Temporal Niches

Ecological niche: Set of (abiotic) conditions where

a species' birth rate ≥ death rate

Population persists within its (species') niche

Fundamental niche: Absent other species (no biotic intx)

Realized niche: Other species present (hence, smaller)

Temporal Niche: Environmental variation ⇒

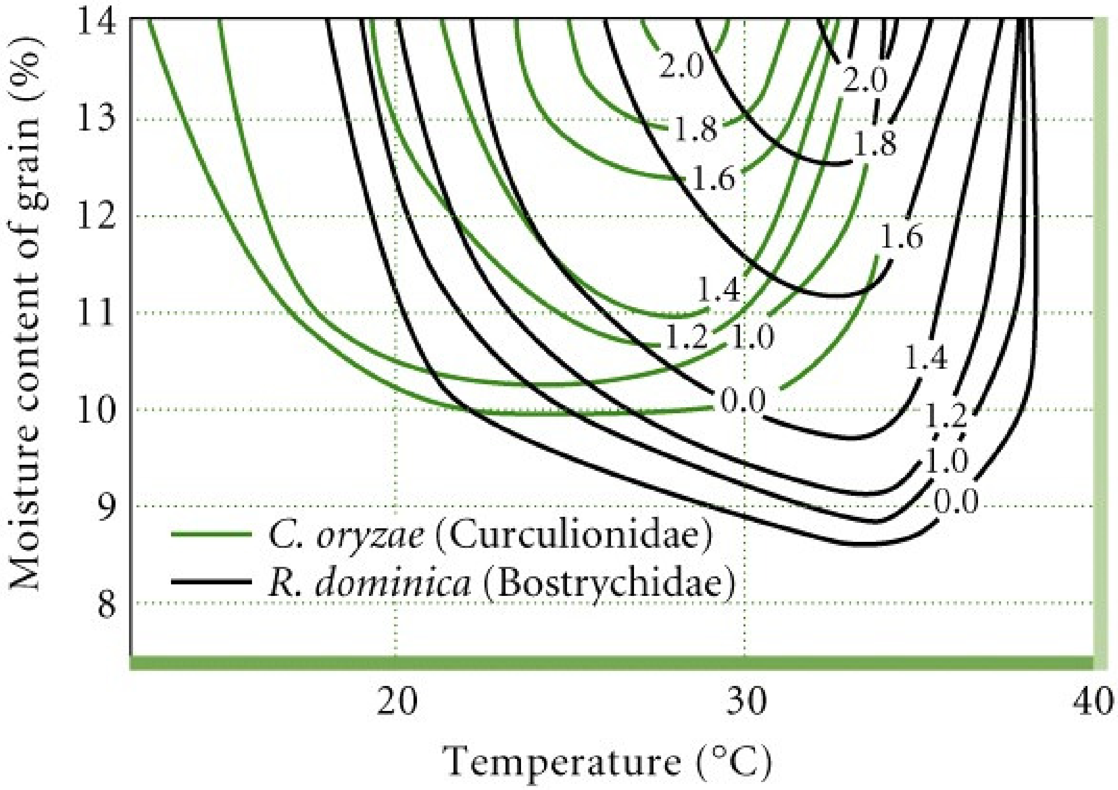
Fluctuations in availability of niche

2 Spp: Use same biotic resource (food), but respond

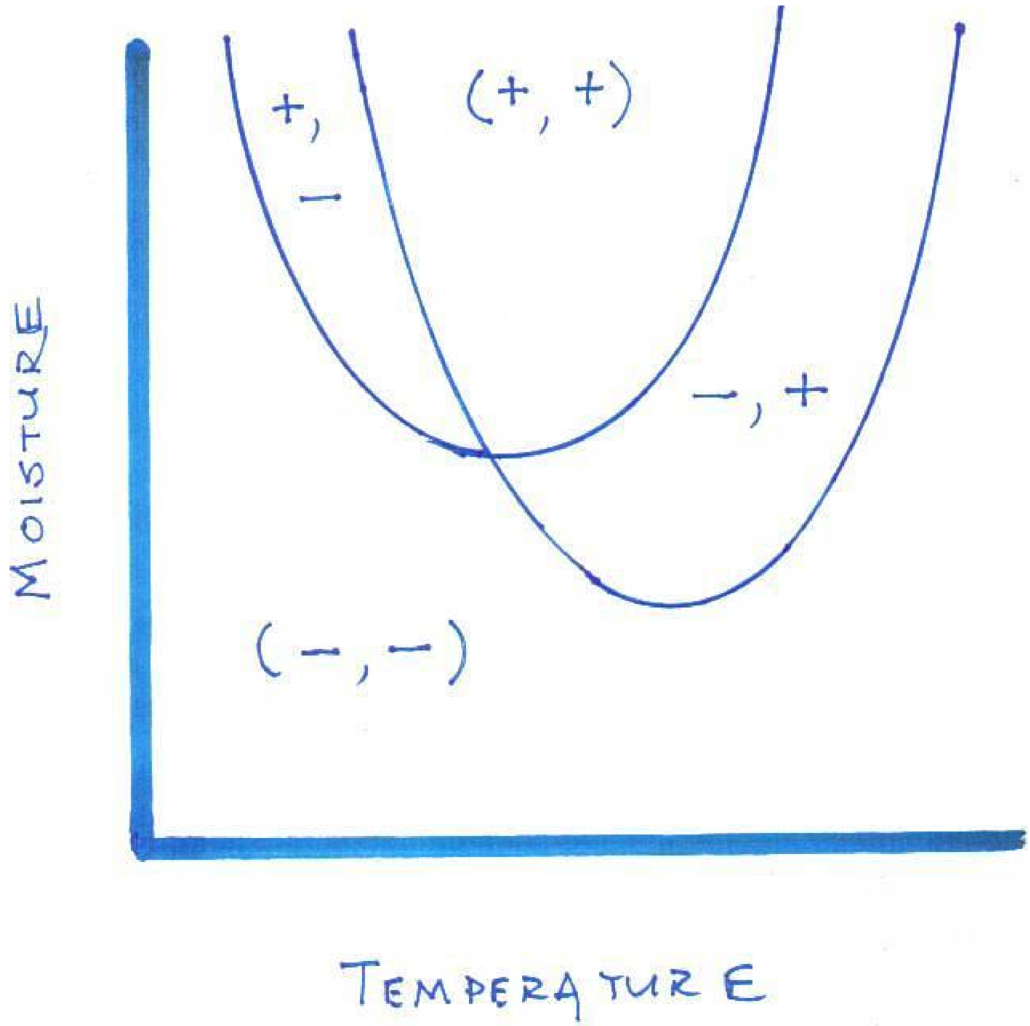
differently to physical environment

Coexist? Will better competitor (for resource) exclude other?

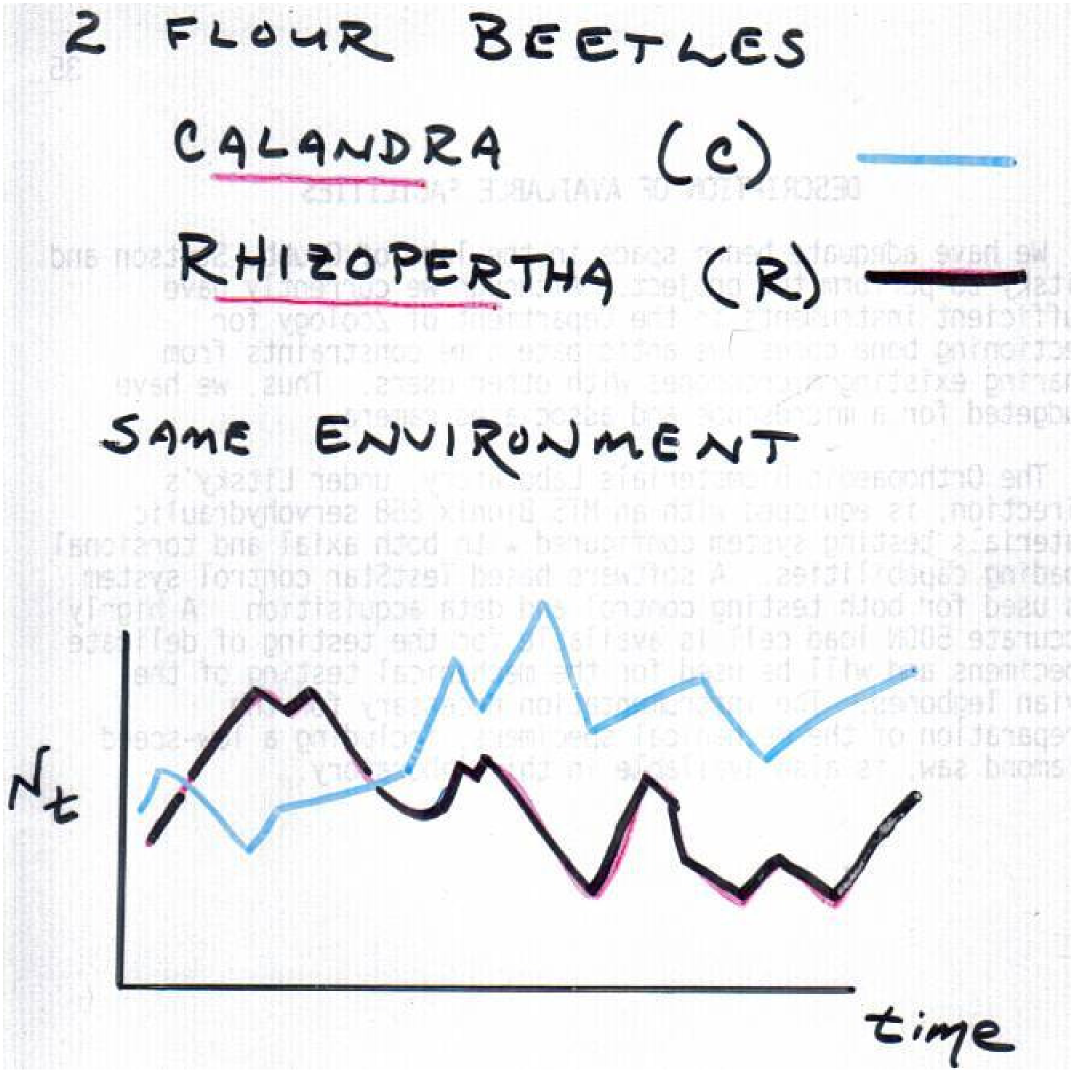
Grain beetles: Growth rates depend on temperature and moisture



Ricklefs and Miller (1999)



$$\mathrm{SGN}\ \ln\left[\lambda_{CAL},\ \lambda_{RHIZ}\right]$$



Growth negatively correlated

Spp coexist: *temporal niches differ*

Geometric Growth: Spatial Variation

Spatial Structure:

Population dispersed among locations (s)

Reproductive success depends on location

Total Population time t: N_t

Spatial location s, $s = 1, 2$

$n_t(s)$ population size, location s

$n_t(1) + n_t(2) = N_t$

$\lambda(s)$: Geometric growth rate in location s

$$\boldsymbol{n_{t+1}(s) = \lambda(s)\, n_t(s)} \quad s = 1, 2$$

Total Population Growth:

$$\boldsymbol{N_{t+1} = \hat{\lambda}\, N_t}$$

$$\widehat{\lambda} = \sum_s \frac{\boldsymbol{n}_s}{\boldsymbol{N}} \lambda(\boldsymbol{s})$$

Two Locations, $s = 1, 2$

$$\widehat{\lambda} = \frac{\boldsymbol{n}_t(1)}{\boldsymbol{N}} \lambda(1) + \frac{\boldsymbol{n}_t(2)}{\boldsymbol{N}} \lambda(2)$$

Arithmetic Averaging for Spatial Variation

Consider Environmental Stochasticity

Reproductive success: varies among generations

Geometric Mean Growth

$$N_t = \left(\tilde{\lambda}\right)^t N_0$$

$$\tilde{\lambda} = \prod_i \ (\lambda_i)^{p_i}$$

Population Synchrony

Coherent dynamics, “Moran Effect”

Consider species with
geographically distributed populations

Each population density varies temporally

Often: Fluctuations *statistical synchrony*

Different local populations:

Grow or decline at *same time*

Synchrony may decline with *distance*

Why?

Ranta et al. 1998. Oikos 83:376.

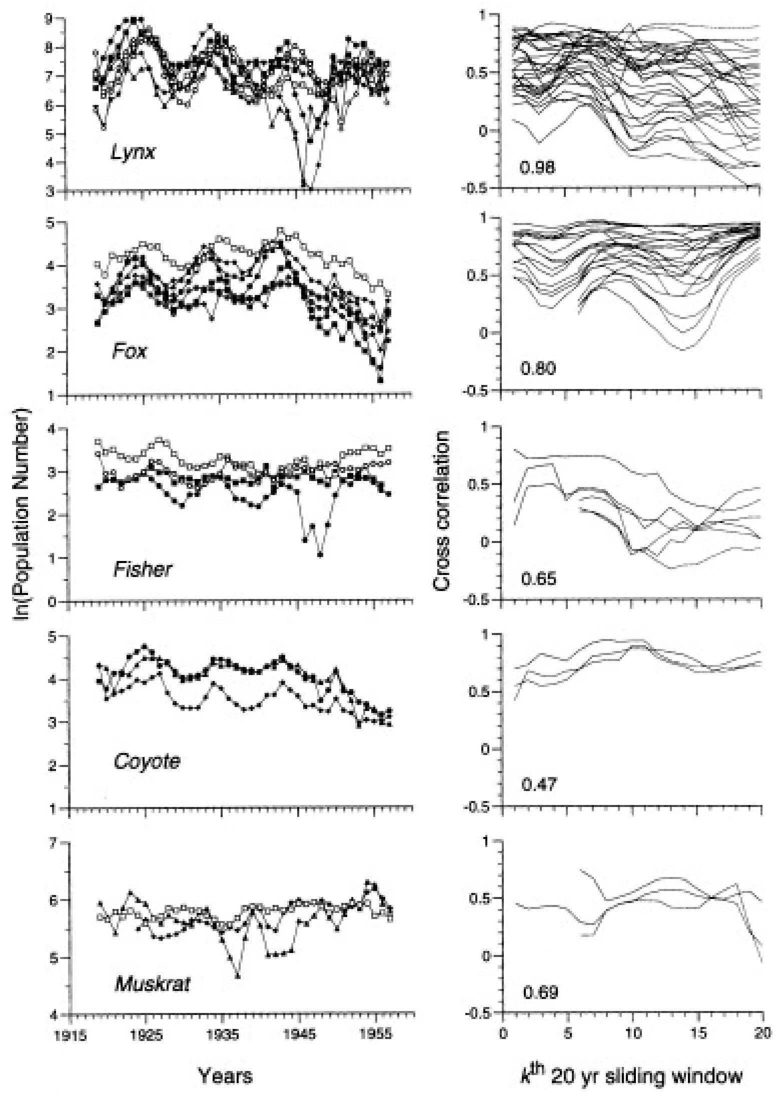


Fig. 2. Long-term dynamics (left-hand panels) of lynx, fox, fisher, coyote and muskrat populations in different Canadian provinces [Alberta (●), British Columbia (■), Manitoba (◆), New Brunswick (✚), North-Western Territories (▼), Nova Scotia (⊙), Ontario (□), Quebec (○), Saskatchewan (▲) and Yukon (◇)]. Synchrony in fluctuations among the provinces (right-hand panels) as calculated with 20-yr sliding windows (maximum amplitude between any pair of provinces is inserted). The data are after Keith (1963).

Mammals: Strong synchrony within species

Sutcliffe et al. 1996. J Animal Ecology 65:85.

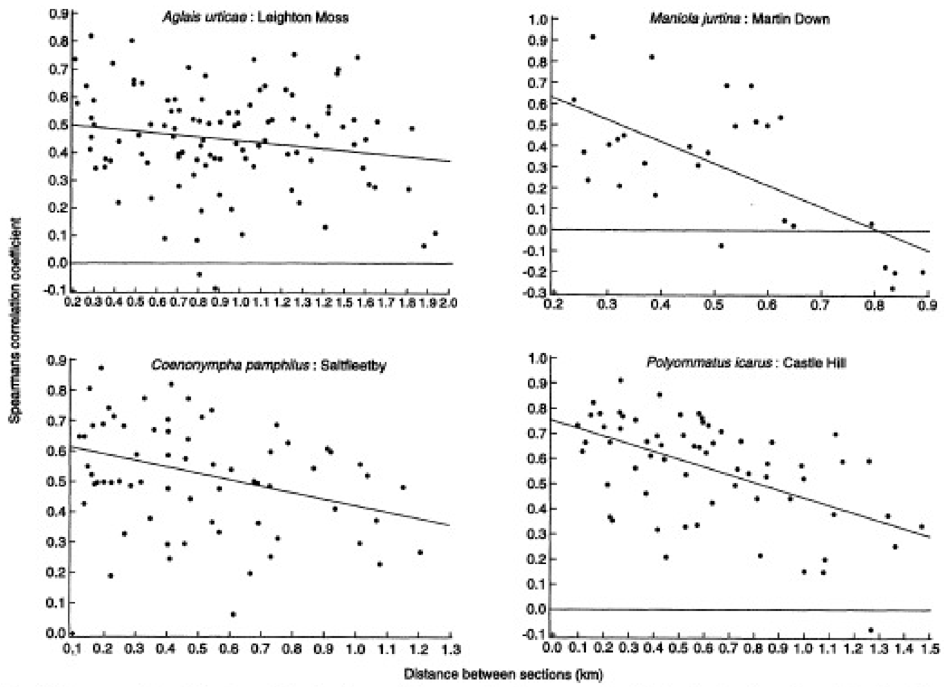


Fig. 4. Four examples of the types of graphs from which regression lines were calculated, showing the wide scatter of points and the regression line indicating a decline in population synchrony with increasing distance between transect sections.

Britain: butterfly populations

Nearby populations highly synchronous

Spatial synchrony declines with distance

1. Moran (1953): First to address synchrony

   Snowshoe hare (prey of lynx)

   "Synchronization and meteorology"

   Synchronous abiotic fluctuations

   induced population synchrony

   Geometric-mean growth model

2. Dispersal

   Local population grows quickly;

   individuals disperse to other populations

   Can synchronize; effect declines with distance

3. Common, fast-dispersing natural enemy

   Predator, macro-parasite or disease

   Disperse quickly, induce common decline

   Natural enemy declines, populations recover together