5.4314 5.5917e-08 Light.average <--> Light.average

e.3     1.397574 0.2573143    5.4314 5.5917e-08 Litter <--> Litter

e.4     1.203481 0.2215787    5.4314 5.5917e-08 Big.rocks <--> Big.rocks

e.5     0.035728 0.0065781    5.4314 5.5917e-08 Phydub <--> Phydub


 Iterations =   0

 5 largest modification indices, A matrix:
   Litter<-Light.average   Light.average<-Litter       Big.rocks<-Phydub
            2.4947699               2.4947699               1.1370060
Big.rocks<-Light.average Light.average<-Big.rocks
            1.1370060               0.9165941


  5 largest modification indices, P matrix:
Light.average<->Litter        Big.rocks<->Moth      Big.rocks<->Litter
            2.4947699               0.8392215               0.8392215
Phydub<->Light.average        Phydub<->Moth
            0.6802393               0.6802393


Running  dot -Tpng -o semPathPhydub.png  semPathPhydub.dot
```
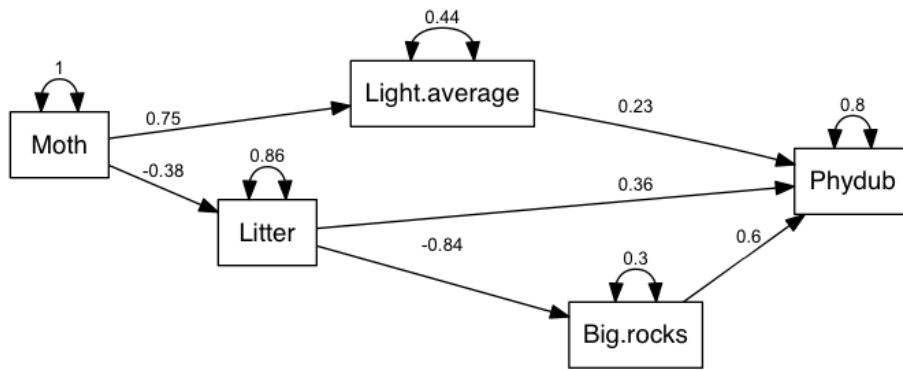
```
>                                         #co-occurrence null models
> library(bipartite)
> source('~/cor_nets/CorNets.R')
> library(audio)
>                                         #all
> x <- com
> if (any(ls()=='null')){}else{null <- nullSim(x,10000)}

NULL

> length(null)

[1] 10000

> if (any(ls()=='null.all')){}else{sim <- lapply(null,C.score);null.all <- unlist(si

NULL

> p.all <- min(c(length(sim[sim>=C.score(x)])/length(sim),length(sim[sim<=C.score(x
> ses.all <- (C.score(x) - mean(sim)) / sd(sim)
>                                         #moth susceptible
> x <- com[env$Moth==0,]
> if (any(ls()=='null')){}else{null <- nullSim(x,10000)}

NULL

> length(null)

[1] 10000
```

```
> if (any(ls()=='null.0')){}else{sim <- lapply(null,C.score);null.0 <- unlist(sim)}

NULL

> p.0 <- min(c(length(sim[sim>=C.score(x)])/length(sim),length(sim[sim<=C.score(x)]
> ses.0 <- (C.score(x) - mean(sim)) / sd(sim)
>                                               #moth resistant
> x <- com[env$Moth==1,]
> if (any(ls()=='null')){}else{null <- nullSim(x,10000)}

NULL

> length(null)

[1] 10000

> if (any(ls()=='null.1')){}else{sim <- lapply(null,C.score);null.1 <- unlist(sim)}

NULL

> p.1 <- min(c(length(sim[sim>=C.score(x)])/length(sim),length(sim[sim<=C.score(x)]
> ses.1 <- (C.score(x) - mean(sim)) / sd(sim)
>                                               #compare co-occurrence patterns
> cooc <- cbind(c(p.0,ses.0),c(p.1,ses.1),c(p.all,ses.all))
> colnames(cooc) <- c('S','R','ALL')
> rownames(cooc) <- c('p.min','SES')
> cooc

              S           R          ALL
p.min  0.171600   0.049900   0.2852000
SES    0.892948  -1.574635  -0.5934756
```

```
> 

> library(xtable)

> xtable(cooc)
```

	S	R	ALL
p.min	0.17	0.05	0.29
SES	0.89	-1.57	-0.59

```
> 

>                                               #co-occurrence network
> source('~/cor_nets/araujo_method/araujo_method.R')
> library(sna)
> x.net <- cbind(env$Moth,com)
> names(x.net)[1] <- 'moth'
> if (any(ls()=='net')){}else{net <- araujoNet(x.net)$dp}

NULL

> if (any(ls()=='net.0')){}else{net.0 <- araujoNet(x.net[env$Moth==0,])$dp}

NULL

> if (any(ls()=='net.1')){}else{net.1 <- araujoNet(x.net[env$Moth==1,])$dp}

NULL
```
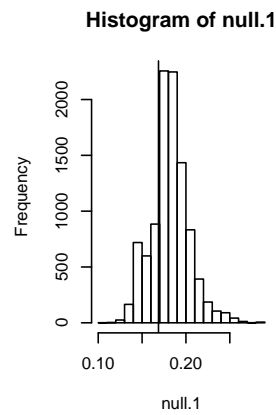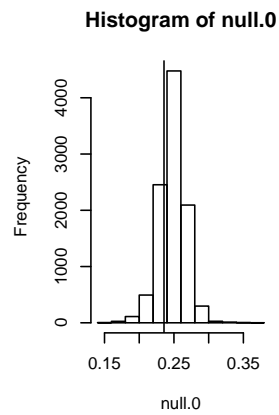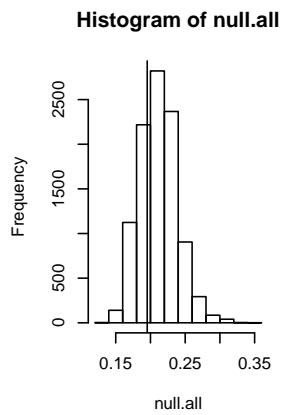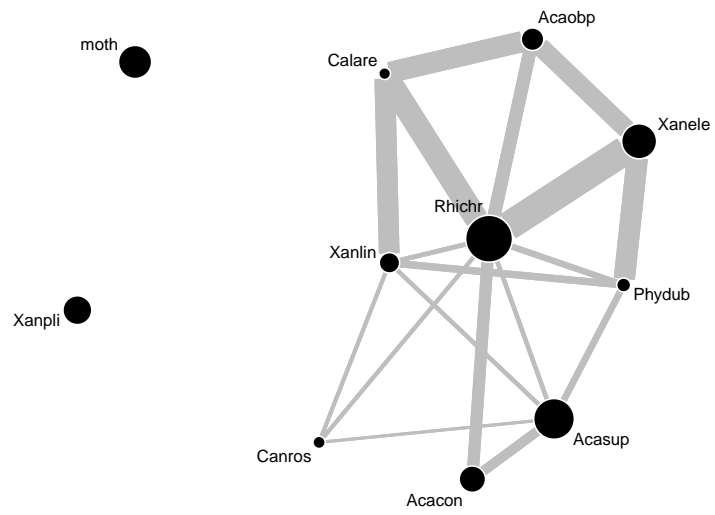
```
> par(mfrow=c(2,3))

> gplot(net,gmode='graph',displaylabels=TRUE,label.cex=0.65)

> gplot(net.0,gmode='graph',displaylabels=TRUE,label.cex=0.65)

> gplot(net.1,gmode='graph',displaylabels=TRUE,label.cex=0.65)

> hist(null.all)

> abline(v=C.score(com))

> hist(null.0)

> abline(v=C.score(com[env$Moth==0,]))

> hist(null.1)

> abline(v=C.score(com[env$Moth==1,]))

>
```
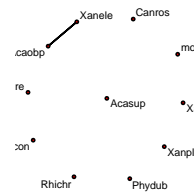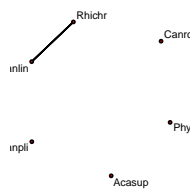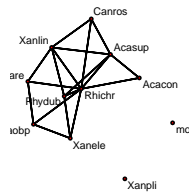
```
> e.col <- net

> e.col[net!=0] <- 'grey'

> v.cex <- apply(x.net,2,function(x) length(x[x!=0]))

> v.cex <- (v.cex / max(v.cex) + 1)^2

> gplot(net,gmode='graph',displaylabels=TRUE,label.cex=0.65,

+       edge.col=e.col,edge.lwd=(net+1)^10,vertex.cex=v.cex,

+       vertex.sides=50,vertex.col='black',vertex.border='white')

>
```

References