Appendix S3 - Biomass analysis

Renata Diaz

Background

This is a modified subset of Appendix S3 from the article "Maintenance of community function through compensation breaks down over time in a desert rodent community" by Renata Diaz and S. K. Morgan Ernest, now published in *Ecology* (Diaz and Ernest 2022).

Compensation

Compensation refers to the degree to which the remaining species on kangaroo rat removal plots absorb resources made available via kangaroo rat removal (Figure 1). We fit a generalized least squares (of the form *compensation ~ timeperiod*; note that "timeperiod" is coded as "oera" throughout) using the `gls` function from the R package `nlme` (Pinheiro, Bates, and R Core Team 2023). Because values from monthly censuses within each time period are subject to temporal autocorrelation, we included a continuous autoregressive temporal autocorrelation structure of order 1 (using the `CORCAR1` function). We compared this model to models fit without the autocorrelation structure and without the time period term using AIC. The model with both the time period term and the autocorrelation structure was the best-fitting model via AIC (Table 1), and we used this model to calculate estimates and contrasts using the package `emmeans` (Lenth et al. 2023) (Table 2, Table 3).

Data analysis

Data preparation

The following code downloads the data and prepares the `compensation` data frame for analysis.

If needed, install the `soar` package:

```r
remotes::install_github('diazrenata/soar')
```

Data can be downloaded directly from the Portal data repository:

```r
plotl <- get_plot_totals(currency = "biomass")
```

```
Loading in data version 3.118.0
```

```
Joining with `by = join_by(plot)`
```

```r
plot_types <- list_plot_types() %>% filter(plot_type == "EE")
```

```
Loading in data version 3.118.0
Joining with `by = join_by(plot)`
```

For interpretability, translating the era and treatment "names" as RMD coded them for analysis to the corresponding dates:

```r
oera_df <- data.frame(
  oera = c("a_pre_pb", "b_pre_reorg", "c_post_reorg"),
  `Timeperiod` = c("1988-1997", "1997-2010", "2010-2020")
)

oplot_df <- data.frame(oplottype = c("CC", "EE"),
                       `Treatment` = c("Control", "Exclosure"))

contrasts_df <- data.frame(
  contrast = c(
    "a_pre_pb - b_pre_reorg",
    "a_pre_pb - c_post_reorg",
    "b_pre_reorg - c_post_reorg"
  ),
  Comparison = c(
    "1988-1997 - 1997-2010",
    "1988-1997 - 2010-2020",
    "1997-2010 - 2010-2020"
  )
)
```

Because there are 5 exclosure plots and 4 control plots in these data, we remove 1 exclosure plot to achieve a balanced design. From the 5 possible exclosures to remove, we randomly select 1 using the seed 1977 (the year the Portal Project was initiated).

```
plot_types <- plot_types  %>%
  filter(plot_type == "EE")

set.seed(1977)
remove_plot <- sample(plot_types$plot, 1, F) # results in removing plot 19

plotl <- plotl %>%
  filter(plot != remove_plot)
```

Finally, take treatment-level means and calculate the compensation variable:

```
# Treatment-level means:
treatl <- plots_to_treatment_means(plotl)

# Format column types
treatl <- treatl %>%
  mutate(censusdate = as.Date(censusdate),
         oera = ordered(oera),
         oplottype = ordered(oplottype))

compensation <- get_compensation(treatl)
```

```
Joining with `by = join_by(period)`
```

GLS model

The following code fits the GLS models:

```
comp_mean_gls <-
  gls(smgran_comp ~ oera,
      correlation = corCAR1(form = ~ period),
      data = compensation)

comp_mean_gls_notime <-
  gls(smgran_comp ~ 1,
      correlation = corCAR1(form = ~ period),
      data = compensation)
```

```r
comp_mean_gls_noautoc <-
  gls(smgran_comp ~ oera, data = compensation)

comp_mean_null <- gls(smgran_comp ~ 1, data = compensation)
```

Model comparison via AIC:

```r
compensation_comparison <- data.frame(
  `Model specification` = c(
    "intercept + timeperiod + autocorrelation",
    "intercept + autocorrelation",
    "intercept + timeperiod",
    "intercept"
  ),
  AIC = c(
    AIC(comp_mean_gls),
    AIC(comp_mean_gls_notime),
    AIC(comp_mean_gls_noautoc),
    AIC(comp_mean_null)
  )
)
```

Calculate estimates:

```r
comp_mean_gls_emmeans <- emmeans(comp_mean_gls, specs = ~ oera)

compensation_estimates <- oera_df %>%
  left_join(as.data.frame(comp_mean_gls_emmeans)) %>%
  select(-oera)
```

```
Joining with `by = join_by(oera)`
```

Calculate contrasts:

```r
compensation_contrasts <-contrasts_df %>%
  left_join(as.data.frame(pairs(comp_mean_gls_emmeans))) %>%
  mutate(p.value = round(p.value, digits = 4)) %>%
  select(-contrast)
```

```
Joining with `by = join_by(contrast)`
```

Results

Tables

Table 1: Comparisons for GLS on compensation.

Model.specification	AIC
intercept + timeperiod + autocorrelation	-17.623354
intercept + autocorrelation	-3.297103
intercept + timeperiod	92.184205
intercept	207.804481

```
knitr::kable(compensation_estimates)
```

Table 2: Estimates for GLS on compensation.

Timeperiod	emmean	SE	df	lower.CL	upper.CL
1988-1997	0.1435663	0.0511419	39.27016	0.0401447	0.2469878
1997-2010	0.5366915	0.0452745	41.90192	0.4453176	0.6280655
2010-2020	0.2441751	0.0517205	41.16587	0.1397362	0.3486140

```
knitr::kable(compensation_contrasts)
```

Table 3: Contrasts for GLS on compensation.

Comparison	estimate	SE	df	t.ratio	p.value
1988-1997 - 1997-2010	-0.3931253	0.0673811	43.21488	-5.834358	0.0000
1988-1997 - 2010-2020	-0.1006089	0.0727090	40.35555	-1.383719	0.3588
1997-2010 - 2010-2020	0.2925164	0.0678003	44.41615	4.314383	0.0003

Figures

```
Loading in data version 3.118.0

Joining with `by = join_by(plot)`
Joining with `by = join_by(oera)`
```

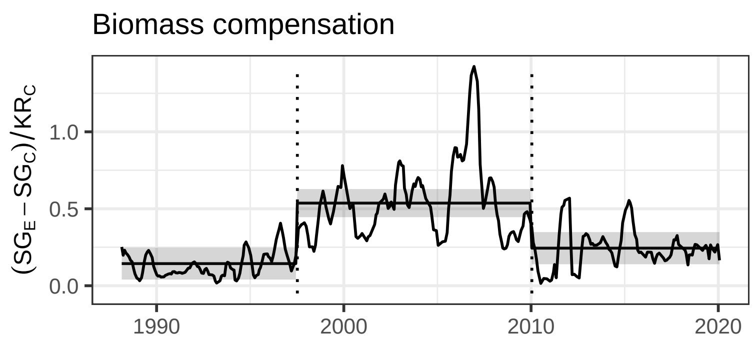

Figure 1: Dynamics of biomass and rodent community composition over time. Lines represent the 6-month moving averages of biomass compensation. Dotted vertical lines mark the boundaries between time periods used for statistical analysis. Horizontal lines are time-period estimates from generalized least squares models, and the semitransparent envelopes mark the 95% confidence or credible intervals.

References

Diaz, Renata M., and S. K. Morgan Ernest. 2022. "Maintenance of Community Function Through Compensation Breaks down over Time in a Desert Rodent Community." *Ecology* 103 (7): e3709. https://doi.org/10.1002/ecy.3709.

Lenth, Russell V., Ben Bolker, Paul Buerkner, Iago Giné-Vázquez, Maxime Herve, Maarten Jung, Jonathon Love, Fernando Miguez, Hannes Riebl, and Henrik Singmann. 2023. "Emmeans: Estimated Marginal Means, Aka Least-Squares Means."

Pinheiro, José, Douglas Bates, and R Core Team. 2023. *Nlme: Linear and Nonlinear Mixed Effects Models*.