Appendix E – R code used for analysis

#clear workspace
rm(list=ls())

#R packages for this analysis:
dplyr
zoo
glmmADMB
ggplot2
ggridExtra
scales

#Read in data
Site_data <- read.csv("E:/Business/PCS_Molonglo_2018/Site_data_2.csv", header = T)
str(Site_data)

#load packages
library(dplyr)
library(zoo)

#1. Calculate patch-level means and counts
###Patch-level analysis

average <- function(i){
  mean(i, na.rm = TRUE)
}

Leng <- function(i){
  length(i[!is.na(i)])
}

Out_patch <- Site_data %>%
  group_by(Year, Patch) %>%
  summarise_at(.
  vars = Variables, .funs = c(Mean = "average", N = "Leng")

#Appending some additional details to the Out_patch file
Meta_var <- Site_data[,3:7]
Meta_var <- Meta_var[,2]

Meta_var <- distinct(Meta_var, Patch, .keep_all = TRUE)
Out_patch <- left_join(Out_patch, Meta_var, by="Patch")

#Remove patches from primary dataset that are not in this analysis
Out_patch <- subset(Out_patch, Out_patch$Patch !="D2")
Out_patch <- subset(Out_patch, Out_patch$Patch !="K cont")
Out_patch <- subset(Out_patch, Out_patch$Patch !="K rest")

#2. Computation of confidence interval – for native species richness. Repeat this analysis for each variable.

#load analysis package. glmmADMB has a clean implementation of linear mixed models. lme4 could be used as well.
library(glmmADMB)

Site_data$Year1 <- Site_data$Year - 2013 #standardise year
Site_data3year <- subset(Site_data, Year1 < 3) #Subset data for baseline calculation (only years 2013, 2014, and 2015)
#Check the distribution of the data - this helps to identify possible issues
hist(Site_data3year$native_spp_richness) #count data = poission distribution
mean(Site_data3year$native_spp_richness)

#subset into listed and un-listed plots
Site_data3yearL <- subset(Site_data3year, Listing == "Listed")
Site_data3yearU <- subset(Site_data3year, Listing != "Listed")

#Check for a 'year' trend effect. Not a big deal if there is one, but a curiosity
Mod1 <- glmmadmb(native_spp_richness ~ Year1 + (1|Patch), family="poisson", data = Site_data3year)
summary(Mod1) #Year not significant

#Run intercept model on listed patches.
Mod2L <- glmmadmb(native_spp_richness ~ 1 + (1|Patch), family="poisson", data = Site_data3yearL)
summary(Mod2L)
#Run intercept model on unlisted patches
Mod2U <- glmmadmb(native_spp_richness ~ 1 + (1|Patch), family="poisson", data = Site_data3yearU)
summary(Mod2U)

#Check the intercept term
exp(coef(Mod2))
#Check the standard error of the intercept term - this is what we use to create the confidence interval
Mod2$stdbeta

#Manually adjust CI to be centred on the patch averages

#Extract the mean for the years 2013 - 2015 from the dataset used for the mixed model
Patch_av <- Site_data3year %>%
  group_by(Patch) %>%
  summarise_at(.vars = Variables, .funs = c(Mean = "average"))

#Join the meta-data
Patch_avL <- inner_join(Patch_av, Meta_var, by = "Patch")
Patch_avL <- subset(Patch_avL, Listing == "Listed")
Patch_avU <- subset(Patch_avU, Listing != "Listed")

#Compute the upper and lower bounds of the confidence interval for each of the listed patches
CI.upper3L <- exp(log(Patch_avL$native_spp_richness_Mean) + 1.96*Mod2L$stdbeta)
CI.lower3L <- exp(log(Patch_avL$native_spp_richness_Mean) - 1.96*Mod2L$stdbeta)

#Compute the upper and lower bounds of the confidence interval for each of the unlisted patches
CI.upper3U <- exp(log(Patch_avU$native_spp_richness_Mean) + 1.96*Mod2U$stdbeta)
CI.lower3U <- exp(log(Patch_avU$native_spp_richness_Mean) - 1.96*Mod2U$stdbeta)

#Create a dataframe of these data
BL <- data.frame(Patch_avL$Patch)
row.names(BL) <- BL$Patch_avL.Patch
BU <- data.frame(Patch_avU$Patch)
row.names(BU) <- BU$Patch_avU.Patch

CI_listL <- data.frame(BL[,1], CI.lower3L, CI.upper3L)
colnames(CI_listL) <- c("Patch", "CI.lower", "CI.upper")
CI_listU <- data.frame(BU[,1], CI.lower3U, CI.upper3U)
colnames(CI_listU) <- c("Patch", "CI.lower", "CI.upper")
CI_list <- bind_rows(CI_listL, CI_listU)

# Merge these to the entire dataset: 2013 - 2017
Out_patch3 <- merge(Out_patch, CI_list, by = "Patch")

# Plot the results - see how they look

# Load ggplot
library(ggplot2)

p <- ggplot()
p <- p + geom_point(data = Out_patch3,
                     aes(y = native_spp_richness_Mean, x = Year),
                     shape = 1,
                     size = 1.5)
p <- p + geom_text(data = Out_patch3,
                     aes(y = native_spp_richness_Mean, x = Year, label =
                         native_spp_richness_N),
                     size = 3,
                     vjust = 1.5,
                     hjust = 0)
p <- p + xlab("Year") +
     ylab("native_spp_richness_Mean + modelled 95% CI")
p <- p + theme(text = element_text(size=15)) + theme_bw()
p <- p + geom_line(data = Out_patch3,
                     aes(x = Year,
                         y = native_spp_richness_Mean),
                     colour = "black")
p <- p + geom_ribbon(data = Out_patch3,
                     aes(x = Year,
                         ymax = CI.upper,
                         ymin = CI.lower),
                     alpha = 0.3)
p <- p + facet_wrap(~ Patch, scales = "fixed")
p
## Save dataset for further plotting
V_native_spp_richness <- data.frame(Out_patch3$Patch, Out_patch3$Year,
                                    Out_patch3$native_spp_richness_Mean, Out_patch3$native_spp_richness_N,
                                    Out_patch3$CI.lower, Out_patch3$CI.upper, Out_patch3$Vegetation_community,
                                    Out_patch3$PTWL)
write.csv(V_native_spp_richness, "E:/.../V_native_spp_richness.csv")

## Creating plots for each patch.

## Read in created datafile. This file contains the patch meta-data, year, mean for each variable, the 95% confidence intervals, critical values and soil moisture index.

# Read in file
Data_2 <- read.csv("E:/.../Data_2.csv", header = T)

# Subset the dataframe to a single patch. Do this for each patch.
A1 <- subset(Data_2, Out_patch3.Patch == "A1")
write.csv(A1, "E:/.../A1.csv")

## Create relevant packages
library(scales)
library(gridExtra)

A1 <- read.csv("E:.../A1.csv")

A1_1 <- subset(A1, Variable == "01. floristic value")
A1_2 <- subset(A1, Variable == "02. native species richness")
A1_3 <- subset(A1, Variable == "03. indicator species richness")
A1_4 <- subset(A1, Variable == "04. non-grass species richness")
A1_5 <- subset(A1, Variable == "05. perennial native groundcover")
A1_6 <- subset(A1, Variable == "06. native grass cover")
A1_7 <- subset(A1, Variable == "07. exotic annuals")
A1_8 <- subset(A1, Variable == "08. cover exotic perennials")
A1_9 <- subset(A1, Variable == "09. bare ground")
A1_10 <- subset(A1, Variable == "10. litter cover")

#Create a plot for each variable:
p1 <- ggplot()
p1 <- p1 + geom_point(data = A1_1,
  aes(y = Mean, x = Out_patch3.Year),
  shape = 1,
  size = 1.5) + scale_y_continuous(limits = c(0, NA))

p1 <- p1 + geom_point(data = A1_1,
  aes(y = Soil_moisture, x = Out_patch3.Year),
  shape = 21,
  size = 1.5,
  fill = "blue")

p1 <- p1 + geom_text(data = A1_1,
  aes(y = Mean, x = Out_patch3.Year, label = N),
  size = 3,
  vjust = 1.5,
  hjust = 0)

p1 <- p1 + theme(text = element_text(size=15)) + theme_bw()

p1 <- p1 + geom_line(data = A1_1,
  aes(x = Out_patch3.Year, y = Mean),
  colour = "black")

p1 <- p1 + geom_line(data = A1_1,
  aes(x = Out_patch3.Year, y = Soil_moisture),
  colour = "blue", linetype = "dashed")

p1 <- p1 + geom_ribbon(data = A1_1,
  aes(x = Out_patch3.Year, ymax = Out_patch3.CI.upper,
  ymin = Out_patch3.CI.lower),
  alpha = 0.3)

p1 <- p1 + geom_ribbon(data = A1_1,
  aes(x = Out_patch3.Year, ymax = BM_upper,
  ymin = BM_lower),
  fill = "lightgreen", colour = "lightgreen", alpha = 0.3)

p1 <- p1 + facet_wrap(~ Variable, scales = "fixed") + labs(x=NULL, y = NULL)

p1

p2 <- ggplot()
p2 <- p2 + geom_point(data = A1_2,
  aes(y = Mean, x = Out_patch3.Year),
```r
shape = 1,
size = 1.5)+ scale_y_continuous(limits = c(0, NA))

p2 <- p2 + geom_point(data = A1_2,
  aes(y = Soil_moisture, x = Out_patch3.Year),
  shape = 21,
  size = 1.5,
  fill = "blue")

p2 <- p2 + geom_text(data = A1_2,
  aes(y = Mean, x = Out_patch3.Year, label = N),
  size = 3,
  vjust = 1.5,
  hjust = 0)

p2 <- p2 + theme(text = element_text(size=15)) + theme_bw()

p2 <- p2 + geom_line(data = A1_2,
  aes(x = Out_patch3.Year,
       y = Mean),
  colour = "black")

p2 <- p2 + geom_line(data = A1_2,
  aes(x = Out_patch3.Year,
       y = Soil_moisture),
  colour = "blue", linetype = "dashed")

p2 <- p2 + geom_ribbon(data = A1_2,
  aes(x = Out_patch3.Year,
       ymax = Out_patch3.CI.upper,
       ymin = Out_patch3.CI.lower),
  alpha = 0.3)

p2 <- p2 + geom_ribbon(data = A1_2,
  aes(x = Out_patch3.Year,
       ymax = BM_upper,
       ymin = BM_lower),
  fill = "lightgreen", colour = "lightgreen", alpha = 0.3)

p2 <- p2 + facet_wrap( ~ Variable, scales = "fixed") + labs(x=NULL, y = NULL)

p3 <- ggplot()
p3 <- p3 + geom_point(data = A1_3,
  aes(y = Mean, x = Out_patch3.Year),
  shape = 1,
  size = 1.5)+ scale_y_continuous(limits = c(0, NA))

p3 <- p3 + geom_point(data = A1_3,
  aes(y = Soil_moisture, x = Out_patch3.Year),
  shape = 21,
  size = 1.5,
  fill = "blue")

p3 <- p3 + geom_text(data = A1_3,
  aes(y = Mean, x = Out_patch3.Year, label = N),
  size = 3,
  vjust = 1.5,
  hjust = 0)

p3 <- p3 + theme(text = element_text(size=15)) + theme_bw()

p3 <- p3 + geom_line(data = A1_3,
  aes(x = Out_patch3.Year,
       y = Mean),
  colour = "black")
```
```r
p6 <- p6 + geom_line(data = A1_6,
  aes(x = Out_patch3.Year,
       y = Mean),
  colour = "black")

p6 <- p6 + geom_line(data = A1_6,
  aes(x = Out_patch3.Year,
       y = Soil_moisture),
  colour = "blue", linetype = "dashed")

p6 <- p6 + geom_ribbon(data = A1_6,
  aes(x = Out_patch3.Year,
       ymax = Out_patch3.CI.upper,
       ymin = Out_patch3.CI.lower),
  alpha = 0.3)

p6 <- p6 + geom_ribbon(data = A1_6,
  aes(x = Out_patch3.Year,
       ymax = BM_upper,
       ymin = BM_lower),
  fill = "lightgreen", colour = "lightgreen", alpha = 0.3)

p6 <- p6 + facet_wrap( ~ Variable, scales = "fixed") + labs(x=NULL, y = NULL)

p7 <- ggplot()

p7 <- p7 + geom_point(data = A1_7,
  aes(y = Mean, x = Out_patch3.Year),
  shape = 1,
  size = 1.5)+ scale_y_continuous(limits = c(0, NA))

p7 <- p7 + geom_point(data = A1_7,
  aes(y = Soil_moisture, x = Out_patch3.Year),
  shape = 21,
  size = 1.5,
  fill = "blue")

p7 <- p7 + geom_text(data = A1_7,
  aes(y = Mean, x = Out_patch3.Year, label = N),
  size = 3,
  vjust = 1.5,
  hjust = 0)

p7 <- p7 + theme(text = element_text(size=15)) + theme_bw()

p7 <- p7 + geom_line(data = A1_7,
  aes(x = Out_patch3.Year,
       y = Mean),
  colour = "black")

p7 <- p7 + geom_line(data = A1_7,
  aes(x = Out_patch3.Year,
       y = Soil_moisture),
  colour = "blue", linetype = "dashed")

p7 <- p7 + geom_ribbon(data = A1_7,
  aes(x = Out_patch3.Year,
       ymax = Out_patch3.CI.upper,
       ymin = Out_patch3.CI.lower),
  alpha = 0.3)

p7 <- p7 + geom_ribbon(data = A1_7,
  aes(x = Out_patch3.Year,
       ymax = BM_upper,
       ymin = BM_lower),
  fill = "lightgreen", colour = "lightgreen", alpha = 0.3)
```

\begin{verbatim}
    ymin = Out_patch3.CI.lower),
           alpha = 0.3)

    p10 <- p10 + geom_ribbon(data = A1_10,
        aes(x = Out_patch3.Year,
             ymax = BM_upper,
             ymin = BM_lower),
           fill = "lightgreen", colour = "lightgreen", alpha = 0.3)

    p10 <- p10 + facet_wrap( ~ Variable, scales = "fixed") + labs(x=NULL, y=NULL)

    #Arrange into a neat single page figure
    grid.arrange(p1,p2,p3,p4,p5,p6,p7,p8,p9,p10, layout_matrix = rbind(c(1,2,3),
        c(4,5,6), c(7,8,9),c(10,11,12)),top = "Patch A1", left = "Mean value + modelled 95% CI and Soil Moisture Index")
\end{verbatim}