DDG Analysis | Supplementary Material

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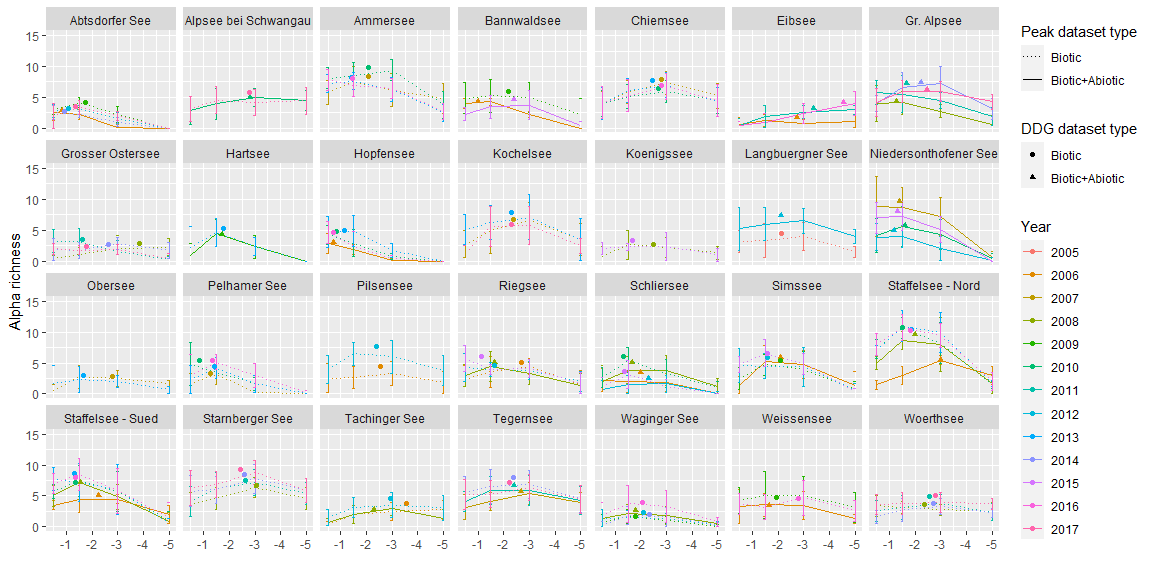
14 Juni 2020

# H1 Pattern

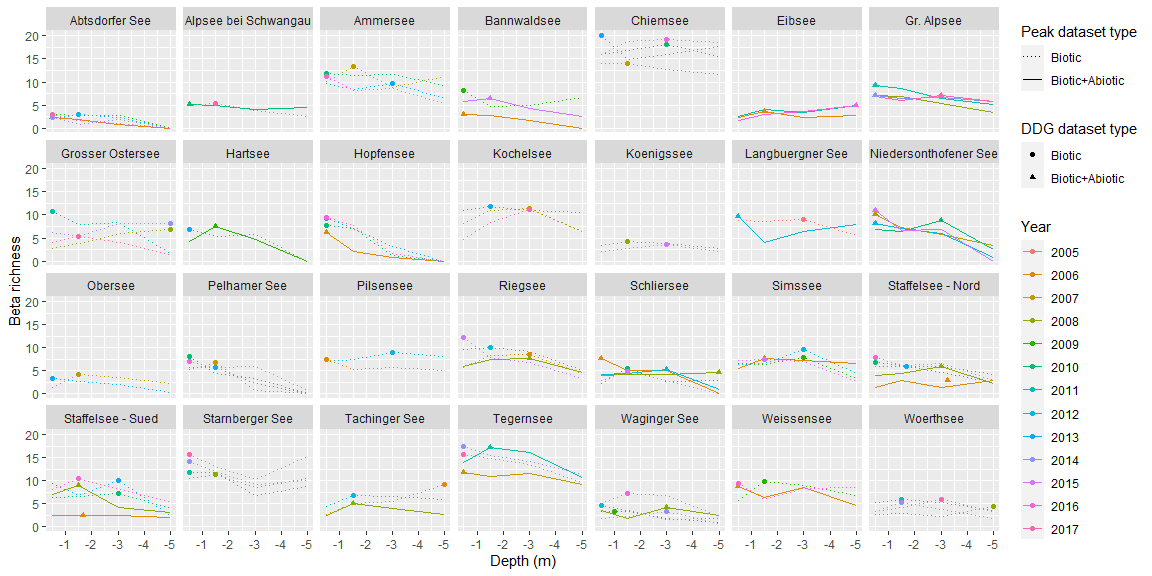
## Depth diversity gradients of macrophytes - overview

Depth pattern of Alpha, Beta and Gamma Richness for full dataset. For Alpha Richness, lines show the mean Alpha Richness per lake and year with their corresponding standard deviation; the single Richness Peaks are depicted as points. The different dataset levels can be distinguished by line type and point shape: Points and dashed line=Biotic dataset of all available macrophyte mapping; triangles and solid line=subset of biotic dataset, where also abiotic data is available.

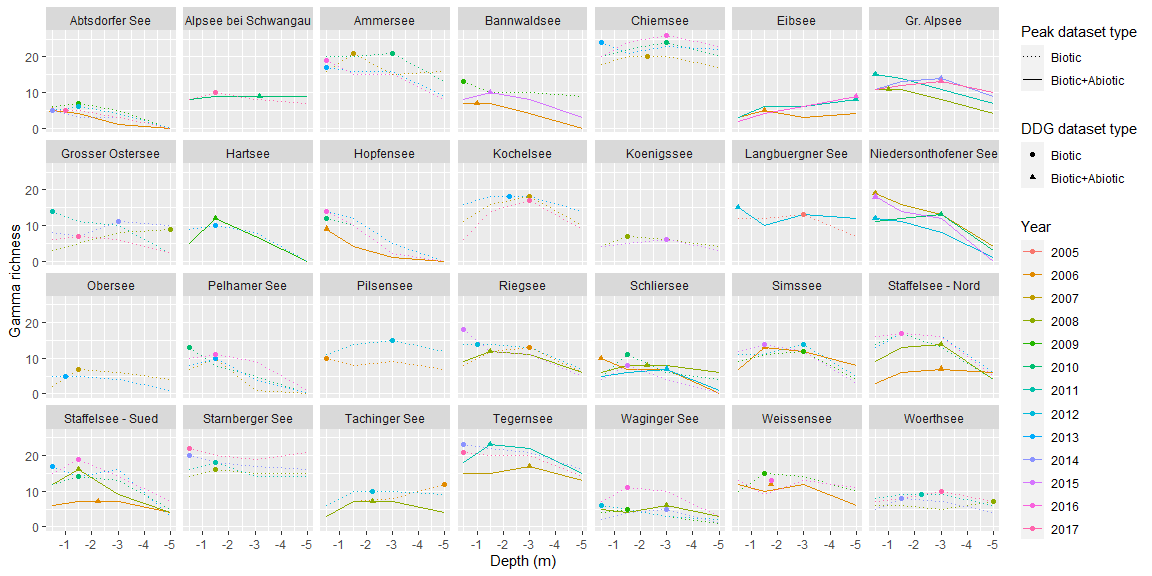
### ALPHA & Peak Plot  
ggplot(data=Makroph\_Lake\_DepthS, aes(x=(Tiefe), y=ALPHA, col=factor(YEAR), group=interaction(Lake,YEAR)))+   
 geom\_line(aes(linetype=datasettotsimpl))+#interaction(dataset,datasetWLF)  
 scale\_linetype\_manual(values=c("dotted", "solid"))+  
 facet\_wrap(~ Lake, ncol=7)+  
 ylab("Alpha richness")+ xlab("")+labs(fill = "Pattern type")+ylim(0,15)+  
 geom\_errorbar(data=Makroph\_Lake\_DepthS,aes(ymin=ALPHA-ALPHAsd, ymax=ALPHA+ALPHAsd), width=.1)+  
 geom\_point(data=PEAK, aes(x=(AlphaPeakDepth), y=AlphaPeakRichness, shape=datasettotsimpl))+ scale\_x\_reverse()+  
 labs(linetype="Peak dataset type",shape="DDG dataset type", colour="Year")



### BETA & Peak Plot  
ggplot(Makroph\_Lake\_DepthS, aes(x=Tiefe, y=BETA, group=interaction(Lake,YEAR), col=factor(YEAR), linetype=datasettotsimpl))+   
 geom\_line()+facet\_wrap(~ Lake, ncol=7)+  
 scale\_linetype\_manual(values=c("dotted", "solid"))+  
 ylab("Beta richness")+ xlab("Depth (m)")+labs(fill = "Pattern type")+  
 geom\_point(data=PEAK, aes(x=BetaPeakDepth, y=BetaPeakRichness, shape=datasettotsimpl))+ scale\_x\_reverse()+  
 labs(linetype="Peak dataset type",shape="DDG dataset type", colour="Year")



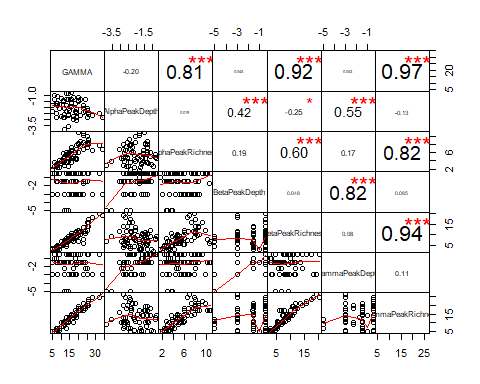
### GAMMA & Peak Plot  
ggplot(Makroph\_Lake\_DepthS, aes(x=Tiefe, y=GAMMA, group=interaction(Lake,YEAR), col=factor(YEAR), linetype=datasettotsimpl))+   
 geom\_line()+facet\_wrap(~ Lake, ncol=7)+  
 scale\_linetype\_manual(values=c("dotted", "solid"))+  
 ylab("Gamma richness")+ xlab("Depth (m)")+labs(fill = "Pattern type")+  
 geom\_point(data=PEAK, aes(x=GammaPeakDepth, y=GammaPeakRichness, shape=datasettotsimpl))+ scale\_x\_reverse()+  
 labs(linetype="Peak dataset type",shape="DDG dataset type", colour="Year")



## Correlations between metrices

Correlations between diversity metrices #TODO Umbenennen! # Problem with greek letters

library(PerformanceAnalytics)  
chart.Correlation(PEAK\_Chem\_norm[c(33,20,22,31,32,29,30)], histogram=F, pch=9, method = "pearson")

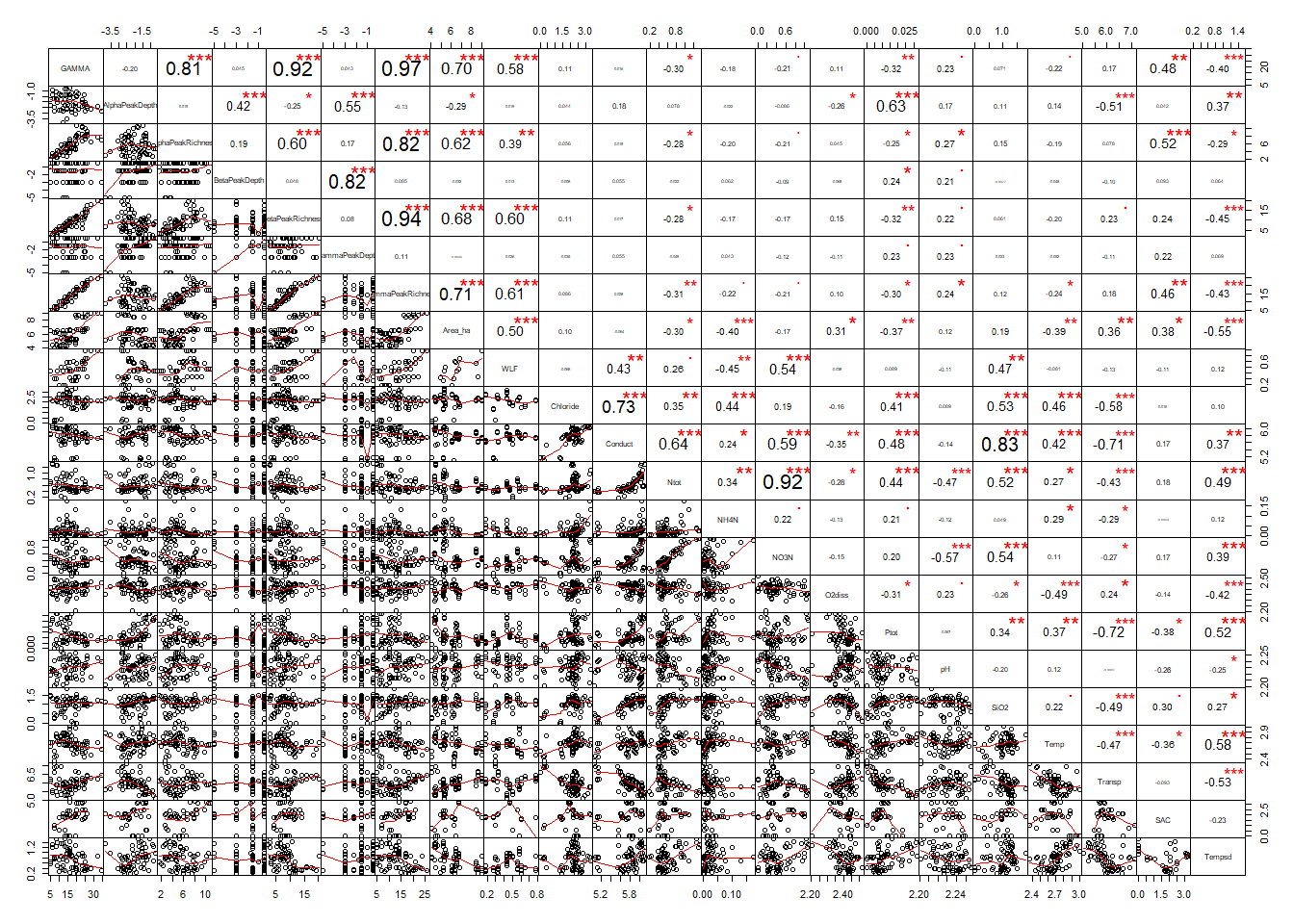


# H2 Driver

## Correlations | Drivers

Correlation between normalized chemical-physical values (!Achtung Level2 Dataset) & Richness measures #TODO: umbenennen: Greek letters?

library(PerformanceAnalytics)  
chart.Correlation(PEAK\_Chem\_norm[c(33,20,22,31,32,29,30,16,19,3:15)], histogram=F, pch=9, method = "pearson")



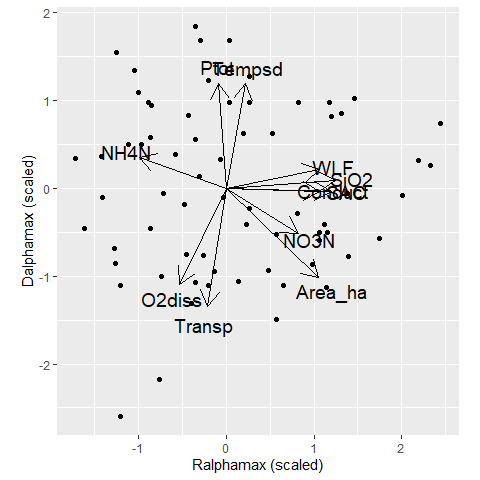
## Environmental fitting

Als Ergänzende Analyse #TODO Umbenennen Environmental fitting for normalized abiotic data and scales DDG measures Dalphamax & Ralphamax

library(vegan)  
ord <- PEAK\_Chem\_norm[c(25,26)]  
vec.sp\_Alpha<-envfit(ord, PEAK\_Chem\_norm[c(16,19,3:15)], permu = 999,na.rm = TRUE)#26:38,  
vec.sp\_Alpha

##   
## \*\*\*VECTORS  
##   
## AlphaPeakDepth\_sc AlphaPeakRichness\_sc r2 Pr(>r)   
## Area\_ha -0.69522 0.71879 0.5331 0.001 \*\*\*  
## WLF 0.19589 0.98063 0.2948 0.014 \*   
## Chloride -0.88056 0.47393 0.0424 0.616   
## Conduct -0.02768 0.99962 0.2837 0.022 \*   
## Ntot -0.62425 0.78122 0.1609 0.140   
## NH4N 0.34062 -0.94020 0.2754 0.015 \*   
## NO3N -0.52624 0.85034 0.2324 0.043 \*   
## O2diss -0.89986 -0.43618 0.3675 0.003 \*\*   
## Ptot 0.99726 -0.07398 0.3630 0.002 \*\*   
## pH 0.94708 -0.32100 0.0550 0.507   
## SiO2 0.07685 0.99704 0.3909 0.004 \*\*   
## Temp 0.92404 -0.38230 0.1558 0.131   
## Transp -0.98751 -0.15754 0.4660 0.002 \*\*   
## SAC -0.03035 0.99954 0.3564 0.004 \*\*   
## Tempsd 0.98319 0.18261 0.3685 0.006 \*\*   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
## Permutation: free  
## Number of permutations: 999  
##   
## 41 observations deleted due to missingness

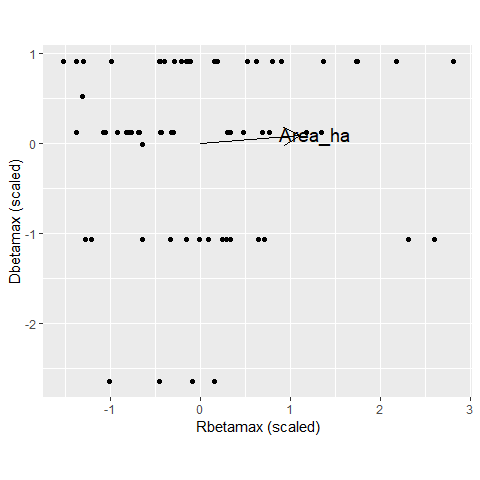
vec.sp.df\_Alpha<-as.data.frame(vec.sp\_Alpha$vectors$arrows\*sqrt(vec.sp\_Alpha$vectors$r))  
vec.sp.df\_Alpha$param<-rownames(vec.sp.df\_Alpha)  
vec.sp.df\_Alpha <- vec.sp.df\_Alpha %>% filter(param %in% (c("Area\_ha","WLF","Conduct","NH4N","NO3N","O2diss","Ptot","SiO2","Tempsd","Transp","SAC")))#"Temp\_0\_6\_sd",  
ggplot(PEAK\_Chem\_norm, aes(y=AlphaPeakDepth\_sc, x=AlphaPeakRichness\_sc))+  
 geom\_point(aes())+ theme(legend.title=element\_blank())+#scale\_fill\_discrete(name = "Groups")+  
 geom\_segment(data=vec.sp.df\_Alpha,aes(y=0,yend=2\*AlphaPeakDepth\_sc,x=0,xend=2\*AlphaPeakRichness\_sc),  
 arrow = arrow(length = unit(0.5, "cm")),colour="black",inherit\_aes=FALSE) +  
 geom\_text(data=vec.sp.df\_Alpha,aes(y=2.3\*AlphaPeakDepth\_sc,x=2.3\*AlphaPeakRichness\_sc,label=param),size=5)+  
 coord\_fixed() + xlab("Ralphamax (scaled)") + ylab("Dalphamax (scaled)")+  
 theme(legend.position = c(0.9, 0.1))

 Dbetamax & Rbetamax

ord <- scale(PEAK\_Chem\_norm[c(31,32)])  
vec.sp\_Beta<-envfit(ord, PEAK\_Chem\_norm[c(16,19,3:15)], permu = 999,na.rm = TRUE)#26:38,  
vec.sp\_Beta

##   
## \*\*\*VECTORS  
##   
## BetaPeakDepth BetaPeakRichness r2 Pr(>r)   
## Area\_ha 0.07857 0.99691 0.3081 0.022 \*  
## WLF -0.27718 0.96082 0.1763 0.100 .  
## Chloride -0.78611 0.61809 0.0194 0.791   
## Conduct -0.52579 0.85062 0.0434 0.582   
## Ntot -0.39239 0.91980 0.1585 0.118   
## NH4N 0.21228 -0.97721 0.0872 0.370   
## NO3N -0.24366 0.96986 0.1265 0.198   
## O2diss -0.71246 0.70171 0.0369 0.611   
## Ptot -0.87776 -0.47911 0.0375 0.624   
## pH 0.68703 0.72663 0.0215 0.788   
## SiO2 0.76891 0.63936 0.0121 0.870   
## Temp -0.53163 -0.84698 0.0638 0.468   
## Transp 0.92831 0.37180 0.0712 0.397   
## SAC 0.79453 0.60723 0.0540 0.522   
## Tempsd -0.05177 -0.99866 0.1542 0.121   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
## Permutation: free  
## Number of permutations: 999  
##   
## 41 observations deleted due to missingness

vec.sp.df\_Beta<-as.data.frame(vec.sp\_Beta$vectors$arrows\*sqrt(vec.sp\_Beta$vectors$r))  
vec.sp.df\_Beta$param<-rownames(vec.sp.df\_Beta)  
vec.sp.df\_Beta <- vec.sp.df\_Beta %>% filter(param %in% (c("Area\_ha")))#"Temp\_0\_6\_sd",  
ggplot(PEAK\_Chem\_norm, aes(y=scale(BetaPeakDepth), x=scale(BetaPeakRichness)))+  
 geom\_point(aes())+ theme(legend.title=element\_blank())+#scale\_fill\_discrete(name = "Groups")+  
 geom\_segment(data=vec.sp.df\_Beta,aes(y=0,yend=2\*(BetaPeakDepth),x=0,xend=2\*(BetaPeakRichness)),  
 arrow = arrow(length = unit(0.5, "cm")),colour="black",inherit\_aes=FALSE) +  
 geom\_text(data=vec.sp.df\_Beta,aes(y=2.3\*(BetaPeakDepth),x=2.3\*(BetaPeakRichness),label=param),size=5)+  
 coord\_fixed() + xlab("Rbetamax (scaled)") + ylab("Dbetamax (scaled)")+  
 theme(legend.position = c(0.9, 0.1))

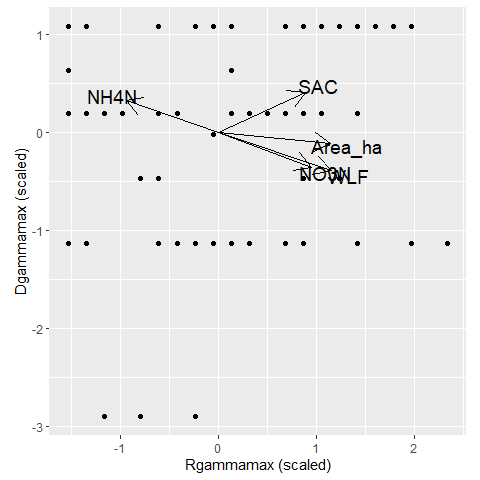


Dgammamax & Rgammamax

ord <- scale(PEAK\_Chem\_norm[c(29,30)])  
vec.sp\_Gamma<-envfit(ord, PEAK\_Chem\_norm[c(16,19,3:15)], permu = 999,na.rm = TRUE)#26:38,  
vec.sp\_Gamma

##   
## \*\*\*VECTORS  
##   
## GammaPeakDepth GammaPeakRichness r2 Pr(>r)   
## Area\_ha -0.09935 0.99505 0.3297 0.013 \*   
## WLF -0.31756 0.94824 0.3694 0.004 \*\*  
## Chloride -0.92693 0.37524 0.0416 0.601   
## Conduct -0.41152 0.91140 0.1905 0.082 .   
## Ntot -0.36639 0.93046 0.1983 0.066 .   
## NH4N 0.32526 -0.94562 0.2481 0.045 \*   
## NO3N -0.34907 0.93710 0.2573 0.024 \*   
## O2diss -0.79512 -0.60646 0.0761 0.373   
## Ptot 0.95095 0.30935 0.0009 0.995   
## pH 0.95766 -0.28792 0.0362 0.682   
## SiO2 0.01811 0.99984 0.1530 0.158   
## Temp -0.17471 -0.98462 0.0461 0.593   
## Transp 0.61896 -0.78542 0.0180 0.811   
## SAC 0.42261 0.90631 0.2386 0.036 \*   
## Tempsd 0.65037 -0.75962 0.0129 0.857   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
## Permutation: free  
## Number of permutations: 999  
##   
## 41 observations deleted due to missingness

vec.sp.df\_Gamma<-as.data.frame(vec.sp\_Gamma$vectors$arrows\*sqrt(vec.sp\_Gamma$vectors$r))  
vec.sp.df\_Gamma$param<-rownames(vec.sp.df\_Gamma)  
vec.sp.df\_Gamma <- vec.sp.df\_Gamma %>% filter(param %in% (c("Area\_ha","WLF","NH4N","NO3N","SAC")))#"Temp\_0\_6\_sd",  
ggplot(PEAK\_Chem\_norm, aes(y=scale(GammaPeakDepth), x=scale(GammaPeakRichness)))+  
 geom\_point(aes())+ theme(legend.title=element\_blank())+#scale\_fill\_discrete(name = "Groups")+  
 geom\_segment(data=vec.sp.df\_Gamma,aes(y=0,yend=2\*(GammaPeakDepth),x=0,xend=2\*(GammaPeakRichness)),  
 arrow = arrow(length = unit(0.5, "cm")),colour="black",inherit\_aes=FALSE) +  
 geom\_text(data=vec.sp.df\_Gamma,aes(y=2.3\*(GammaPeakDepth),x=2.3\*(GammaPeakRichness),label=param),size=5)+  
 coord\_fixed() + xlab("Rgammamax (scaled)") + ylab("Dgammamax (scaled)")+  
 theme(legend.position = c(0.9, 0.1))



## Represetitvity of small dataset

Comparing the environmental data for the two dataset levels Level3 and Level2 with a permanova test shows that Level3 data (N=27) is highly significant (p<0.001) representative for full dataset.

##TEST for Represantativity #Permanova  
adonis2(PEAK[,c(3,5)]~datasettotsimpl, data=PEAK, by = NULL) #ALPHAPEAK

## Permutation test for adonis under reduced model  
## Permutation: free  
## Number of permutations: 999  
##   
## adonis2(formula = PEAK[, c(3, 5)] ~ datasettotsimpl, data = PEAK, by = NULL)  
## Df SumOfSqs R2 F Pr(>F)  
## Model 1 0.871 0.00663 0.6545 0.566  
## Residual 98 130.361 0.99337   
## Total 99 131.231 1.00000

adonis2(PEAK[,c(14,15)]~datasettotsimpl, data=PEAK, by = NULL) #GammaPEAK

## Permutation test for adonis under reduced model  
## Permutation: free  
## Number of permutations: 999  
##   
## adonis2(formula = PEAK[, c(14, 15)] ~ datasettotsimpl, data = PEAK, by = NULL)  
## Df SumOfSqs R2 F Pr(>F)  
## Model 1 0.1690 0.02018 2.0189 0.141  
## Residual 98 8.2047 0.97982   
## Total 99 8.3738 1.00000

#adonis2(PEAK[,c(16,17)]~datasettotsimpl, data=PEAK, by = NULL) #BetaPEAK

No significant inpluence of dataset type

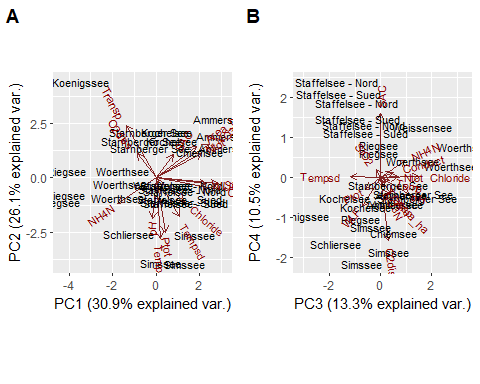
## PCA

PCA for all abiotic data. Multiple years for lakes

library(ggbiplot)  
  
label\_lake<- PEAK\_Chem\_norm[complete.cases(PEAK\_Chem\_norm[,c(3:16,19)]),] #LEVEL 3 data #19 #  
lak.pca <- prcomp(na.omit(label\_lake[,c(3:16,19)]),center = TRUE, scale. = TRUE)  
#print(lak.pca)  
#plot(lak.pca, type="l")  
summary(lak.pca)

## Importance of components:  
## PC1 PC2 PC3 PC4 PC5 PC6 PC7  
## Standard deviation 2.1542 1.9791 1.4106 1.2579 0.89524 0.78922 0.67224  
## Proportion of Variance 0.3094 0.2611 0.1327 0.1055 0.05343 0.04152 0.03013  
## Cumulative Proportion 0.3094 0.5705 0.7032 0.8086 0.86207 0.90359 0.93372  
## PC8 PC9 PC10 PC11 PC12 PC13  
## Standard deviation 0.60783 0.53218 0.37405 0.32663 0.20941 0.16798  
## Proportion of Variance 0.02463 0.01888 0.00933 0.00711 0.00292 0.00188  
## Cumulative Proportion 0.95835 0.97723 0.98656 0.99367 0.99659 0.99848  
## PC14 PC15  
## Standard deviation 0.13554 0.06711  
## Proportion of Variance 0.00122 0.00030  
## Cumulative Proportion 0.99970 1.00000

p1<- ggbiplot(lak.pca, choices = 1:2, obs.scale = 1, var.scale = 1,labels=label\_lake$Lake, arrow.color = "#FF0000",  
 ellipse = TRUE, cicle = TRUE)  
p2<- ggbiplot(lak.pca, choices = 3:4, obs.scale = 1, var.scale = 1,labels=label\_lake$Lake, arrow.color = "#FF0000",  
 ellipse = TRUE, cicle = TRUE)   
figure <- ggarrange(p1,p2,  
 labels = c("A","B"),  
 ncol = 2, nrow = 1, common.legend = TRUE, legend = "bottom", align = "hv")  
figure



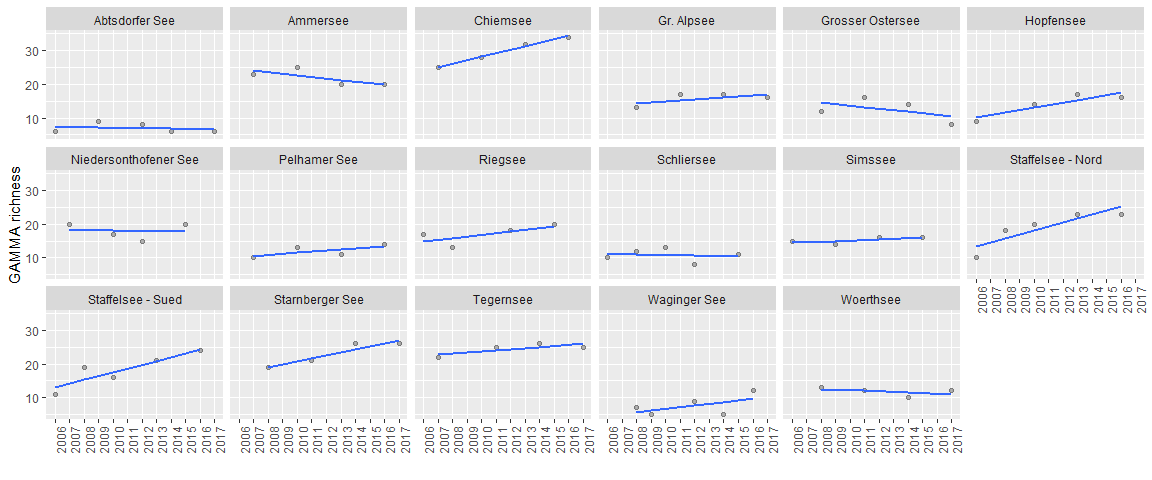
# PCA <- (data.frame(label\_lake$Lake))  
# PCA$YEAR <- label\_lake$YEAR  
# PCA$Morph\_PC1 <- lak.pca$x[,1]  
# PCA$Morph\_PC2 <- lak.pca$x[,2]  
# PCA$Morph\_PC3 <- lak.pca$x[,3]  
# PCA$Morph\_PC4 <- lak.pca$x[,4]  
# PCA$Morph\_PC5 <- lak.pca$x[,5]  
# names(PCA)[1]<-"Lake"

# H3 Temporal change

## Gamma change

Temporal change of Gamma richness for Temporal change dataset

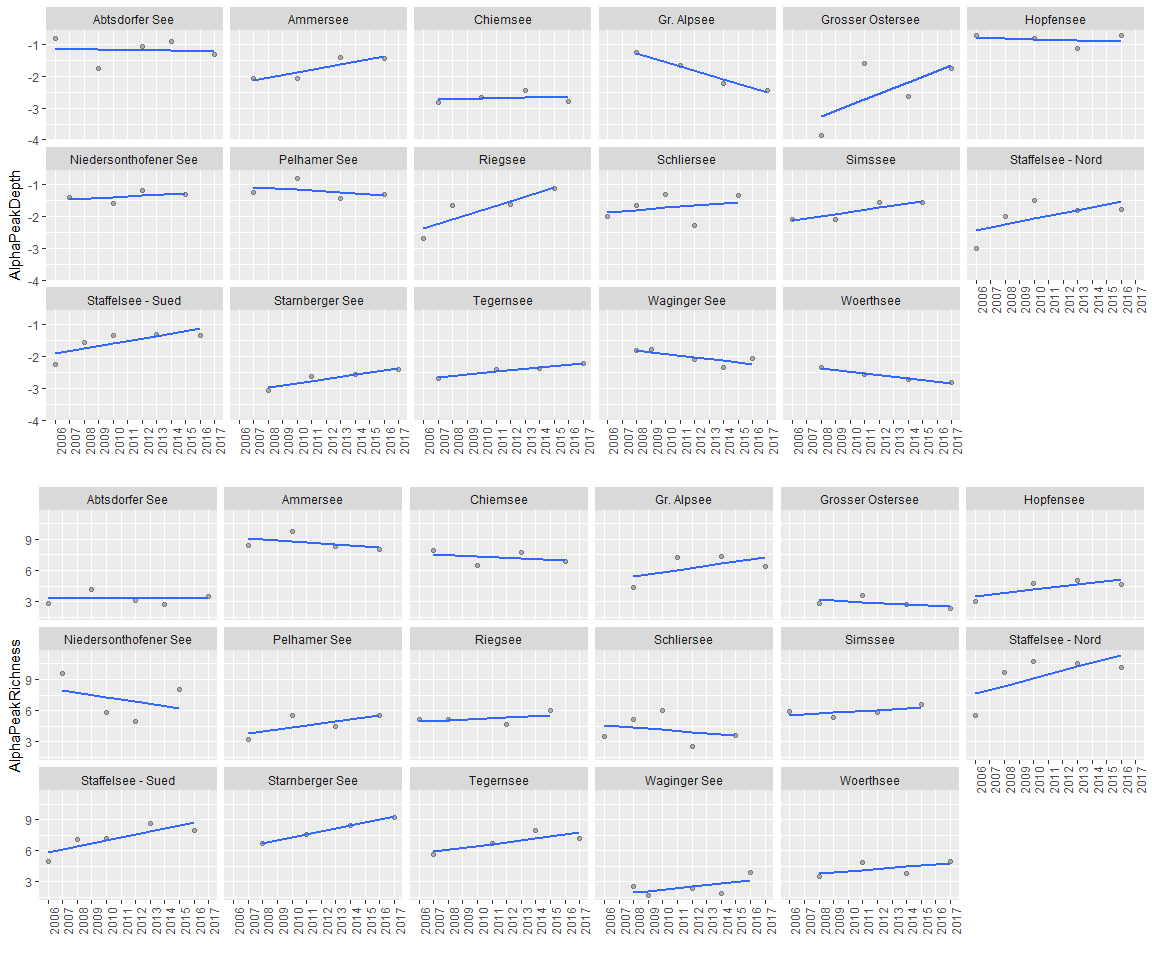
library(ggpmisc)  
ggplot(PEAK%>%group\_by(Lake)%>%filter(n\_distinct(YEAR)>3), aes(x=factor(YEAR), y=GAMMA, group=factor(Lake))) +  
 xlab("")+ylab("GAMMA richness")+theme(axis.text.x = element\_text(angle = 90, hjust = 1))+  
 geom\_point(alpha = 0.3) +facet\_wrap(vars(Lake),nrow=3) +  
 geom\_smooth(method = "lm", se = F) +  
 stat\_poly\_eq(aes(label = paste(..eq.label.., ..rr.label.., sep = "~~~")),  
 label.x.npc = "left", label.y.npc = 0.15,  
 formula = formula, parse = TRUE, size = 3)+  
 stat\_fit\_glance(method = 'lm',  
 method.args = list(formula = formula),  
 geom = 'text',  
 aes(label = paste("P-value = ", signif(..p.value.., digits = 4), sep = "")),  
 label.x = 'left', label.y = 0.35, size = 3)



## Peak change

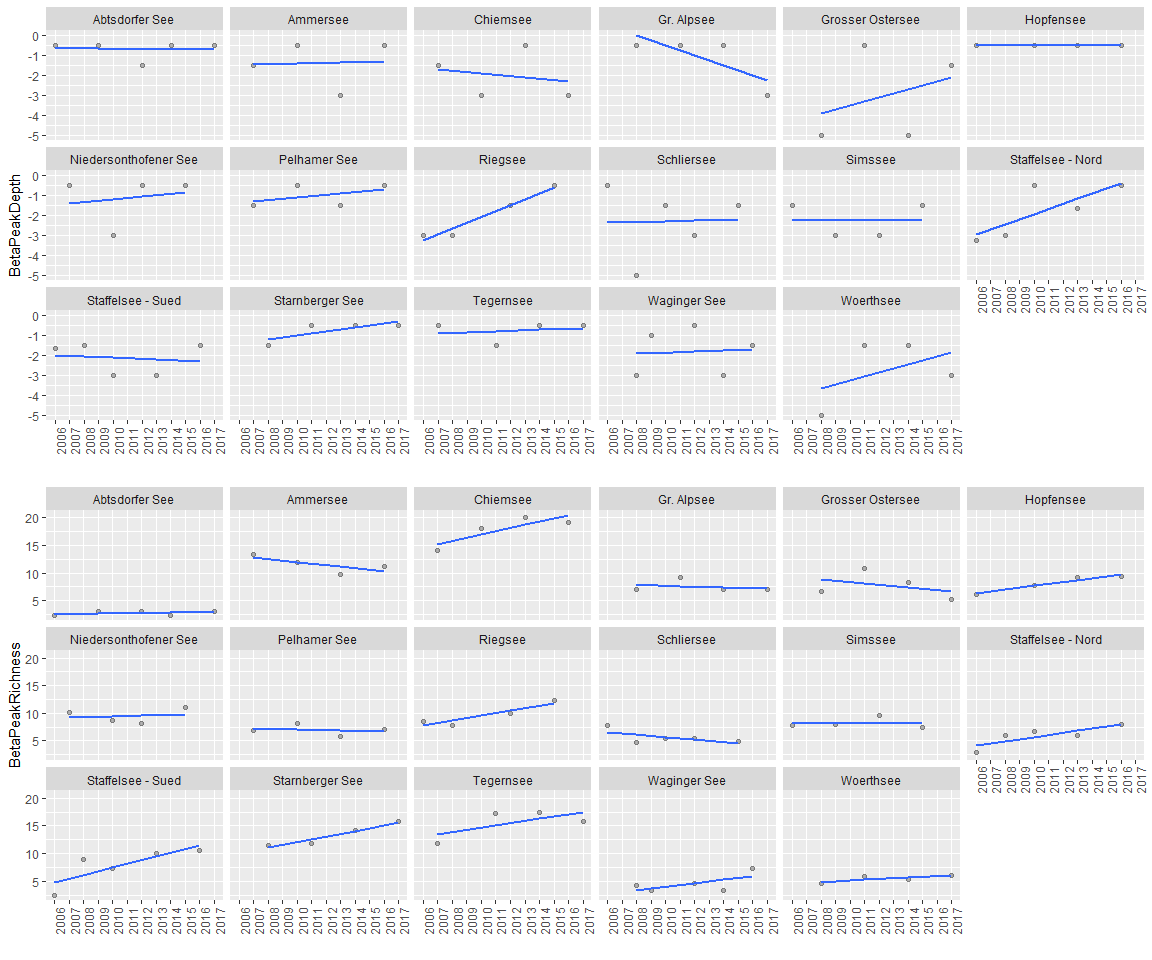
Temporal change for Dalphamax and Ralphamax

library(ggpmisc)  
  
T1<-ggplot(PEAK%>%group\_by(Lake)%>%filter(n\_distinct(YEAR)>3), aes(x=factor(YEAR), y=AlphaPeakDepth, group=factor(Lake)))+  
 xlab("")+ylab("AlphaPeakDepth")+  
 theme(axis.text.x = element\_text(angle = 90, hjust = 1))+   
 geom\_point(alpha = 0.3) +facet\_wrap(vars(Lake),nrow=3) +  
 geom\_smooth(method = "lm", se = F) +  
 stat\_poly\_eq(aes(label = paste(..eq.label.., ..rr.label.., sep = "~~~")),   
 label.x.npc = "left", label.y.npc = 0.15,  
 formula = formula, parse = TRUE, size = 3)+  
 stat\_fit\_glance(method = 'lm',  
 method.args = list(formula = formula),  
 geom = 'text',  
 aes(label = paste("P-value = ", signif(..p.value.., digits = 4), sep = "")),  
 label.x = 'left', label.y = -3.8, size = 3)  
  
  
  
T2<-ggplot(PEAK%>%group\_by(Lake)%>%filter(n\_distinct(YEAR)>3), aes(x=factor(YEAR), y=AlphaPeakRichness, group=factor(Lake)))+  
 xlab("")+ylab("AlphaPeakRichness")+  
 theme(axis.text.x = element\_text(angle = 90, hjust = 1))+   
 geom\_point(alpha = 0.3) +facet\_wrap(vars(Lake),nrow=3) +  
 geom\_smooth(method = "lm", se = F) +  
 stat\_poly\_eq(aes(label = paste(..eq.label.., ..rr.label.., sep = "~~~")),   
 label.x.npc = "left", label.y.npc = 0.15,  
 formula = formula, parse = TRUE, size = 3)+  
 stat\_fit\_glance(method = 'lm',  
 method.args = list(formula = formula),  
 geom = 'text',  
 aes(label = paste("P-value = ", signif(..p.value.., digits = 4), sep = "")),  
 label.x = 'left', label.y = -3.8, size = 3)  
  
ggarrange(T1,T2, nrow=2)



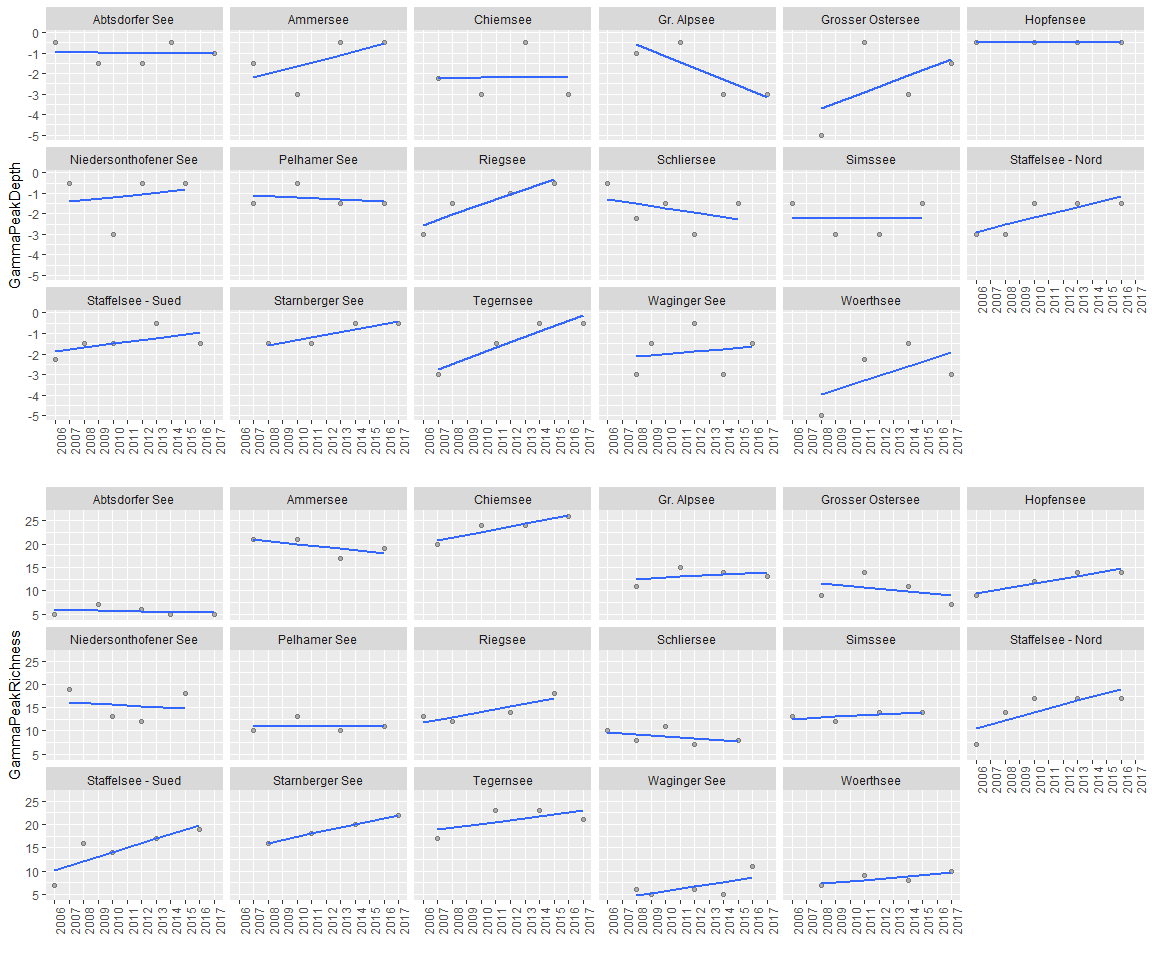
Temporal change for Dbetamax and Rbetamax

T3<-ggplot(PEAK%>%group\_by(Lake)%>%filter(n\_distinct(YEAR)>3), aes(x=factor(YEAR), y=BetaPeakDepth, group=factor(Lake)))+  
 xlab("")+ylab("BetaPeakDepth")+  
 theme(axis.text.x = element\_text(angle = 90, hjust = 1))+   
 geom\_point(alpha = 0.3) +facet\_wrap(vars(Lake),nrow=3) +  
 geom\_smooth(method = "lm", se = F) +  
 stat\_poly\_eq(aes(label = paste(..eq.label.., ..rr.label.., sep = "~~~")),   
 label.x.npc = "left", label.y.npc = 0.15,  
 formula = formula, parse = TRUE, size = 3)+  
 stat\_fit\_glance(method = 'lm',  
 method.args = list(formula = formula),  
 geom = 'text',  
 aes(label = paste("P-value = ", signif(..p.value.., digits = 4), sep = "")),  
 label.x = 'left', label.y = -3.8, size = 3)  
  
T4<-ggplot(PEAK%>%group\_by(Lake)%>%filter(n\_distinct(YEAR)>3), aes(x=factor(YEAR), y=BetaPeakRichness, group=factor(Lake)))+  
 xlab("")+ylab("BetaPeakRichness")+  
 theme(axis.text.x = element\_text(angle = 90, hjust = 1))+   
 geom\_point(alpha = 0.3) +facet\_wrap(vars(Lake),nrow=3) +  
 geom\_smooth(method = "lm", se = F) +  
 stat\_poly\_eq(aes(label = paste(..eq.label.., ..rr.label.., sep = "~~~")),   
 label.x.npc = "left", label.y.npc = 0.15,  
 formula = formula, parse = TRUE, size = 3)+  
 stat\_fit\_glance(method = 'lm',  
 method.args = list(formula = formula),  
 geom = 'text',  
 aes(label = paste("P-value = ", signif(..p.value.., digits = 4), sep = "")),  
 label.x = 'left', label.y = -3.8, size = 3)  
  
ggarrange(T3,T4, nrow=2)



Temporal change for Dgammamax and Rgammamax

T5<-ggplot(PEAK%>%group\_by(Lake)%>%filter(n\_distinct(YEAR)>3), aes(x=factor(YEAR), y=GammaPeakDepth, group=factor(Lake)))+  
 xlab("")+ylab("GammaPeakDepth")+  
 theme(axis.text.x = element\_text(angle = 90, hjust = 1))+   
 geom\_point(alpha = 0.3) +facet\_wrap(vars(Lake),nrow=3) +  
 geom\_smooth(method = "lm", se = F) +  
 stat\_poly\_eq(aes(label = paste(..eq.label.., ..rr.label.., sep = "~~~")),   
 label.x.npc = "left", label.y.npc = 0.15,  
 formula = formula, parse = TRUE, size = 3)+  
 stat\_fit\_glance(method = 'lm',  
 method.args = list(formula = formula),  
 geom = 'text',  
 aes(label = paste("P-value = ", signif(..p.value.., digits = 4), sep = "")),  
 label.x = 'left', label.y = -3.8, size = 3)  
  
T6<-ggplot(PEAK%>%group\_by(Lake)%>%filter(n\_distinct(YEAR)>3), aes(x=factor(YEAR), y=GammaPeakRichness, group=factor(Lake)))+  
 xlab("")+ylab("GammaPeakRichness")+  
 theme(axis.text.x = element\_text(angle = 90, hjust = 1))+   
 geom\_point(alpha = 0.3) +facet\_wrap(vars(Lake),nrow=3) +  
 geom\_smooth(method = "lm", se = F) +  
 stat\_poly\_eq(aes(label = paste(..eq.label.., ..rr.label.., sep = "~~~")),   
 label.x.npc = "left", label.y.npc = 0.15,  
 formula = formula, parse = TRUE, size = 3)+  
 stat\_fit\_glance(method = 'lm',  
 method.args = list(formula = formula),  
 geom = 'text',  
 aes(label = paste("P-value = ", signif(..p.value.., digits = 4), sep = "")),  
 label.x = 'left', label.y = -3.8, size = 3)  
  
ggarrange(T5,T6, nrow=2)



## Abiotic change

Chem\_0\_6m\_mean\_STAFF <- Chem\_uniform\_LOIx[rowSums(is.na(Chem\_uniform\_LOIx[,c(3:15)]))==0,] %>%   
 group\_by(Lake) %>%  
 filter(n\_distinct(YEAR)>1)  
   
STAFF1<-ggplot(Chem\_0\_6m\_mean\_STAFF,aes(x=factor(YEAR), y=Chloride, group=(Lake), col=Lake))+  
 geom\_line()+geom\_point()+xlab("")+theme(axis.text.x = element\_text(angle = 90, hjust = 1))  
STAFF2<-ggplot(Chem\_0\_6m\_mean\_STAFF,aes(x=factor(YEAR), y=Conduct, group=(Lake), col=Lake))+  
 geom\_line()+geom\_point()+xlab("")+theme(axis.text.x = element\_text(angle = 90, hjust = 1))  
STAFF3<-ggplot(Chem\_0\_6m\_mean\_STAFF,aes(x=factor(YEAR), y=Ntot, group=(Lake), col=Lake))+  
 geom\_line()+geom\_point()+xlab("")+theme(axis.text.x = element\_text(angle = 90, hjust = 1))  
STAFF4<-ggplot(Chem\_0\_6m\_mean\_STAFF,aes(x=factor(YEAR), y=NH4N, group=(Lake), col=Lake))+  
 geom\_line()+geom\_point()+xlab("")+theme(axis.text.x = element\_text(angle = 90, hjust = 1))  
STAFF5<-ggplot(Chem\_0\_6m\_mean\_STAFF,aes(x=factor(YEAR), y=NO3N, group=(Lake), col=Lake))+  
 geom\_line()+geom\_point()+xlab("")+theme(axis.text.x = element\_text(angle = 90, hjust = 1))  
STAFF6<-ggplot(Chem\_0\_6m\_mean\_STAFF,aes(x=factor(YEAR), y=O2diss, group=(Lake), col=Lake))+  
 geom\_line()+geom\_point()+xlab("")+theme(axis.text.x = element\_text(angle = 90, hjust = 1))  
STAFF7<-ggplot(Chem\_0\_6m\_mean\_STAFF,aes(x=factor(YEAR), y=pH, group=(Lake), col=Lake))+  
 geom\_line()+geom\_point()+xlab("")+theme(axis.text.x = element\_text(angle = 90, hjust = 1))  
STAFF7A<-ggplot(Chem\_0\_6m\_mean\_STAFF,aes(x=factor(YEAR), y=Ptot, group=(Lake), col=Lake))+  
 geom\_line()+geom\_point()+xlab("")+theme(axis.text.x = element\_text(angle = 90, hjust = 1))  
  
STAFF8<-ggplot(Chem\_0\_6m\_mean\_STAFF,aes(x=factor(YEAR), y=SiO2, group=(Lake), col=Lake))+  
 geom\_line()+geom\_point()+xlab("")+theme(axis.text.x = element\_text(angle = 90, hjust = 1))  
STAFF9<-ggplot(Chem\_0\_6m\_mean\_STAFF,aes(x=factor(YEAR), y=Temp, group=(Lake), col=Lake))+  
 geom\_line()+geom\_point()+xlab("")+theme(axis.text.x = element\_text(angle = 90, hjust = 1))  
STAFF10<-ggplot(Chem\_0\_6m\_mean\_STAFF,aes(x=factor(YEAR), y=Transp, group=(Lake), col=Lake))+  
 geom\_line()+geom\_point()+xlab("YEAR")+theme(axis.text.x = element\_text(angle = 90, hjust = 1))  
STAFF11<-ggplot(Chem\_0\_6m\_mean\_STAFF,aes(x=factor(YEAR), y=SAC, group=(Lake), col=Lake))+  
 geom\_line()+geom\_point()+xlab("YEAR")+theme(axis.text.x = element\_text(angle = 90, hjust = 1))  
STAFF12<-ggplot(Chem\_0\_6m\_mean\_STAFF,aes(x=factor(YEAR), y=Tempsd, group=(Lake), col=Lake))+  
 geom\_line()+geom\_point()+xlab("YEAR")+theme(axis.text.x = element\_text(angle = 90, hjust = 1))  
  
ggarrange(STAFF1,STAFF2,STAFF3,STAFF4,STAFF5,STAFF6,STAFF7,STAFF7A,STAFF8,STAFF9,STAFF10,STAFF11,STAFF12, nrow = 5, ncol = 3, common.legend = TRUE, legend = "bottom", align = "hv")

