Appendix S1. Linear regression models and non-linear population dynamics

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1 One species, logistic growth

Population growth over time in a single species is first modelled using a Beverton-Holt (discrete-time, logistic) model (Beverton and Holt (1957)), using an intra-specific competition coefficient for density-dependent growth (Hart and Marshall (2013)).

$$N_{i,t+1} = \frac{r_i N_{i,t}}{1 + \alpha_{ii} N_{i,t}}$$

Note that in this model, the system is at equilibrium when $N_{i,t+1} = N_{i,t}$, and therefore:

$$N^* = N^* \frac{r_i}{1 + \alpha_{ii} N^*}$$

$$1 = \frac{r_i}{1 + \alpha_{ii} N^*}$$

$$N^* = \frac{r_i - 1}{\alpha_{ii}}$$

Population dynamics simulation In the metacommunity simulation in the main text, a species resides in a site with an initial population size $N_{i,0} \sim Pois(10)$, a growth rate r_i that depends on the local environmental value E_k and the species trait x_i, and a fixed intra-specific competition coefficient of $\alpha_{ii} = 0.00125$. We simulate population growth here:

```r
set.seed(42)
# Simulate initial species population growth
N1.0 <- rpois(1, 10)
r1.0 <- 1.67
alpha.11 <- 0.00125
# model function
disc_log <- function(r, N0, alpha) {
    Nt1 <- (r * N0)/(1 + alpha * N0)
    return(Nt1)
}
# Simulation of model for t time steps
```

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```r
t <- 30
N <- rep(NA, t)
N[1] <- N1.0
for (i in 2:t) {
    N[i] <- disc_log(r = r1.0, N0 = N[i - 1], alpha = alpha.11)
}
```

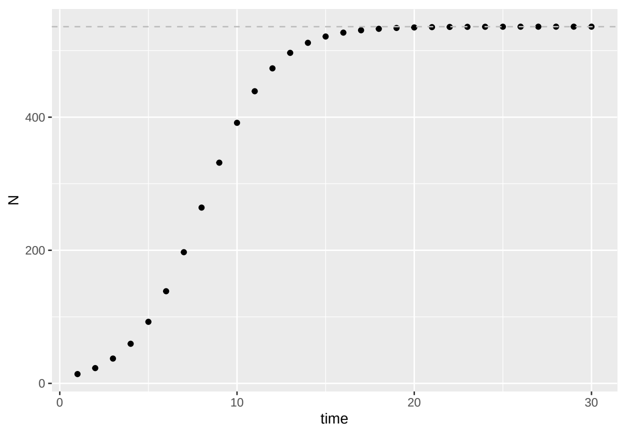

Figure 1: Population size N over time t for a discrete-time logistic growth model, with parameters $r_i = 1.67$, $N_{1,0} = 14$, and $\alpha_{11} = 0.00125$.

1.1 Linear statistical model

We fit the population time series data to a first-order auto-regressive model to predict N_{t+1} as a function of {N_t}:

$$N_{t+1} = \beta_0 + \beta_1 N_t + \epsilon_t$$

```r
m.1 <- arima(N, order = c(1, 0, 0))
# plotting the series along with the fitted values
m.1.fit <- N - residuals(m.1)
dat$ar1.fit <- m.1.fit
```

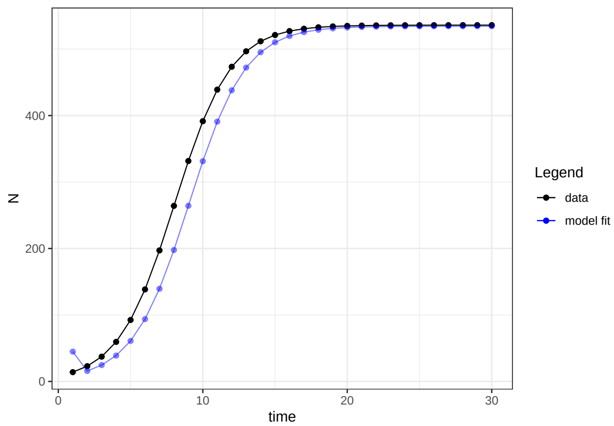

Figure 2: Population size over time (black line) with fitted values from a first-order autoregressive model (red dashed line).

```
knitr::knit_exit()
```

Beverton, R. J., and S. J. Holt. 1957. On the dynamics of exploited fish populations (Vol. 11). Springer Science & Business Media.

Hart, S. P., and D. J. Marshall. 2013. Environmental stress, facilitation, competition, and coexistence. Ecology 94:2719–2731.