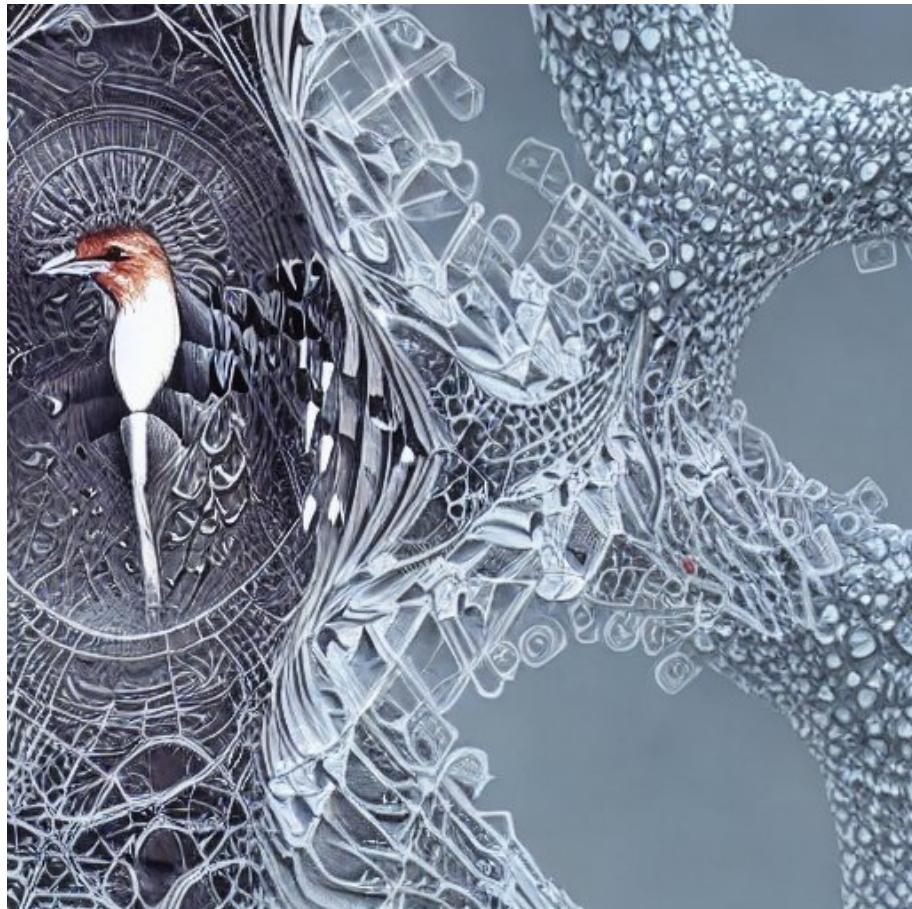


Decomposing abundance change to recruitment and loss: analysis of the North-American avifauna

François Leroy
Marta Jarzyna
Petr Keil

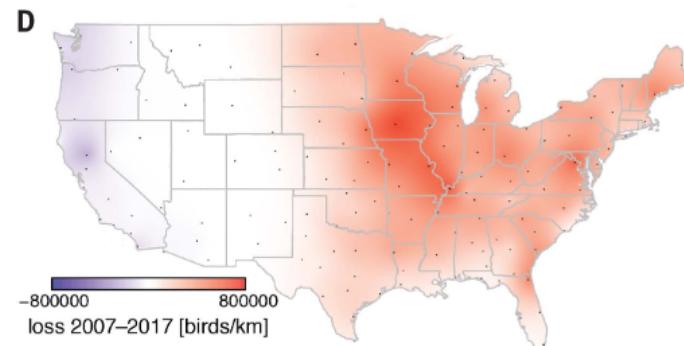
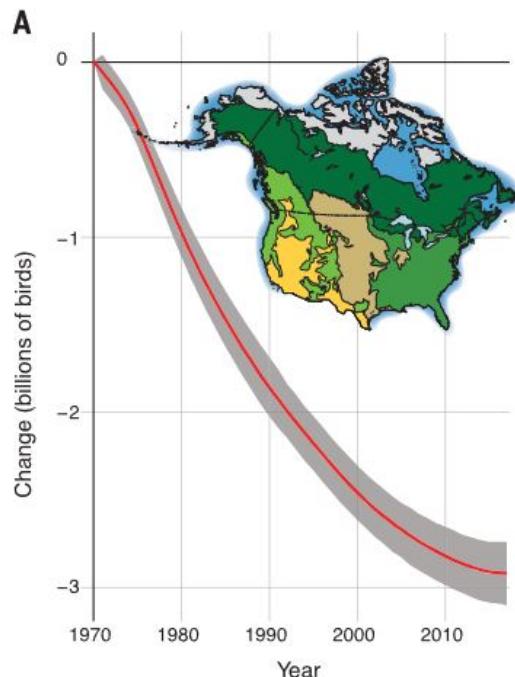
Czech University of Life Sciences,
Prague

Ohio State University



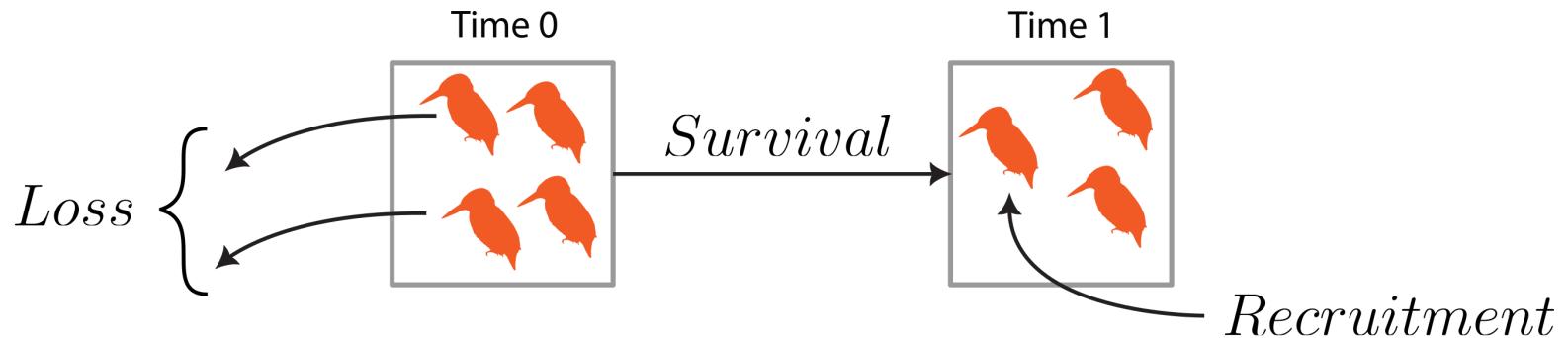
Temporal change of abundance

- Sensitive indicator of biodiversity state
- Perturbed by human activities
- Average decline of relative abundance → 69% (Living Planet Index)
⇒ -3 billion North-American birds since 70's



Rosenberg *et al.*, 2019

Decomposing abundance change



$$N_{t0} = L + S$$

$$N_{t1} = S + R$$

Abundance change:

$$\Delta N = N_{t1} - N_{t0} = R - L$$

$$\Leftrightarrow \Delta^2 N = \Delta R - \Delta L$$

Decomposing growth rate

- **Growth rate:** per individual average change in population

$$\frac{\Delta N}{N_{t0}} = \frac{R}{N_{t0}} - \frac{L}{N_{t0}}$$



- **Recruitment rate** = individual addition of individuals
- **Loss rate** = individual probability of dying/emigrating

$$\frac{R}{N_{t0}}$$

$$\frac{L}{N_{t0}}$$

Problem

- ⇒ Assessing the ongoing decrease of abundance does not tell us how loss and recruitment change through time
- ⇒ Decrease in recruitment \neq Increase in loss, but they both result in an acceleration of the decrease of abundance

From a conservation perspective

- measures to "bend the curve" of recruitment (e.g. working on reproductive success, protecting breeding habitat)

\neq

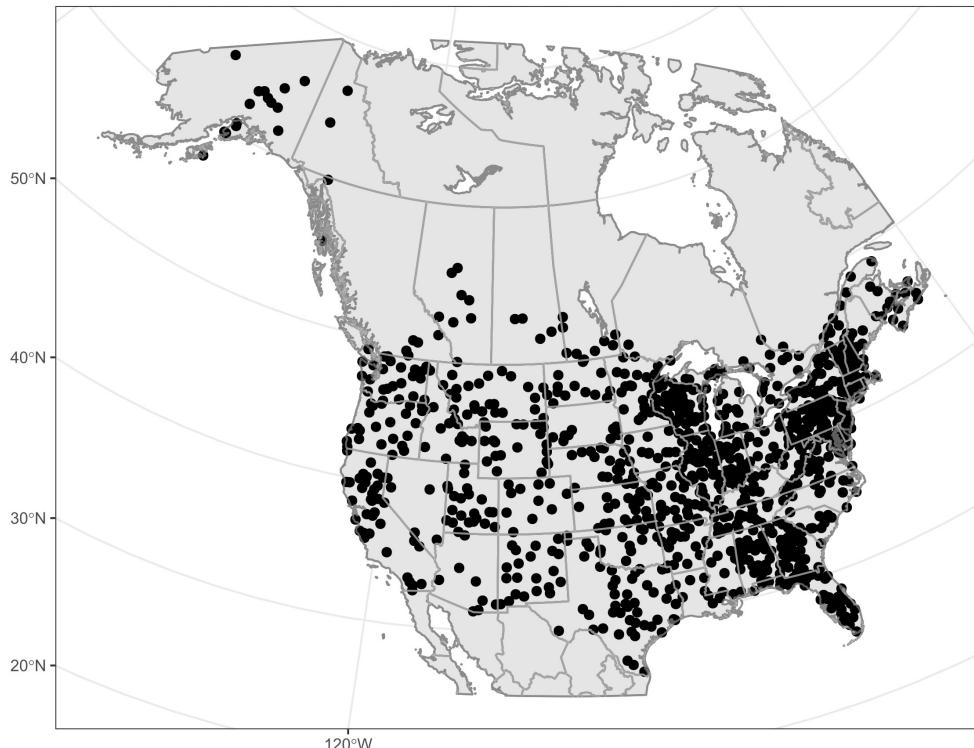
- measures to "bend the curve" of loss (e.g. reduction of threats, increasing habitat quality)

For North-American avifauna, we assessed:

- 1) temporal change of abundance, recruitment and loss from 1987 and 2021**
- 2) temporal change of growth rate, recruitment rate and loss rate**
- 3) which process (recruitment or loss) is driving temporal change of abundance**

Data - Breeding Bird Survey (BBS)

- Structured data on North American avifauna
- From 1987 to 2021
- More than 1000 routes
- 564 species



Model - Dail & Madsen

- Assess survival and recruitment from abundance data
- Bayesian stacked hierarchical model

$$N_{t+1} = \text{Survival}_{t+1} + \text{Recruitment}_{t+1}$$

with

$$\text{Survival}_{t+1} \sim \text{Bin}(N_t, \omega)$$

$$\text{Recruitment}_{t+1} \sim \text{Poisson}(\gamma)$$

$$\text{Loss}_t = N_t - S_{t+1}$$

- Accounting for detection probabilities, depending on weather:

$$N^*_t \sim \text{Bin}(N_t, p)$$

⇒ Sky condition, wind condition, temperature & time of the day

Model - Dail & Madsen

- 3 MCMC chains per species \times 564 species = 1692 MCMC chains
⇒ 9.3 years to fit the model using 1 core (\sim 1 year using 8 cores)

Marta Jarzyna



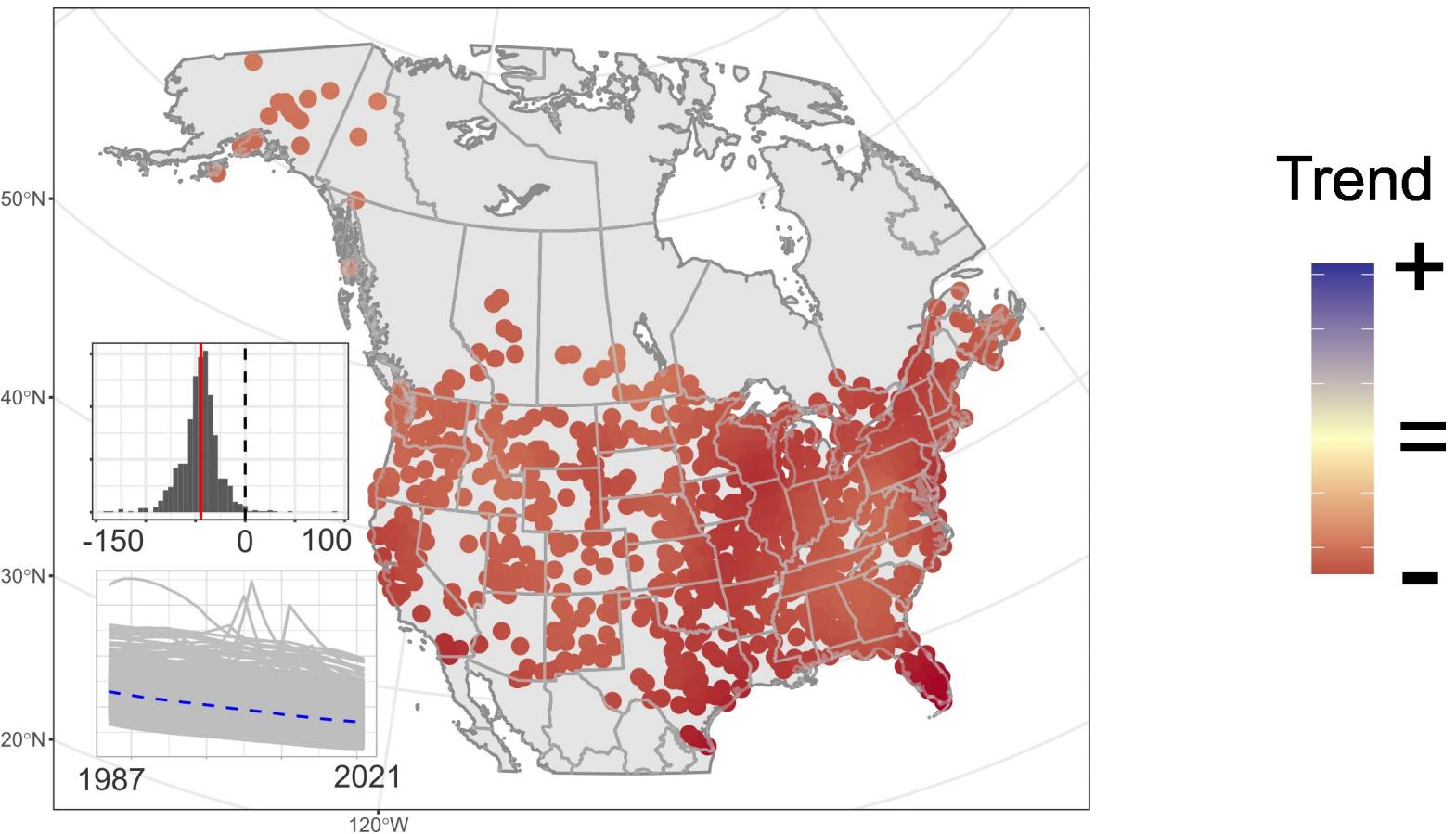
- Ohio State University

⇒ Ohio SuperComputer to parallelize the learning on 1692 cores

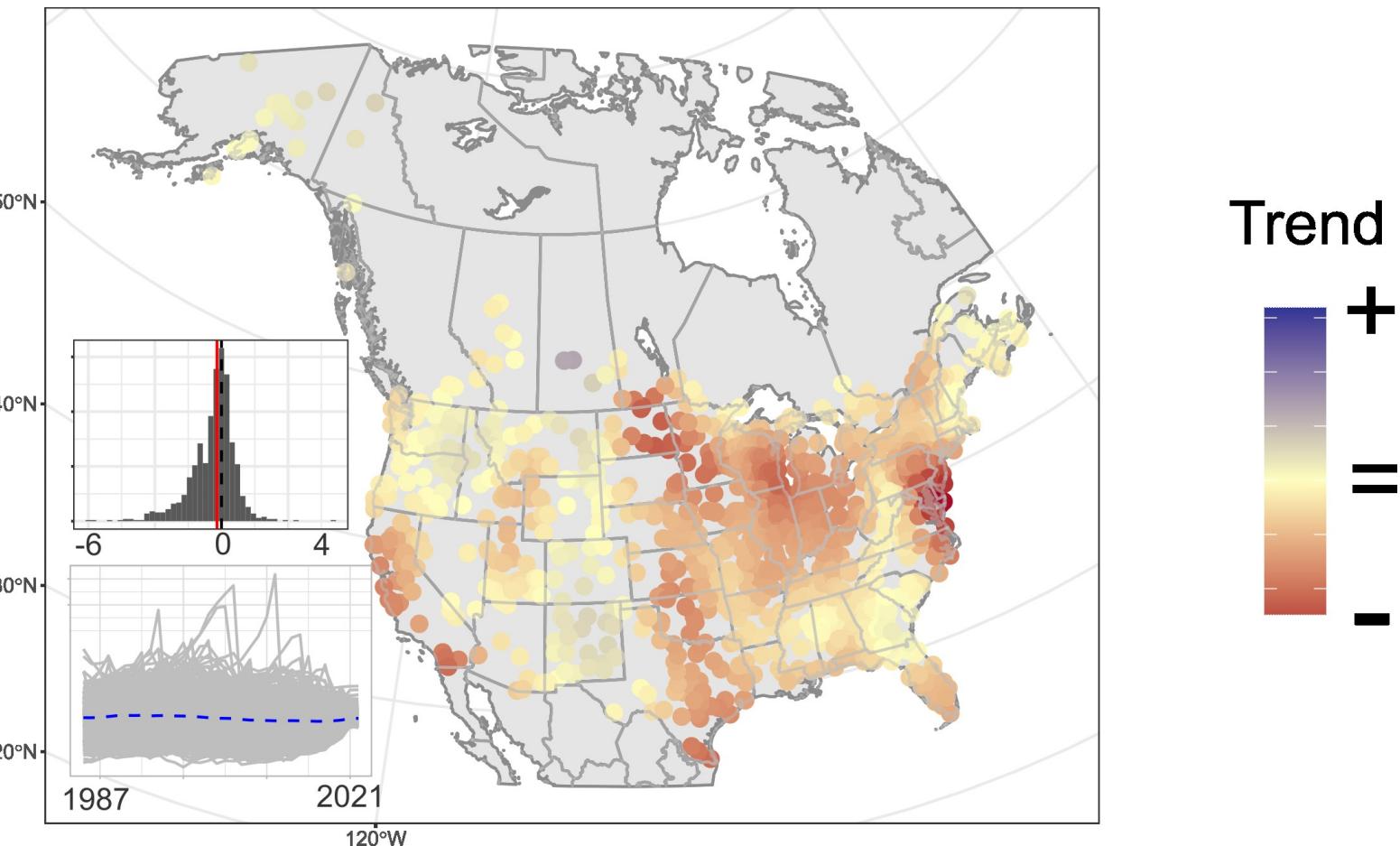


Ohio Supercomputer Center
An OH-TECH Consortium Member

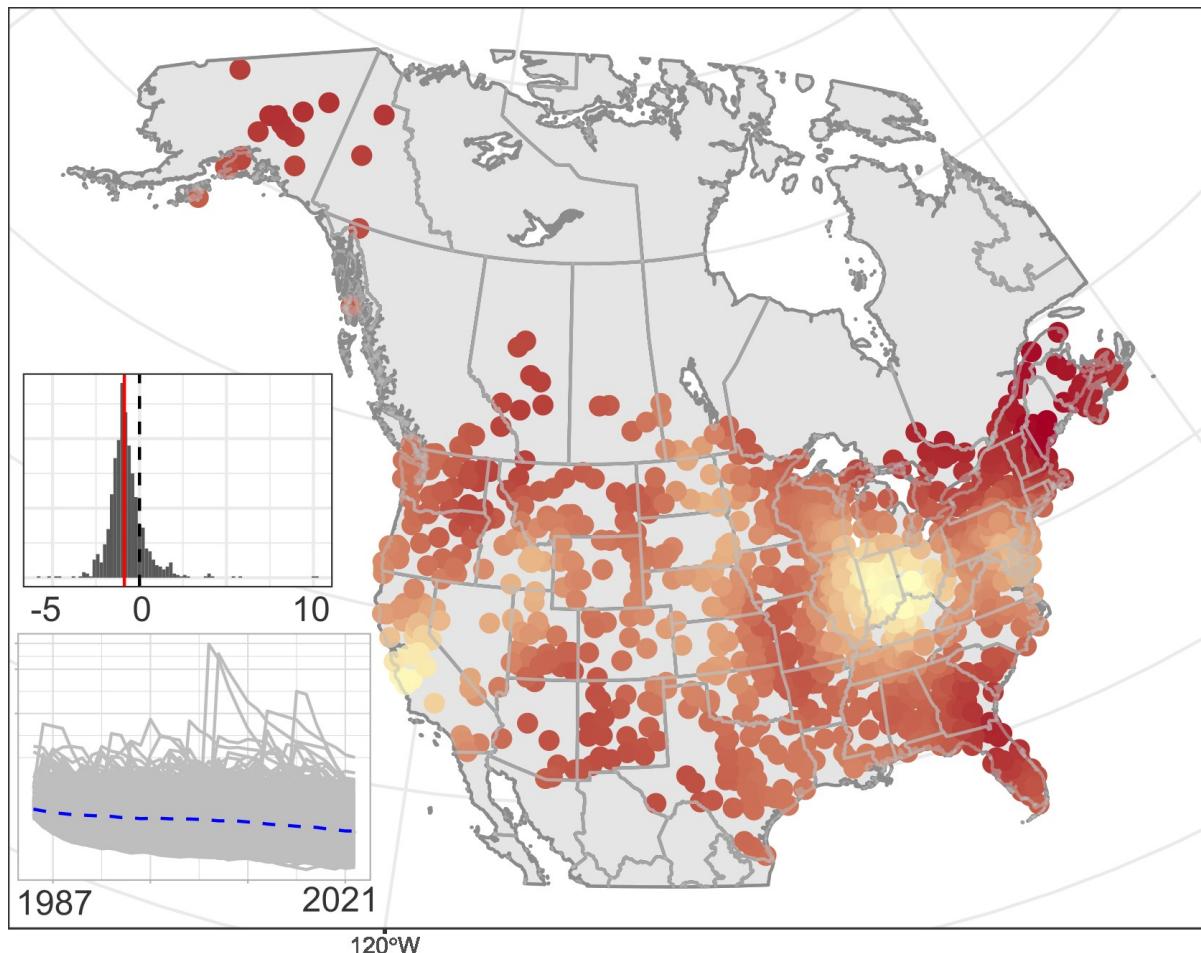
Trend in abundance



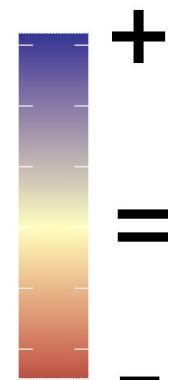
Trend in number of recruited individuals



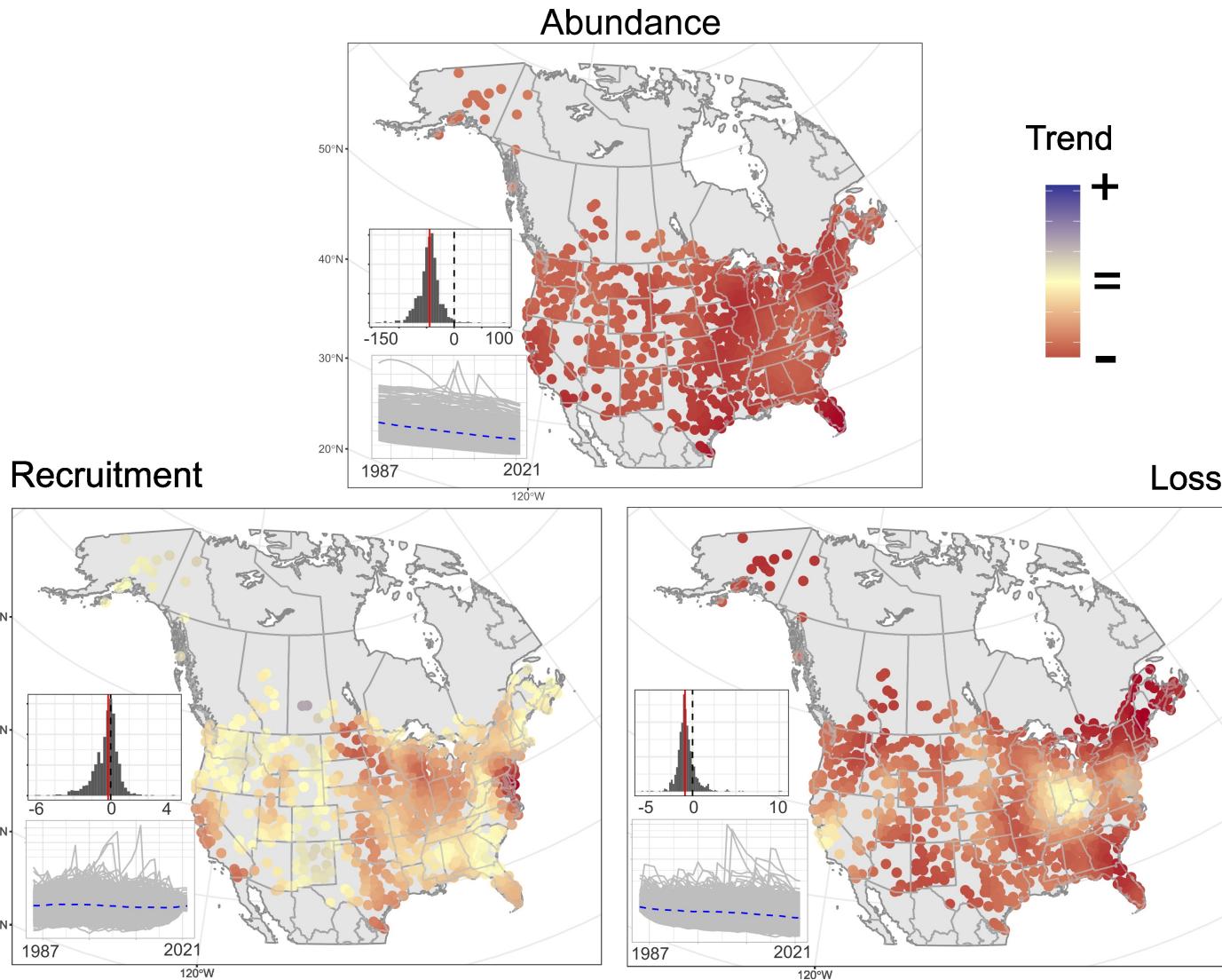
Trend in number of lost individuals



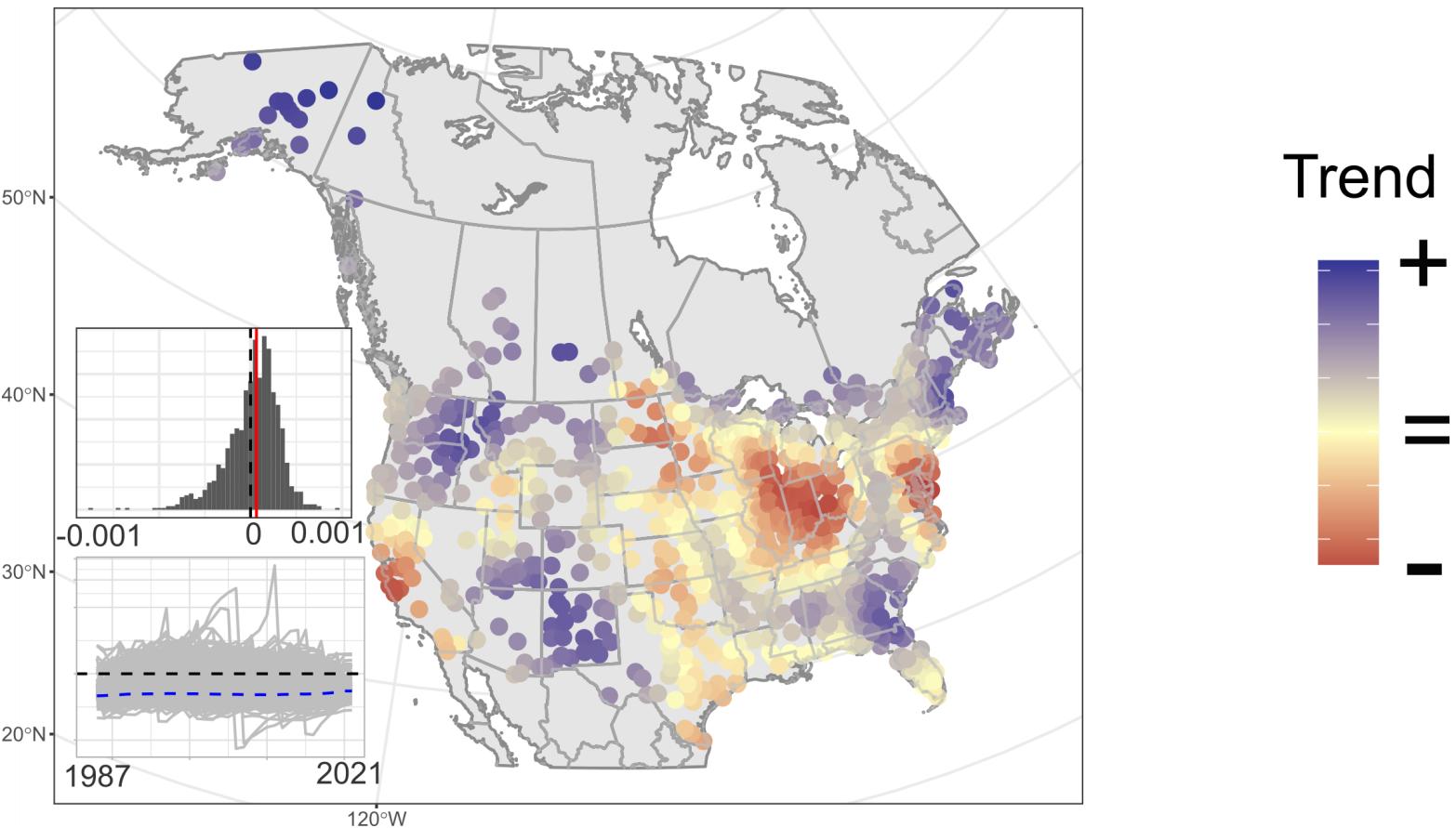
Trend



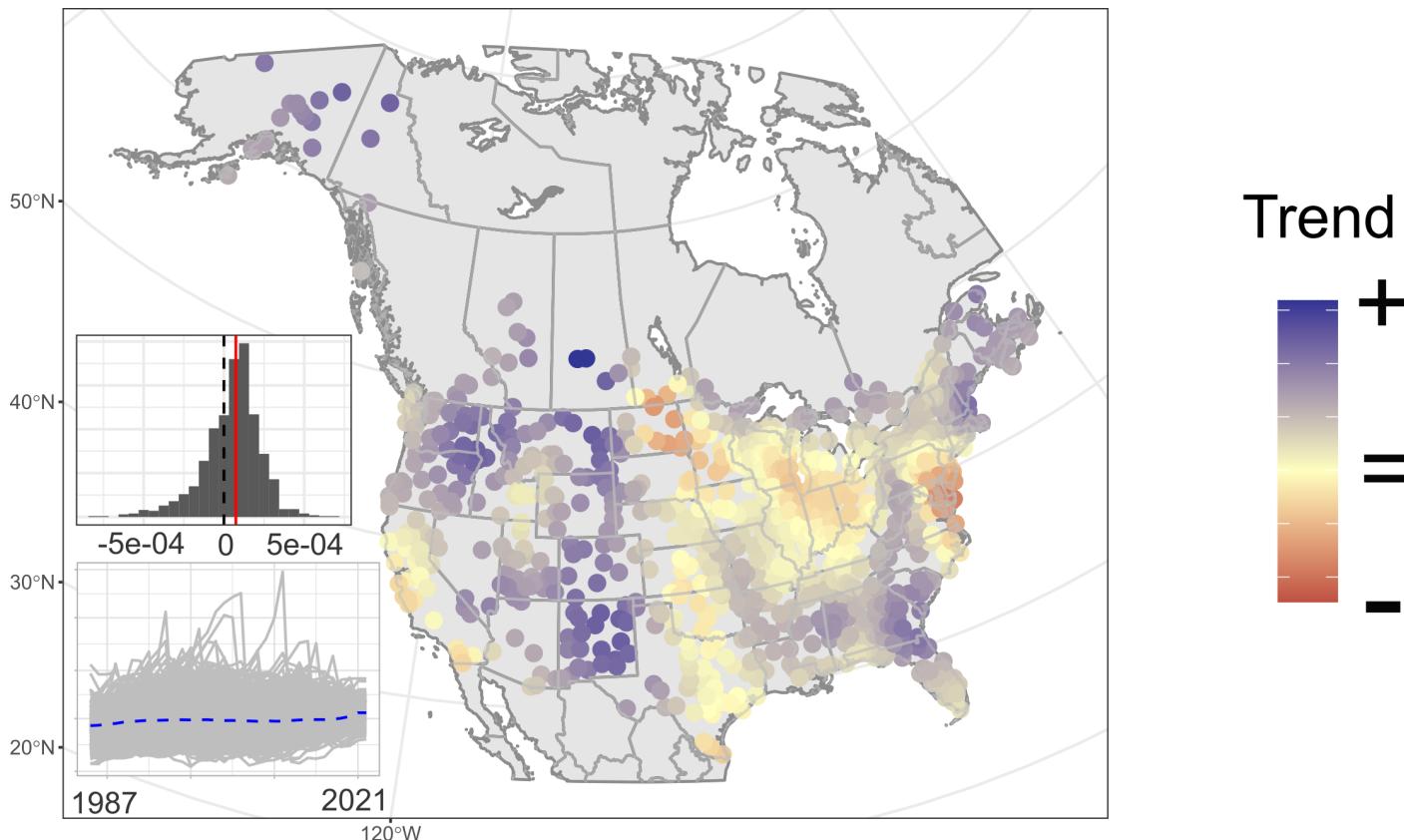
Trends in abundance, recruitment and loss



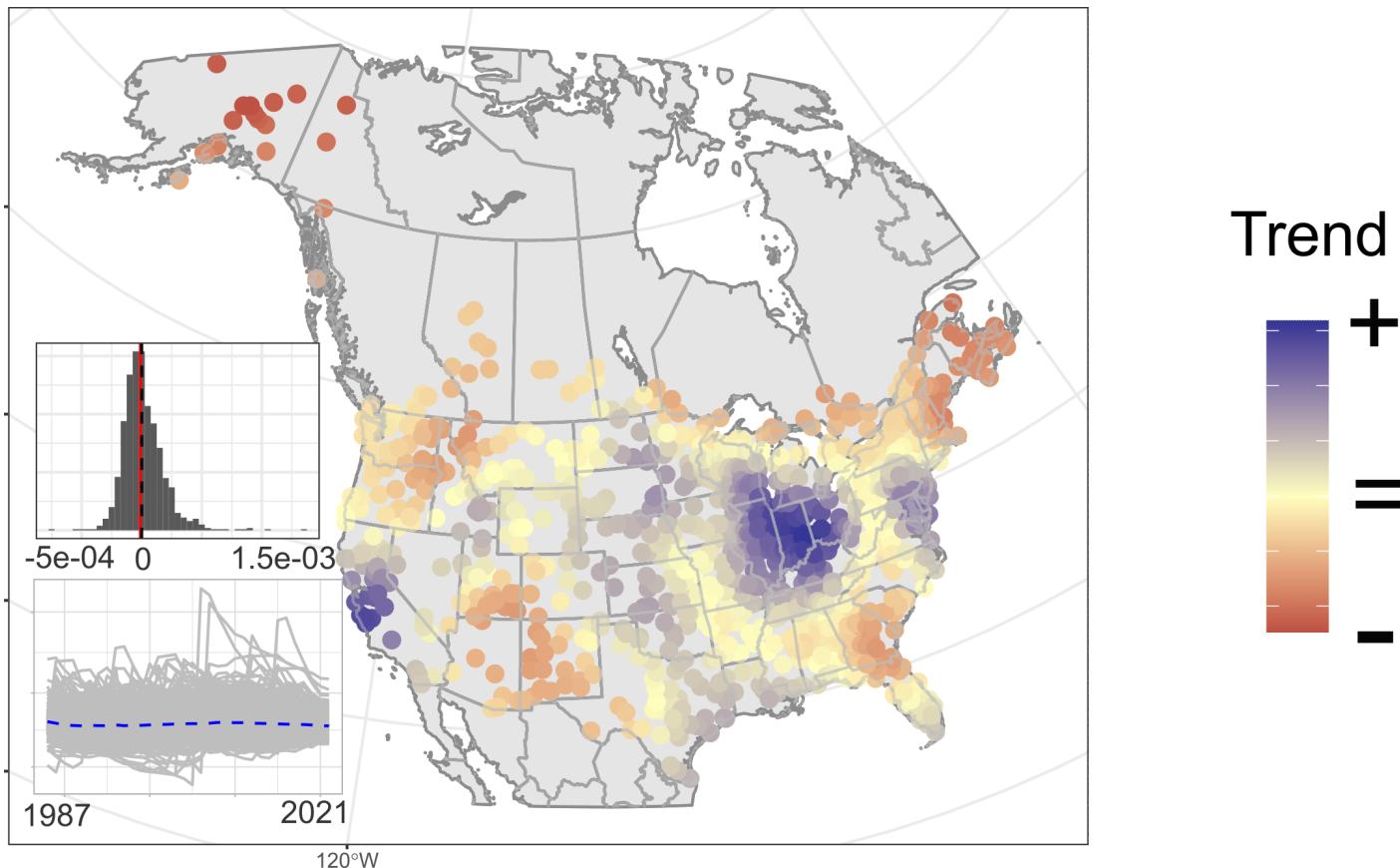
Trend in growth rate



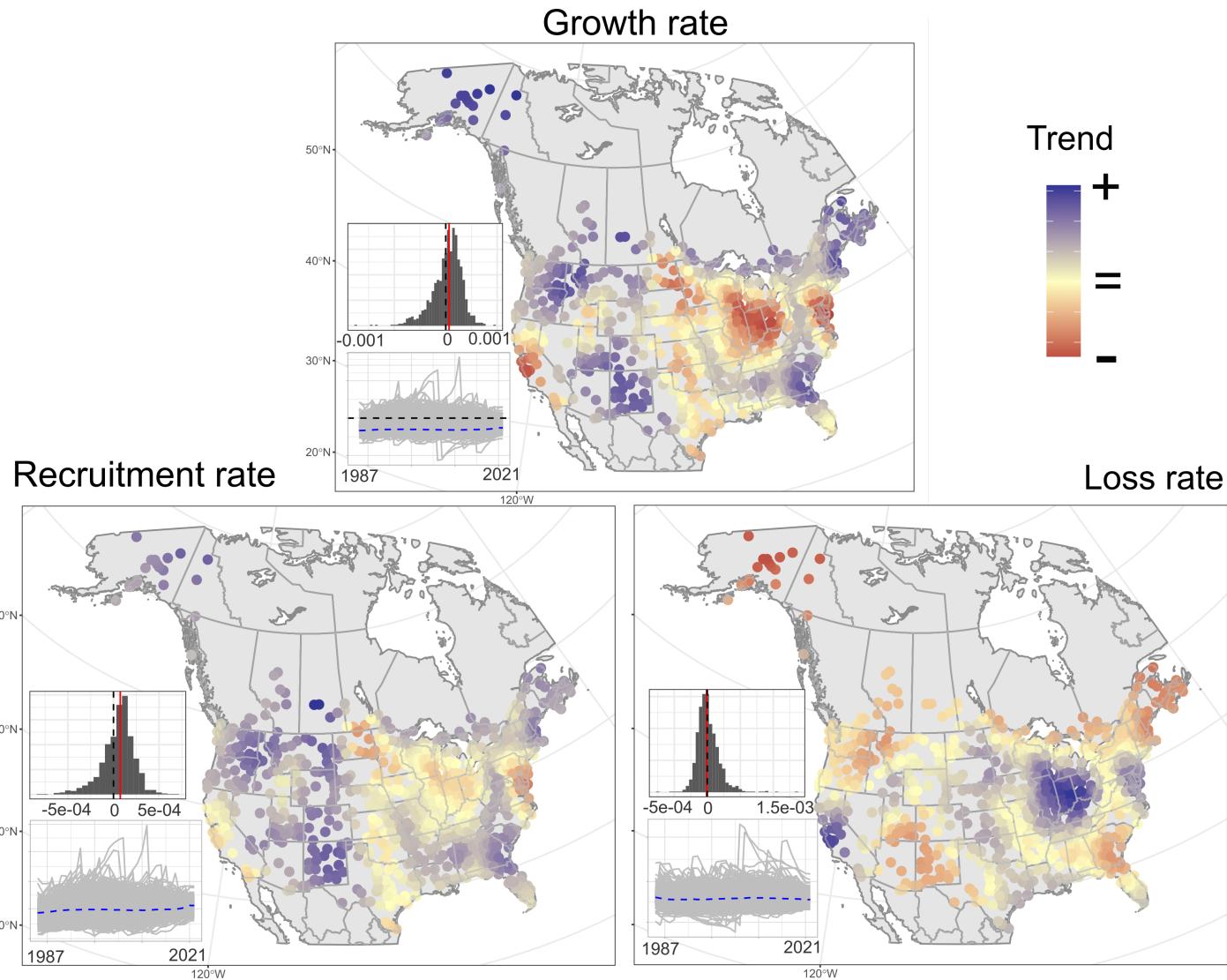
Trend in recruitment rate



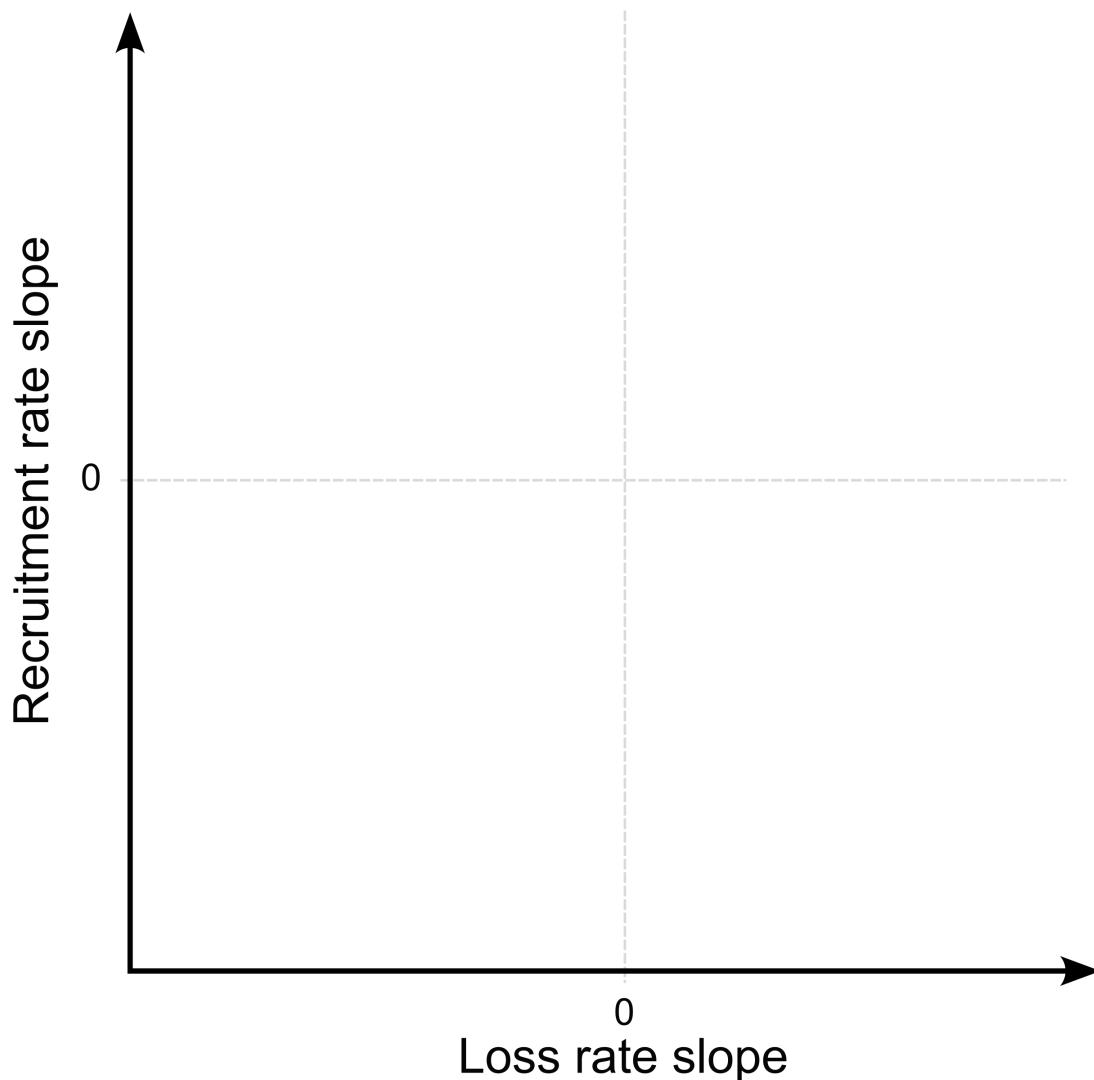
Trend in loss rate



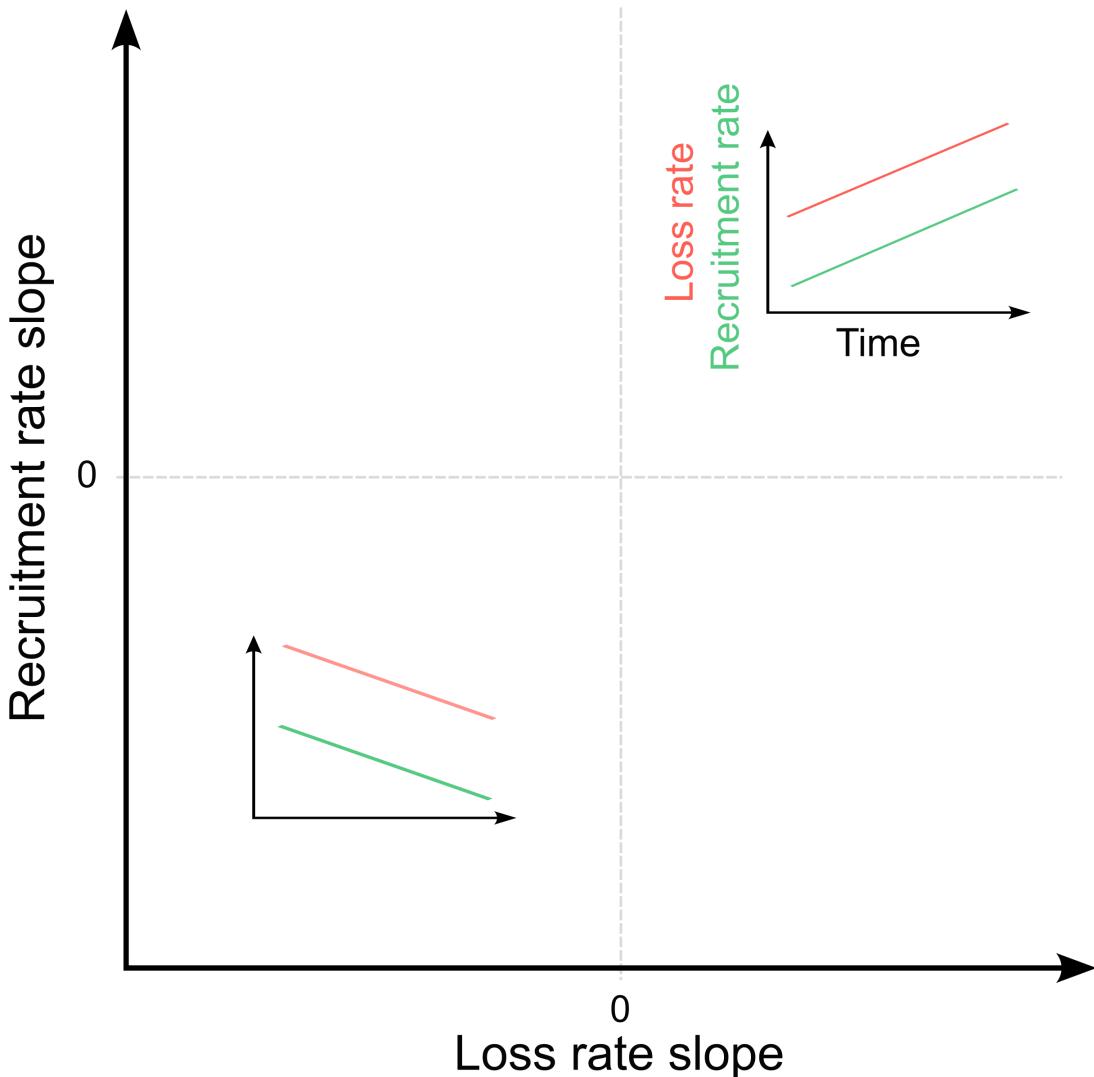
Trends in growth, recruitment and loss rates



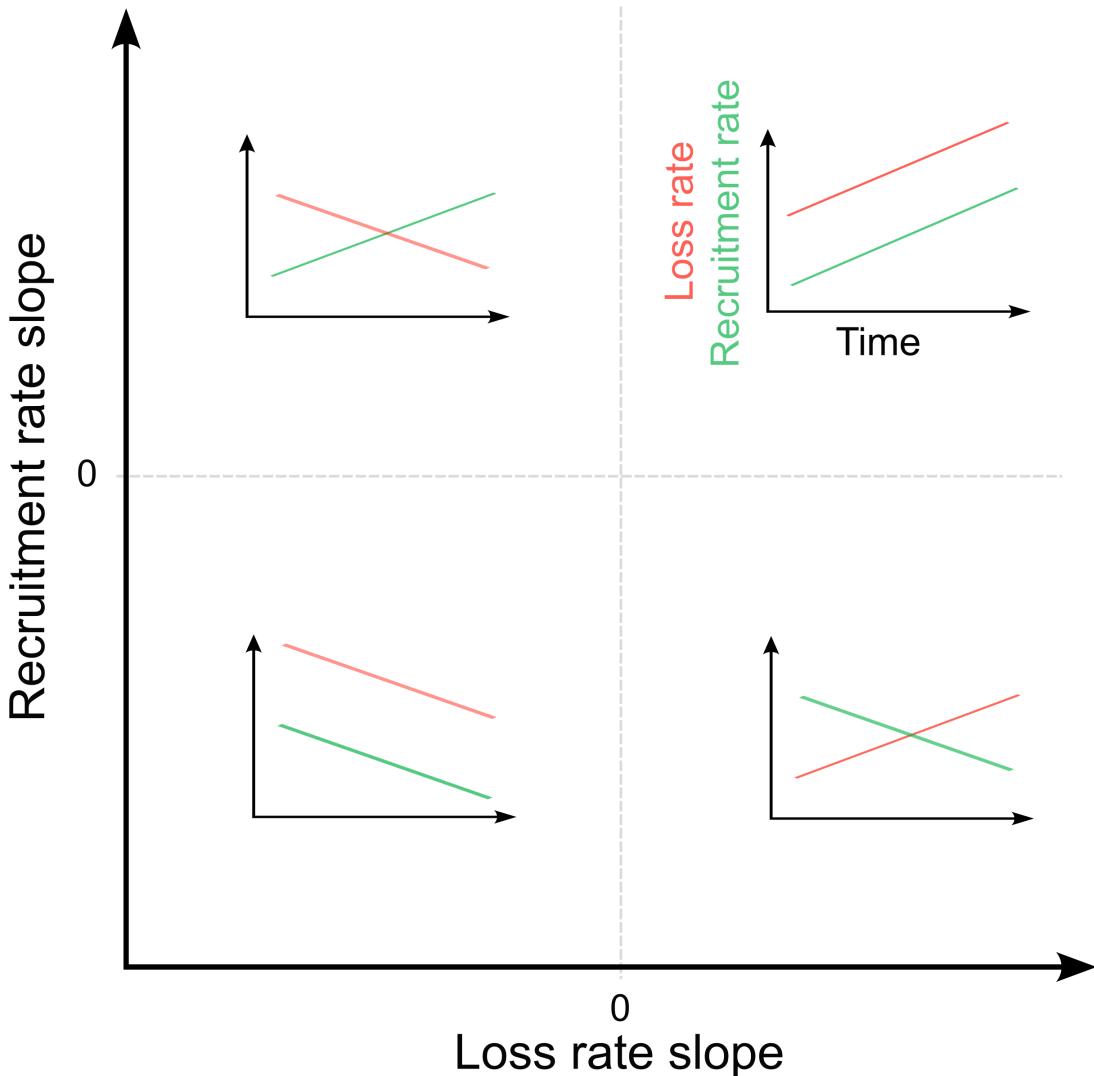
Recruitment vs. Loss rates



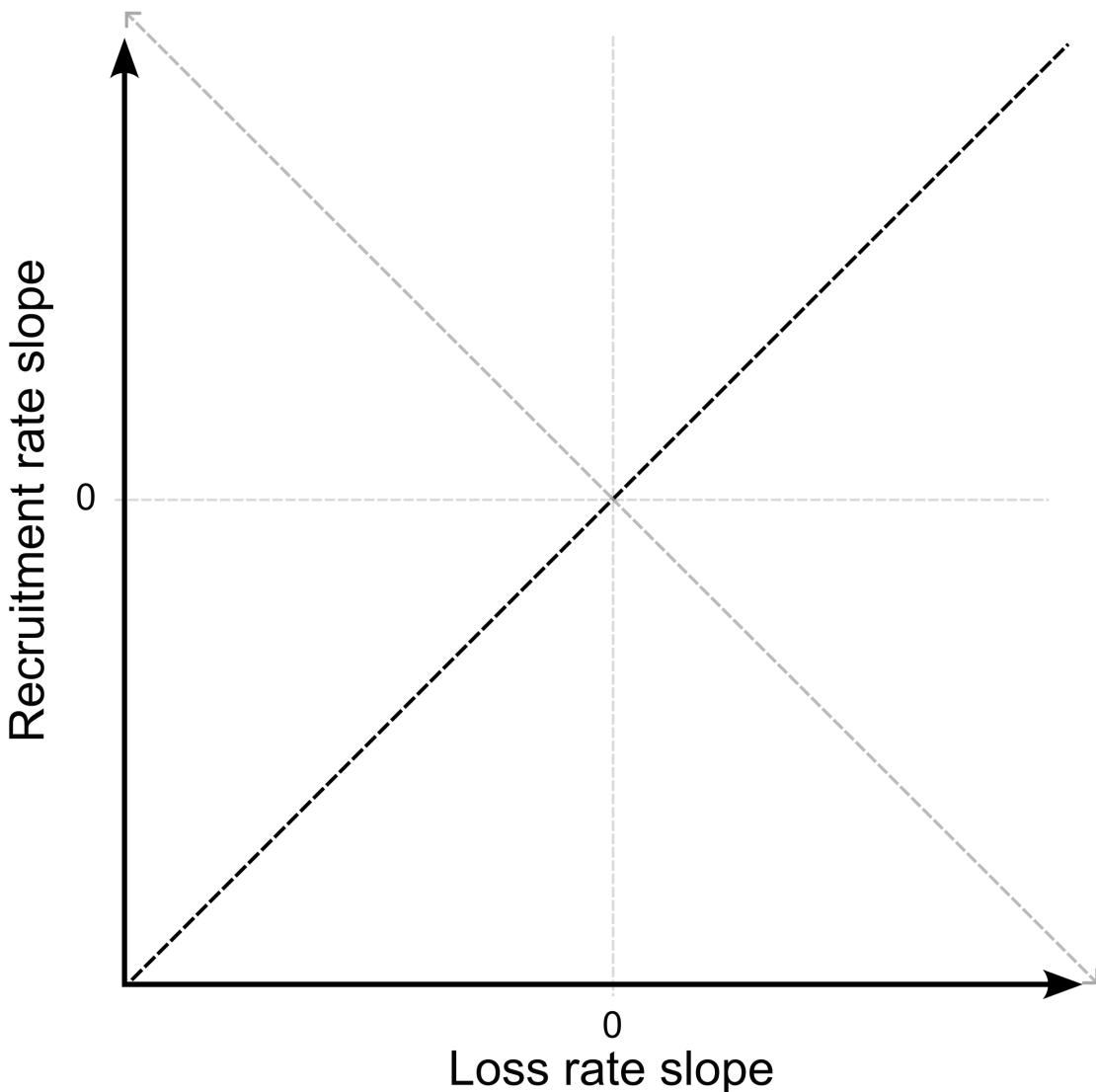
Recruitment vs. Loss rates



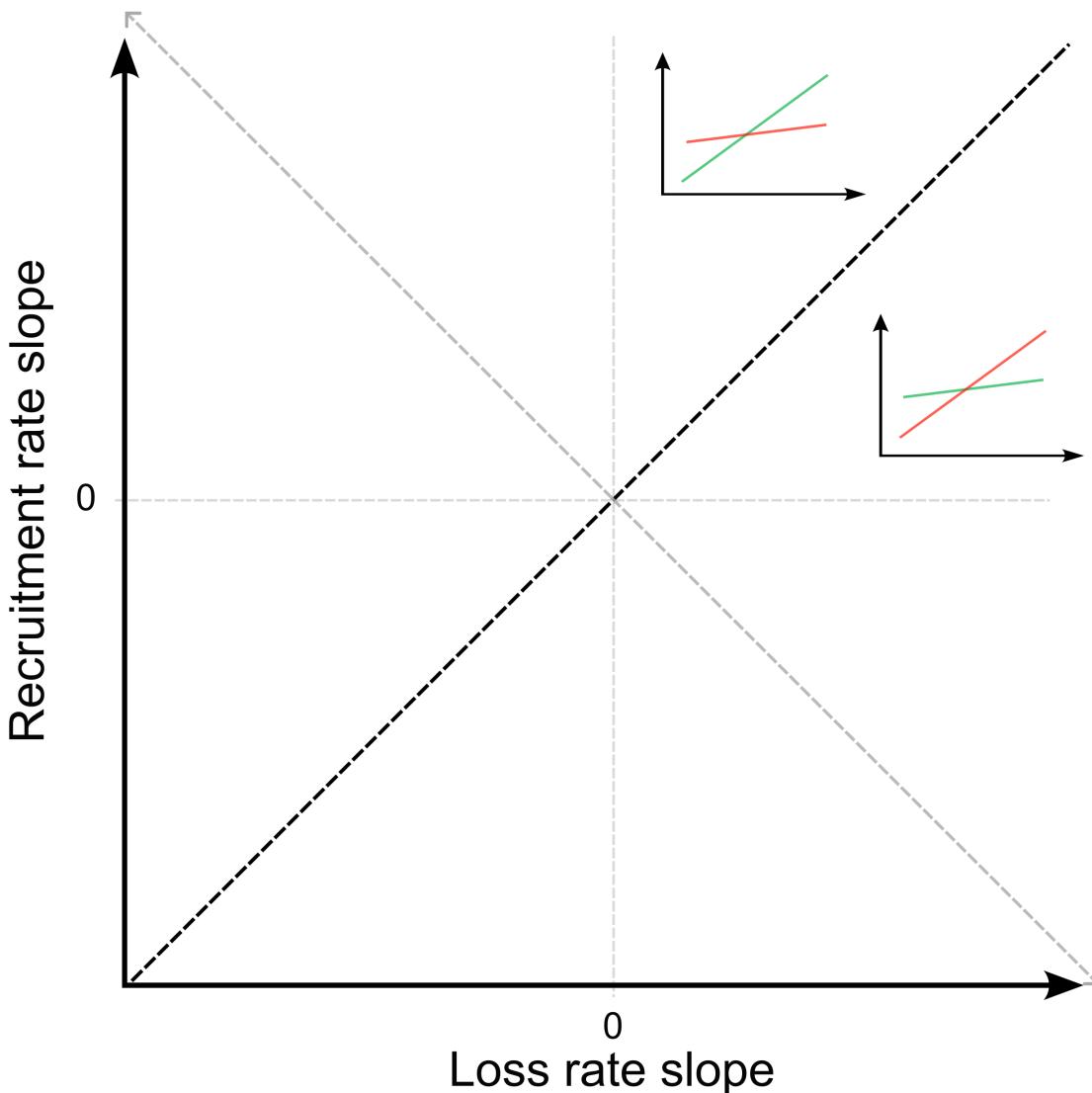
Recruitment vs. Loss rates



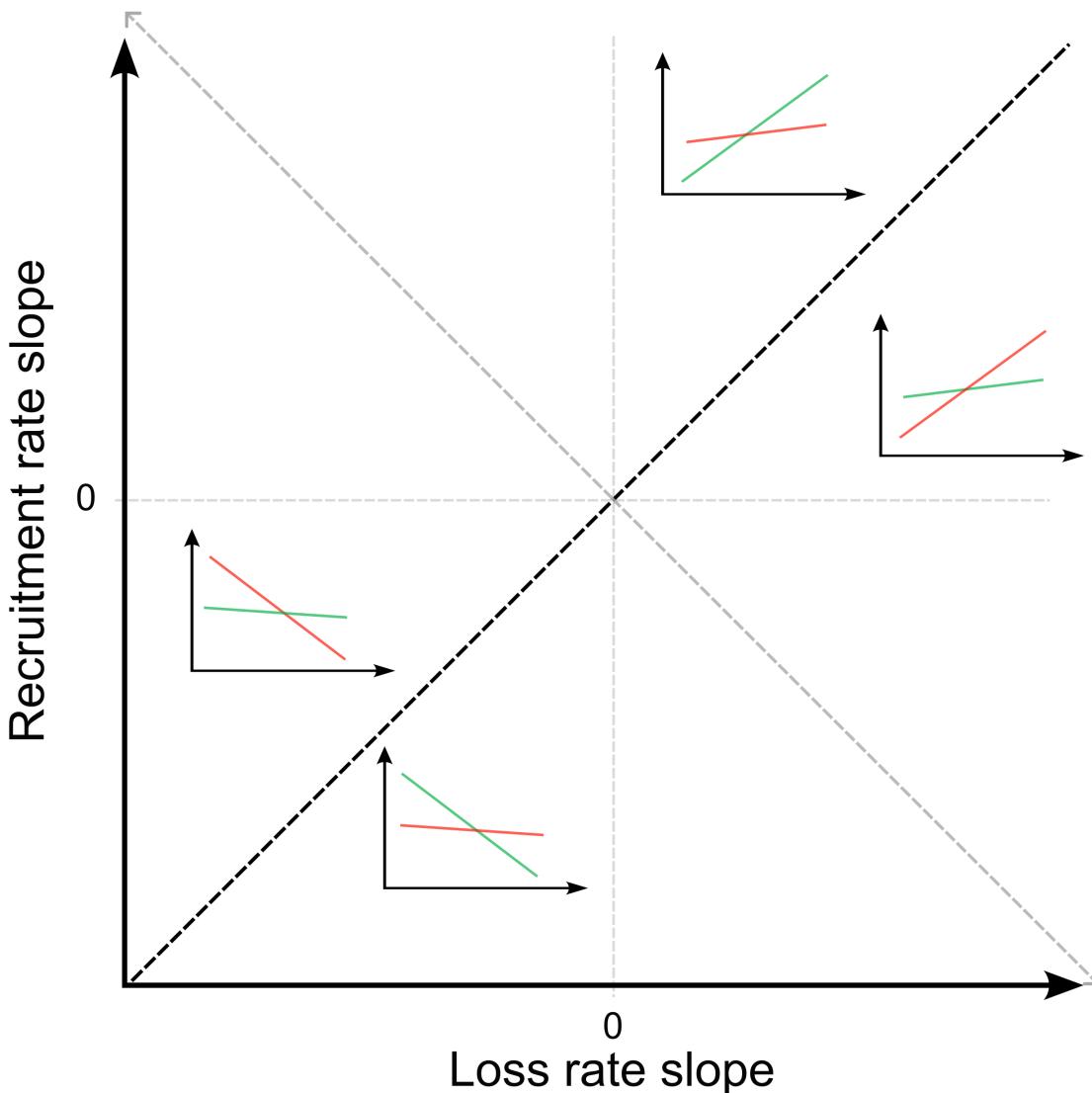
Recruitment vs. Loss rates



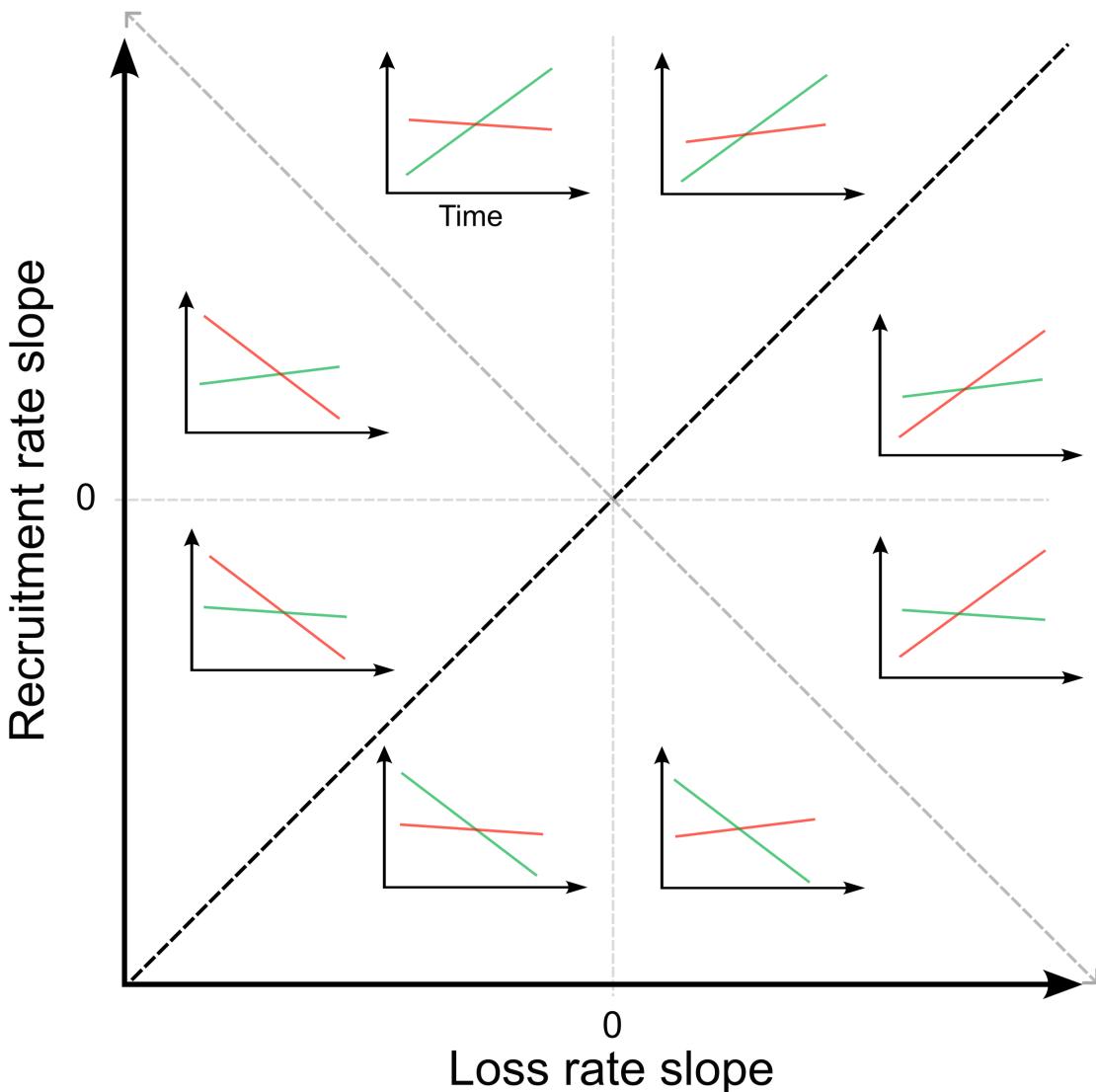
Recruitment vs. Loss rates



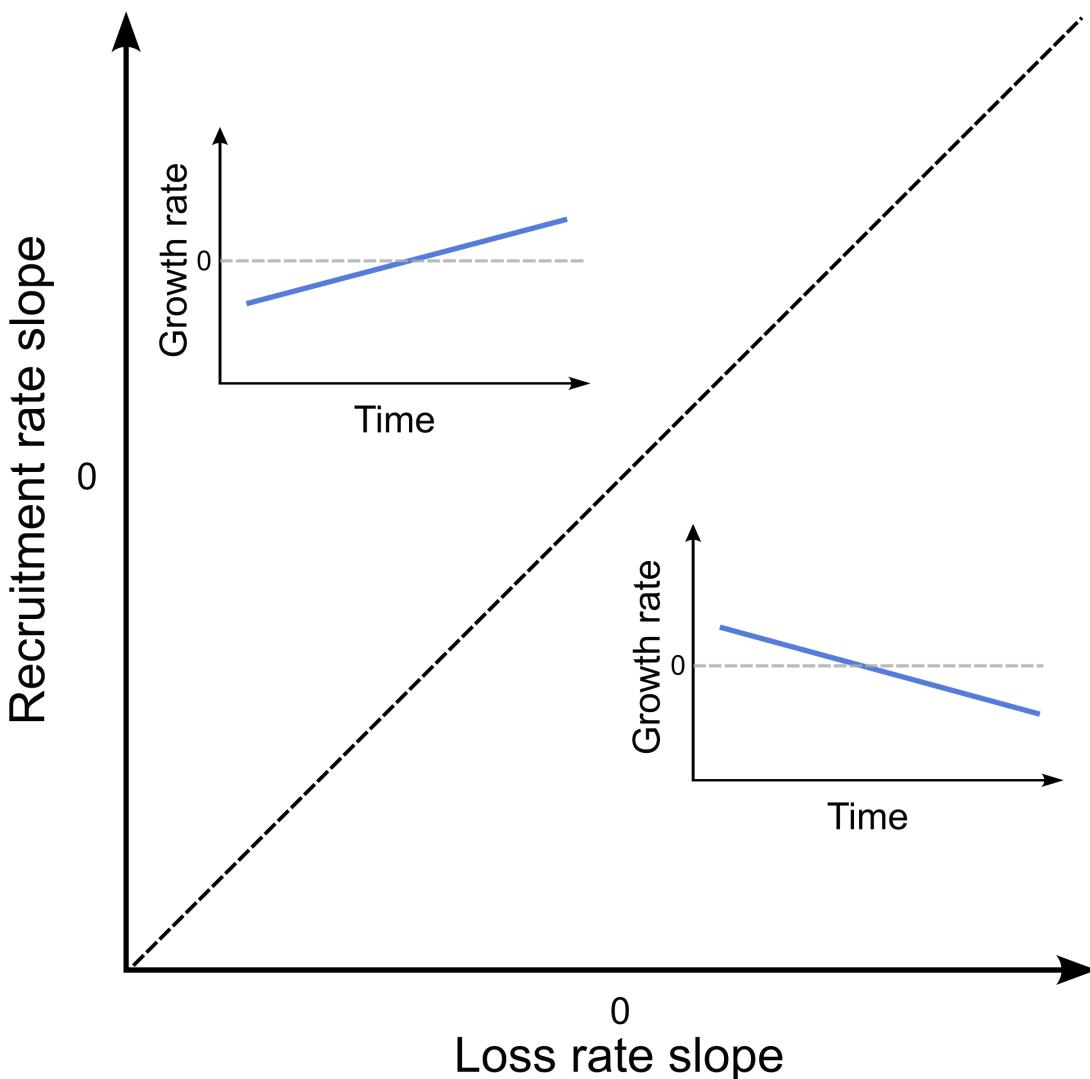
Recruitment vs. Loss rates



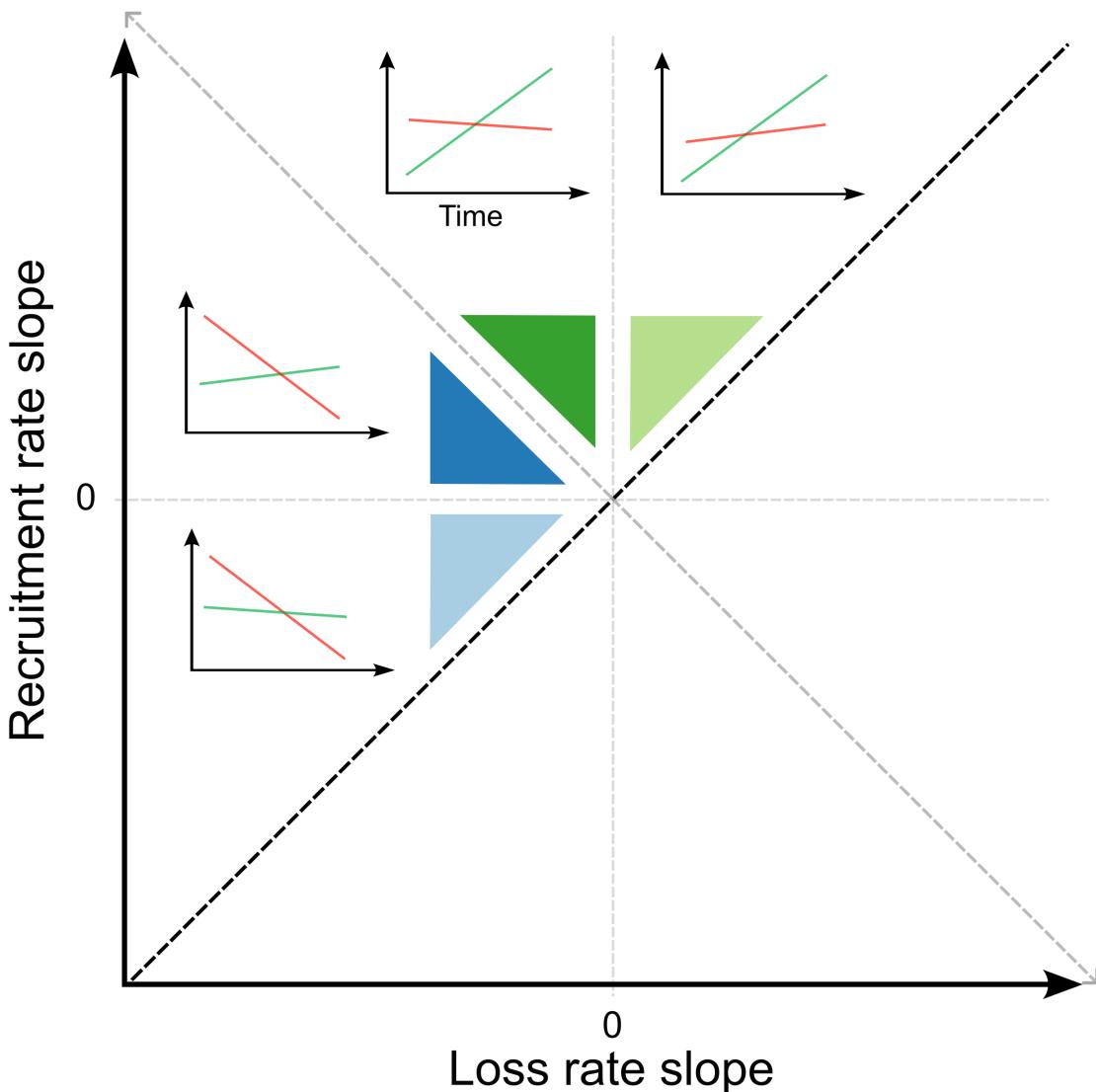
Recruitment vs. Loss rates



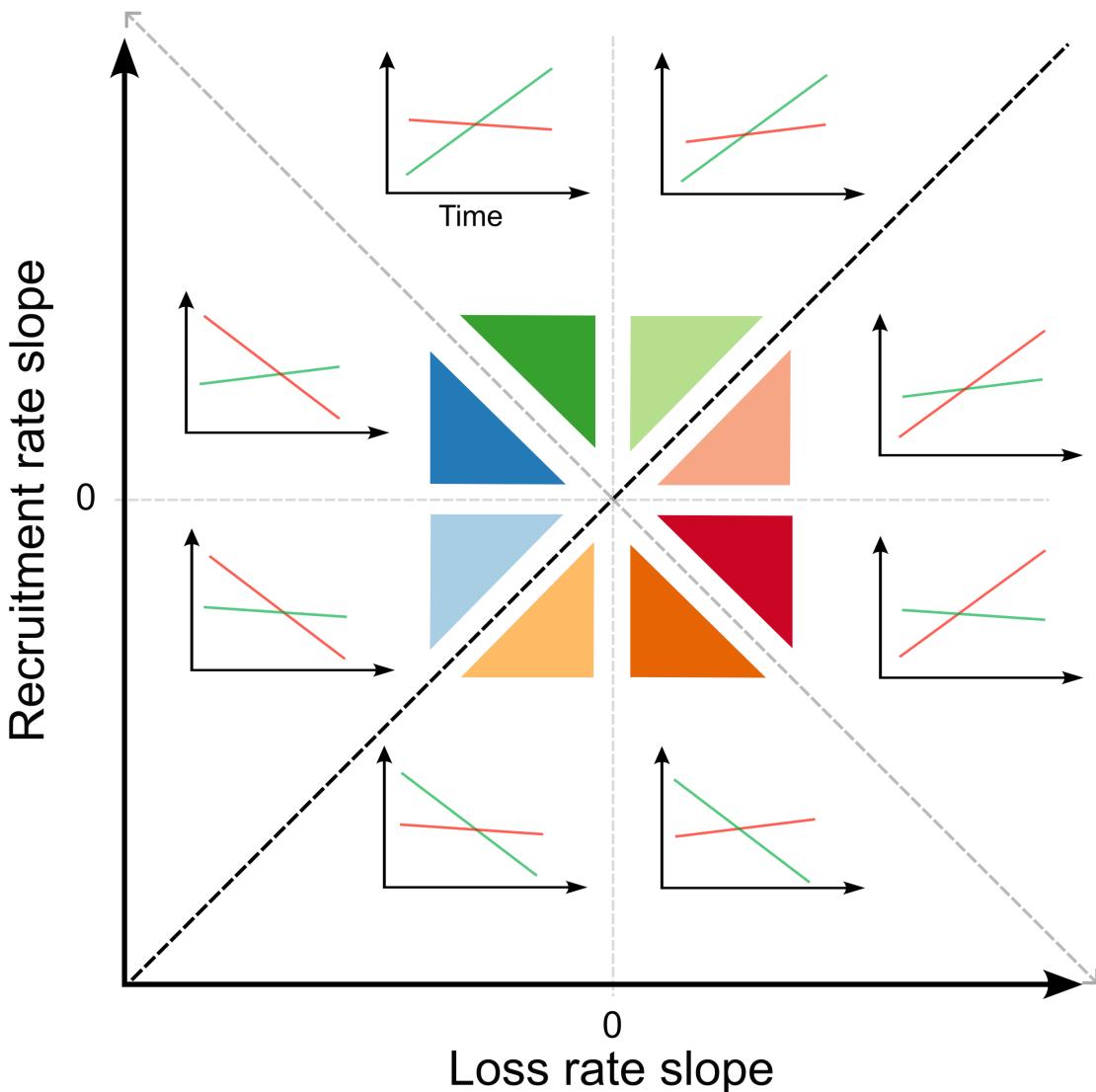
Recruitment vs. Loss rates



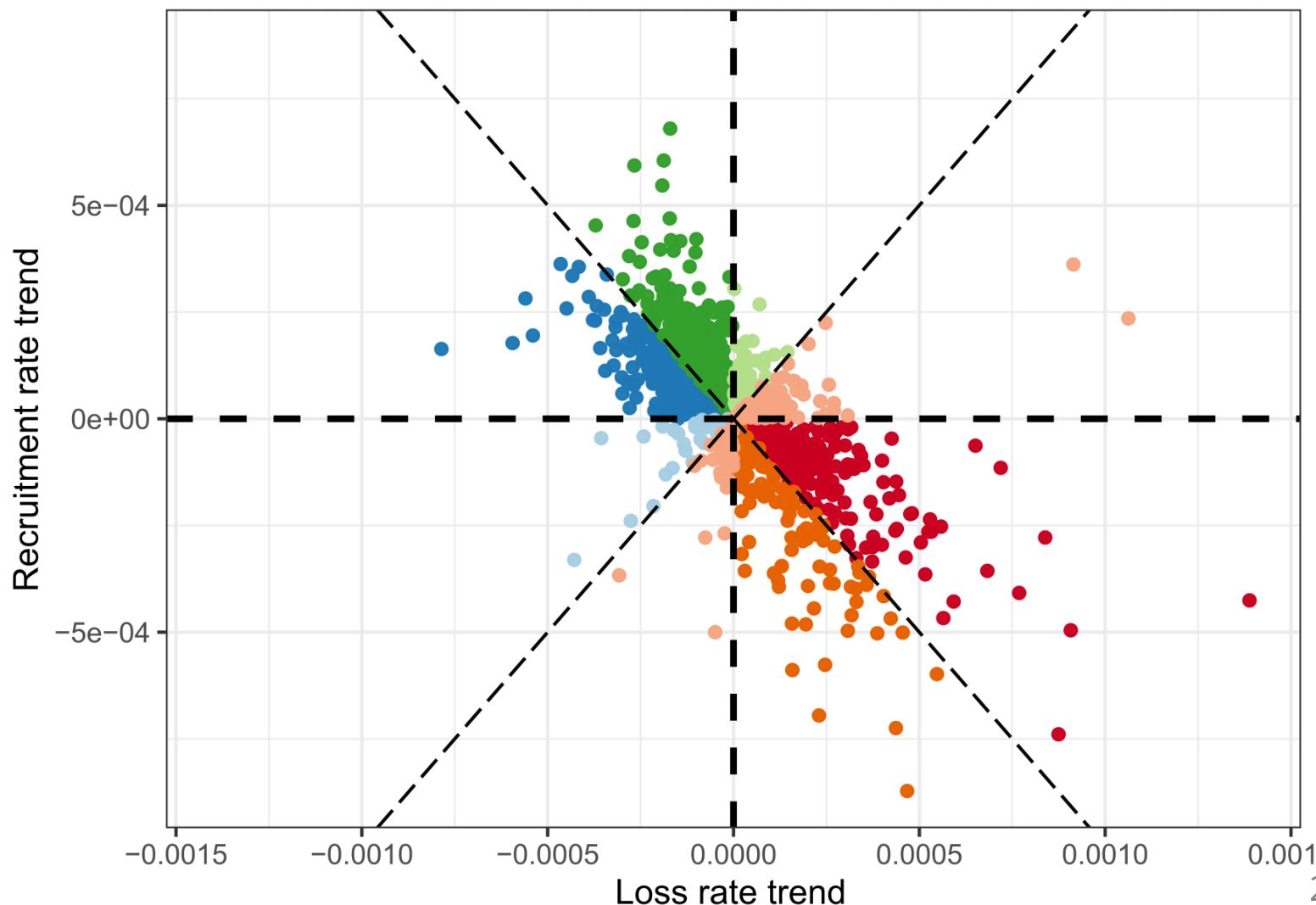
Recruitment vs. Loss rates



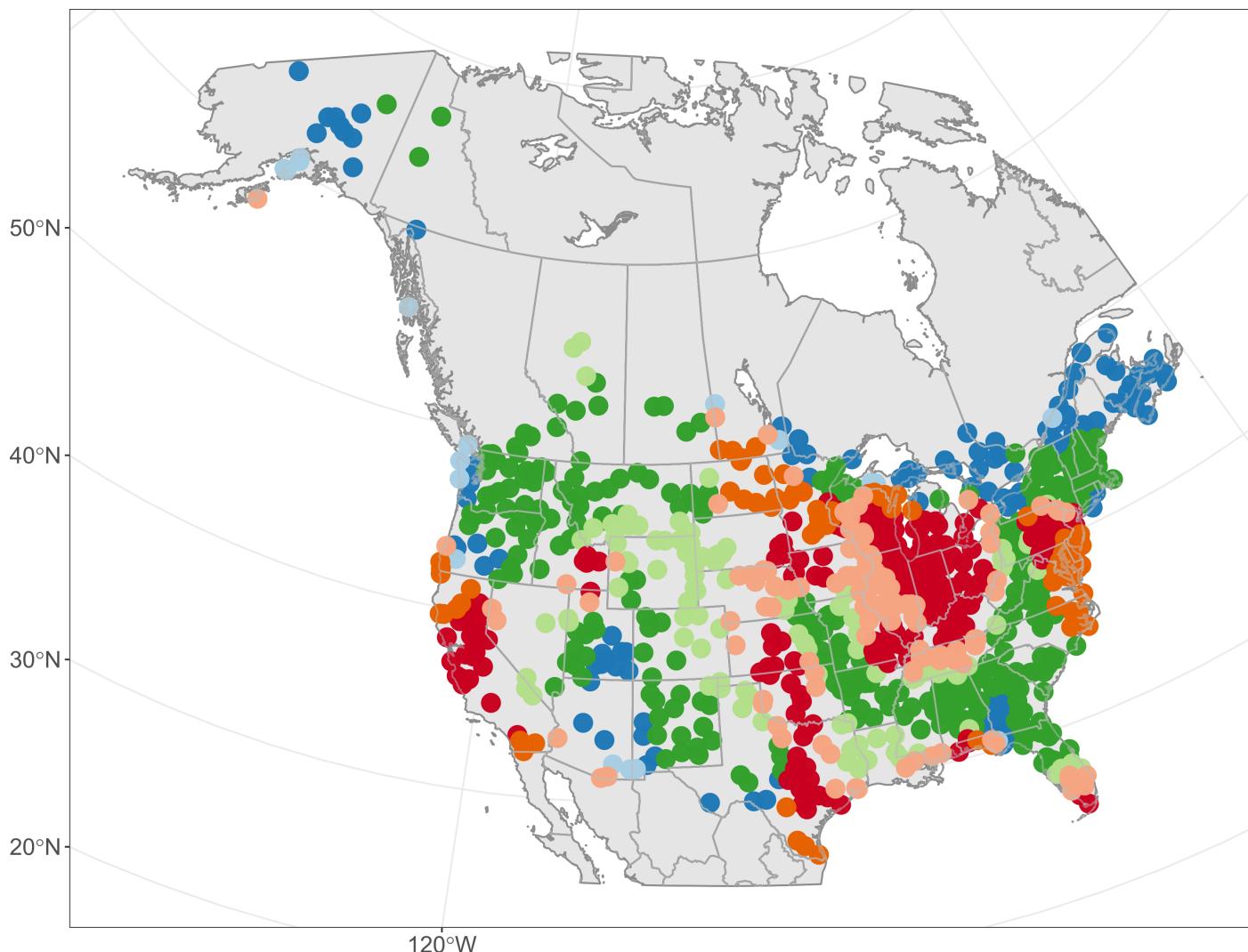
Recruitment vs. Loss rates



Recruitment rate vs. Loss rate



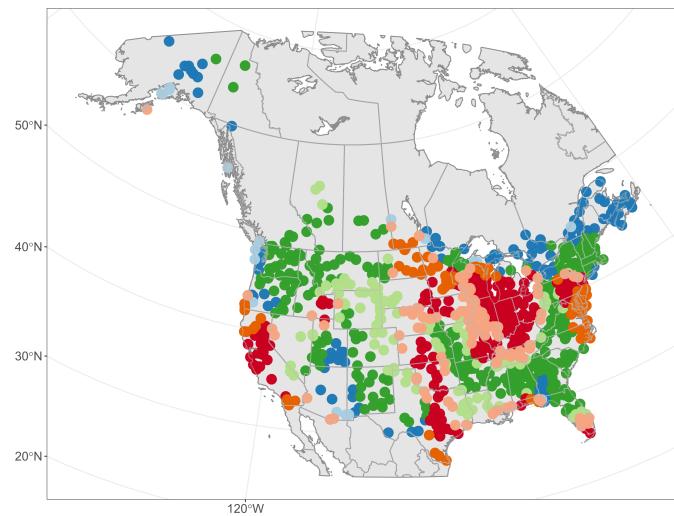
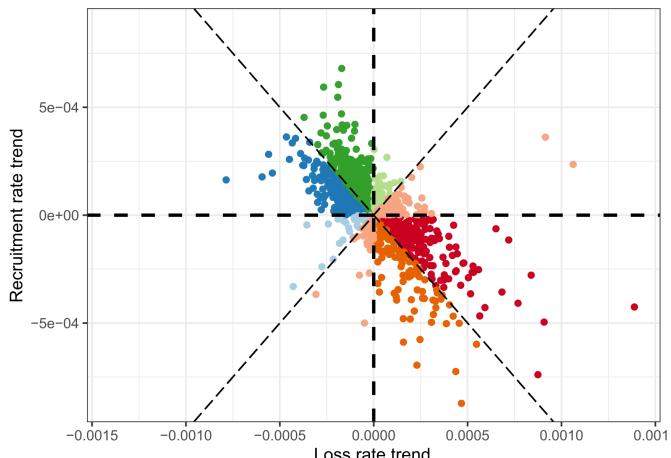
Recruitment rate vs. Loss rate (smoothed)



Conclusion

⇒ First time decomposing changes of abundance at this continental and macroecological scale

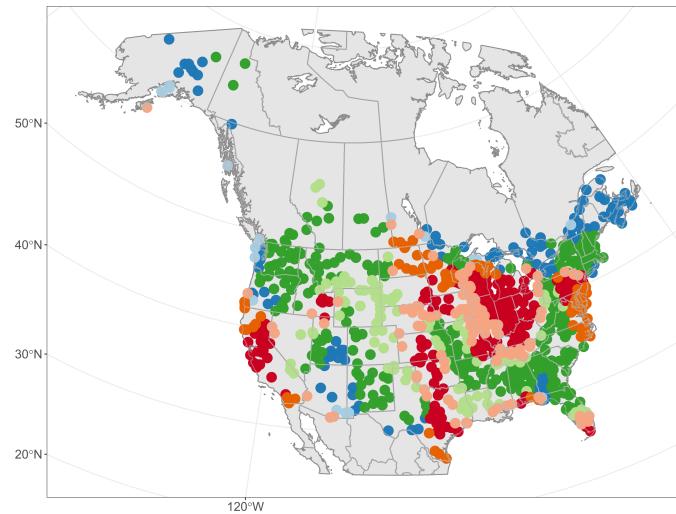
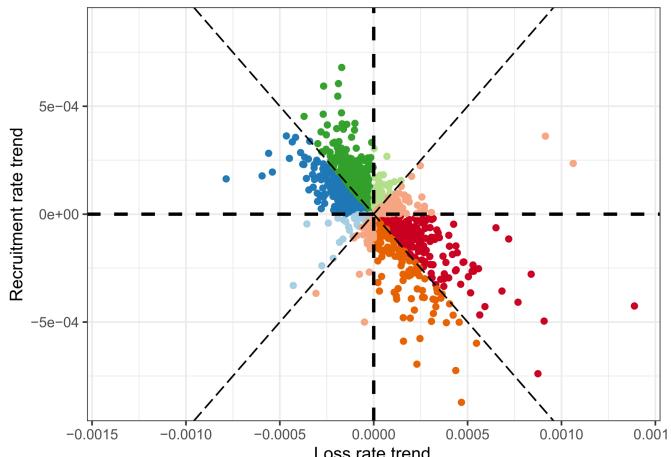
⇒ Mapping the ecological processes responsible for population change



Conclusion

⇒ From a conservation perspective, working at the individual level is the most important

⇒ Focus must be done on bending the "right curve" (*i.e.* loss or recruitment rate)



Acknowledgements

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 @FrsLry

Marta Jarzyna

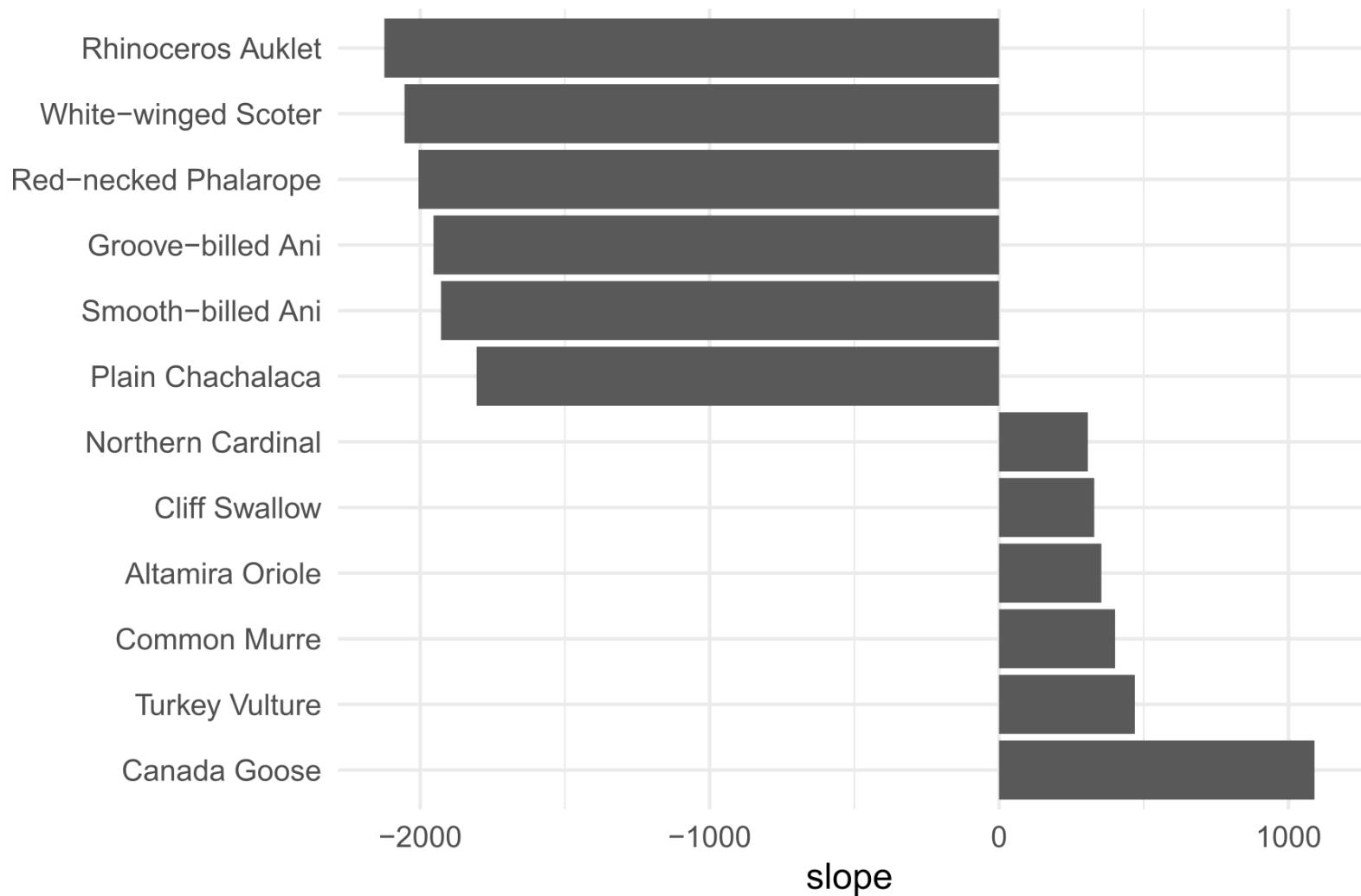


Petr Keil

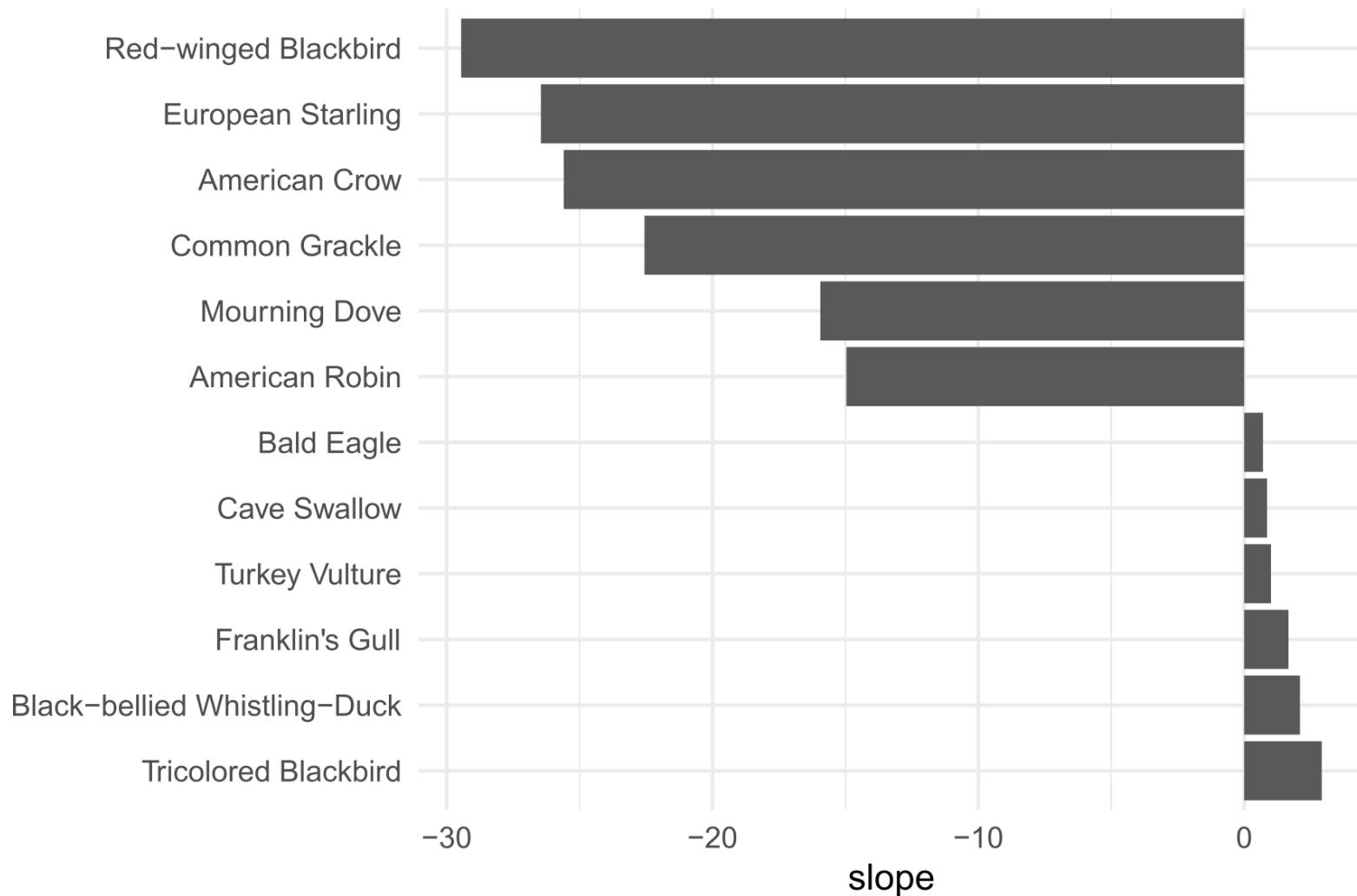


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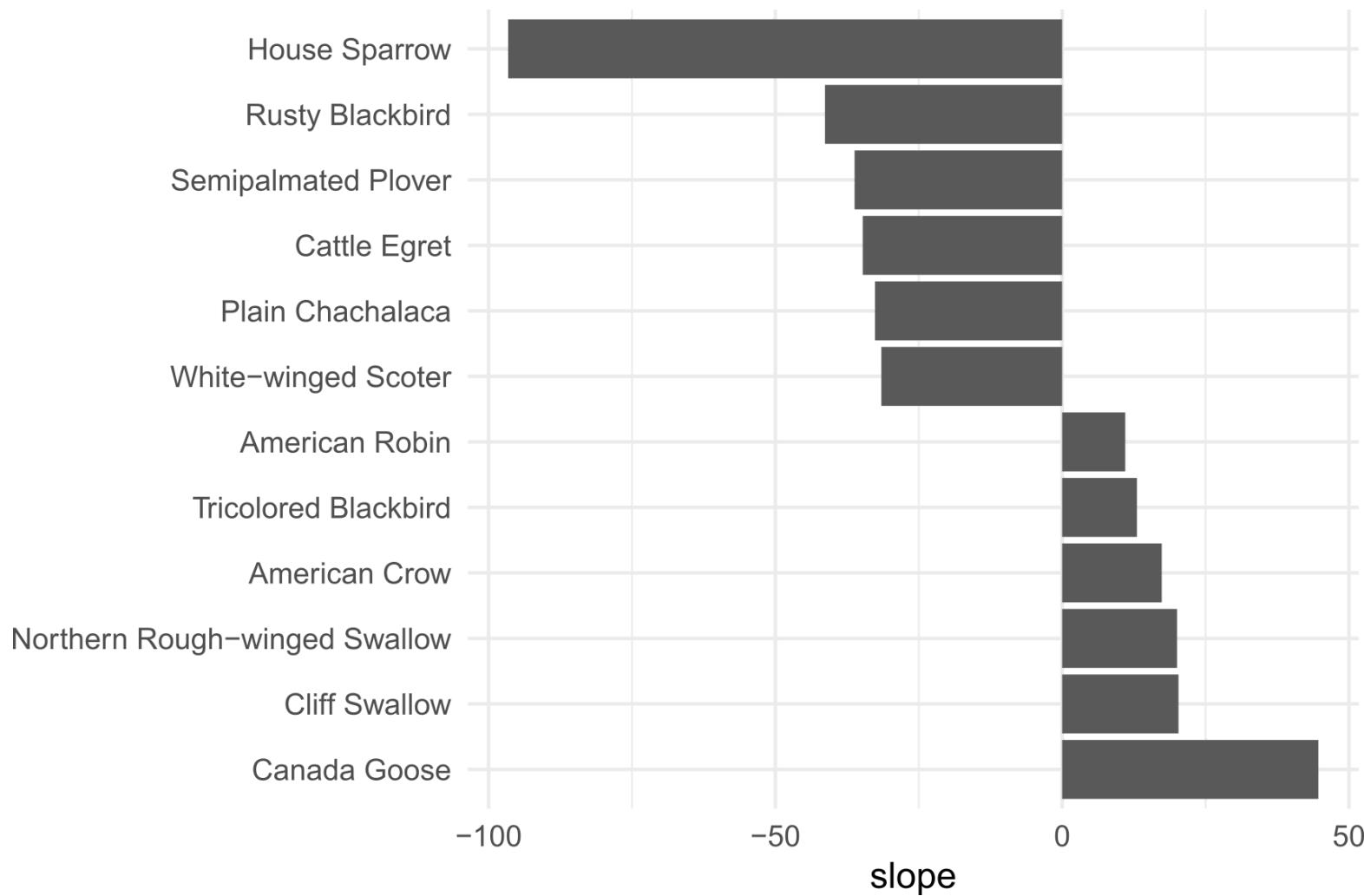
Per species change - Abundance



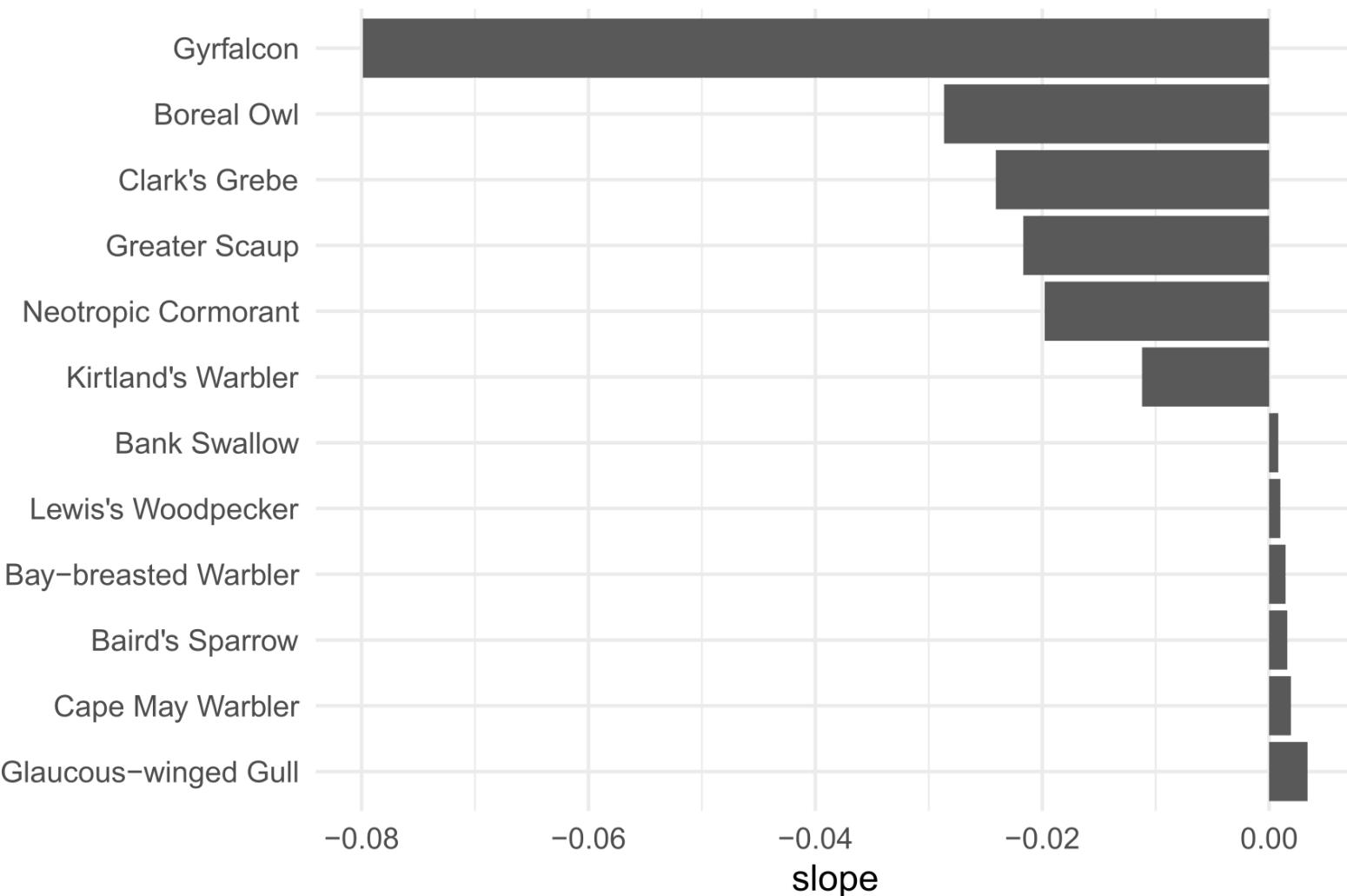
Per species change - Recruitment



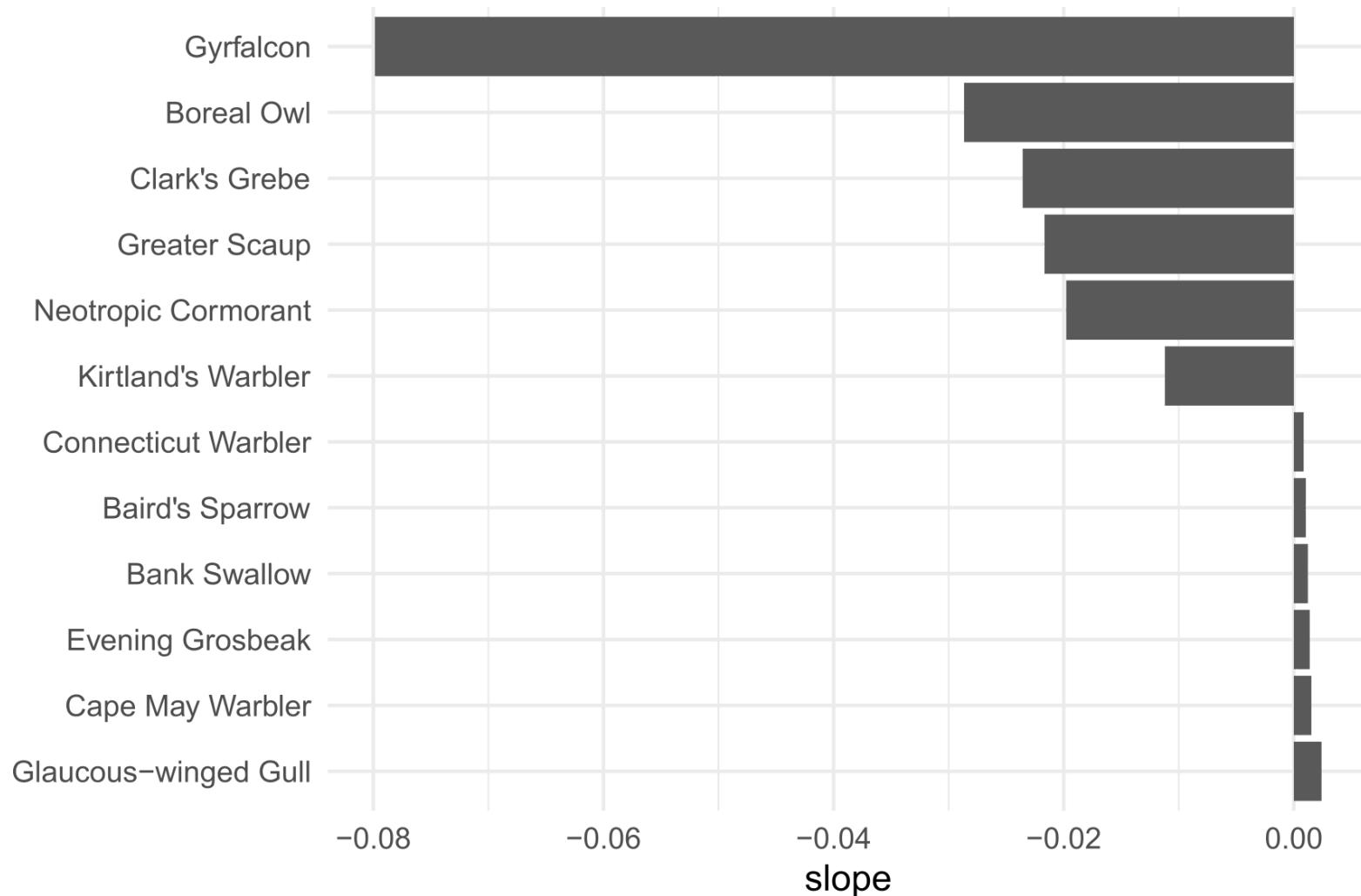
Per species change - Loss



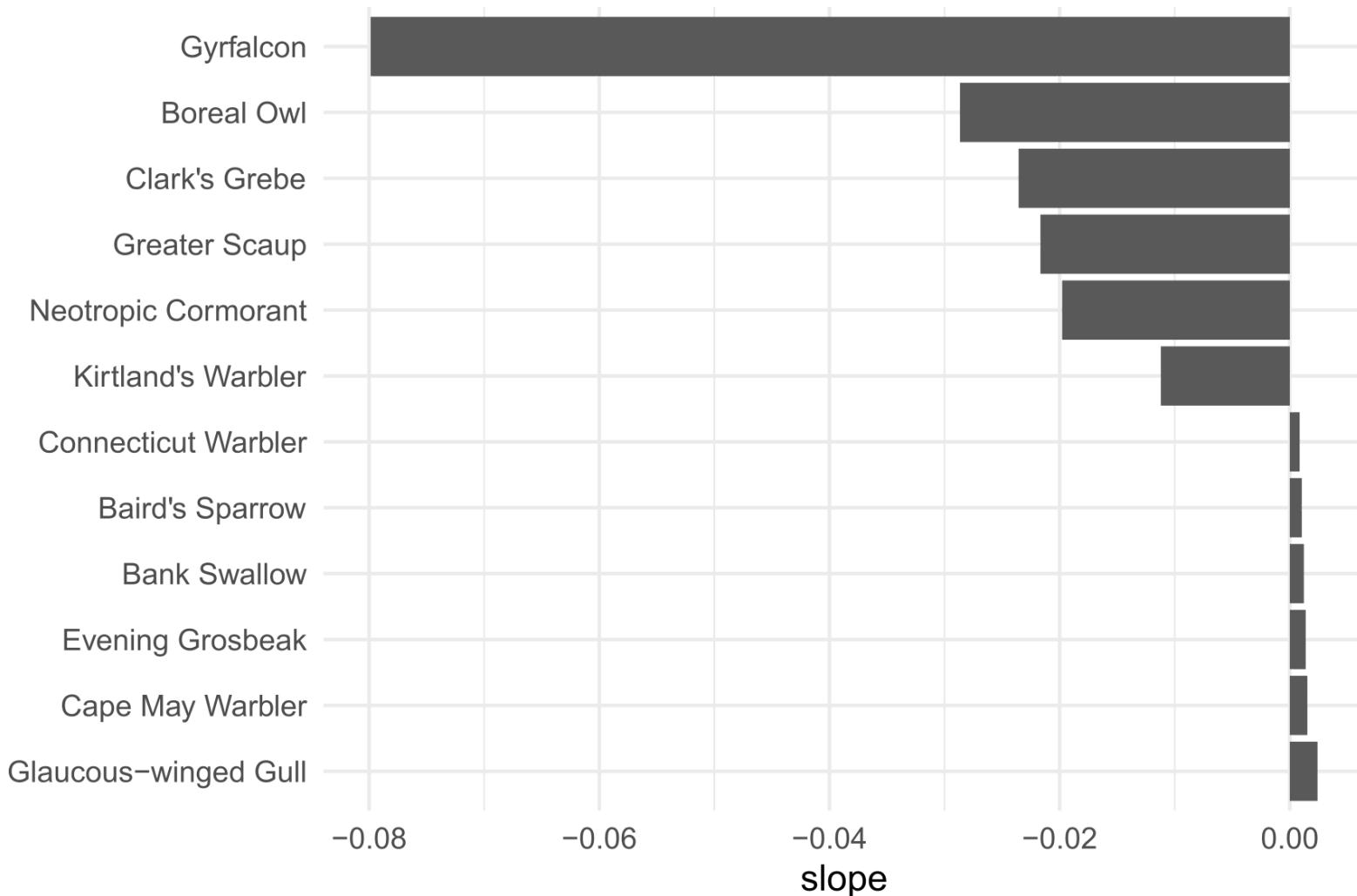
Per species change - Growth rate



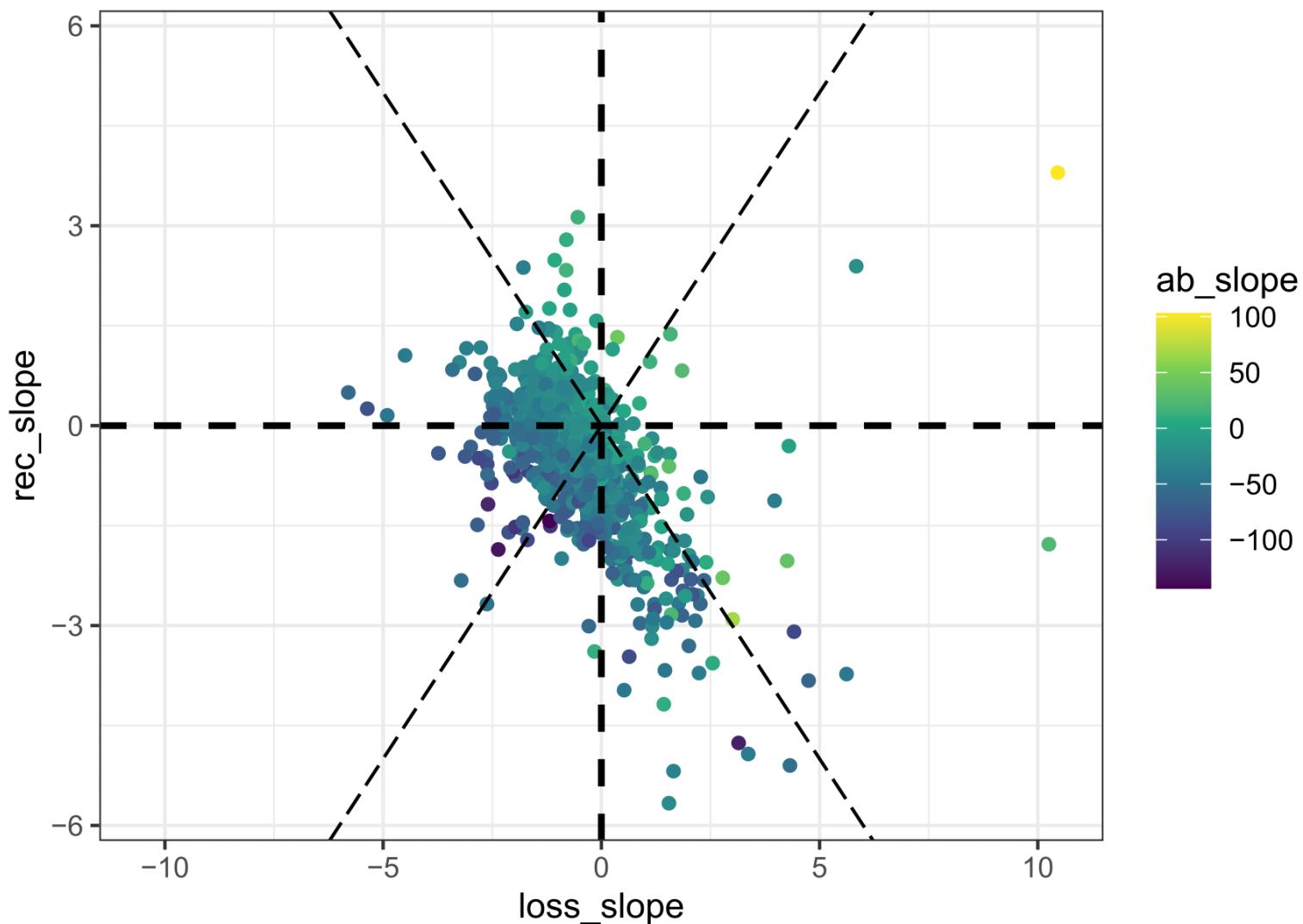
Per species change - Recruitment rate



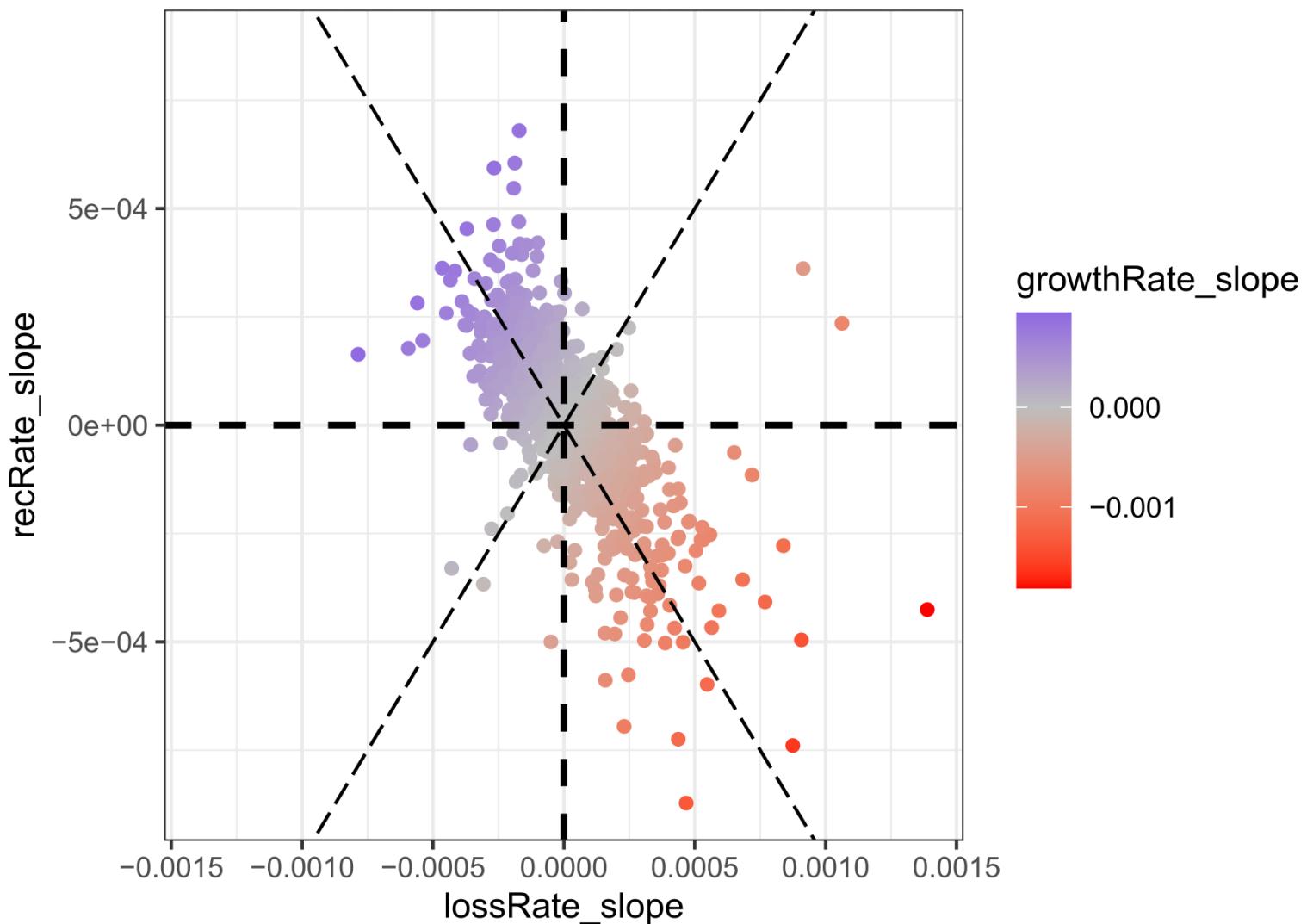
Per species change - Loss rate



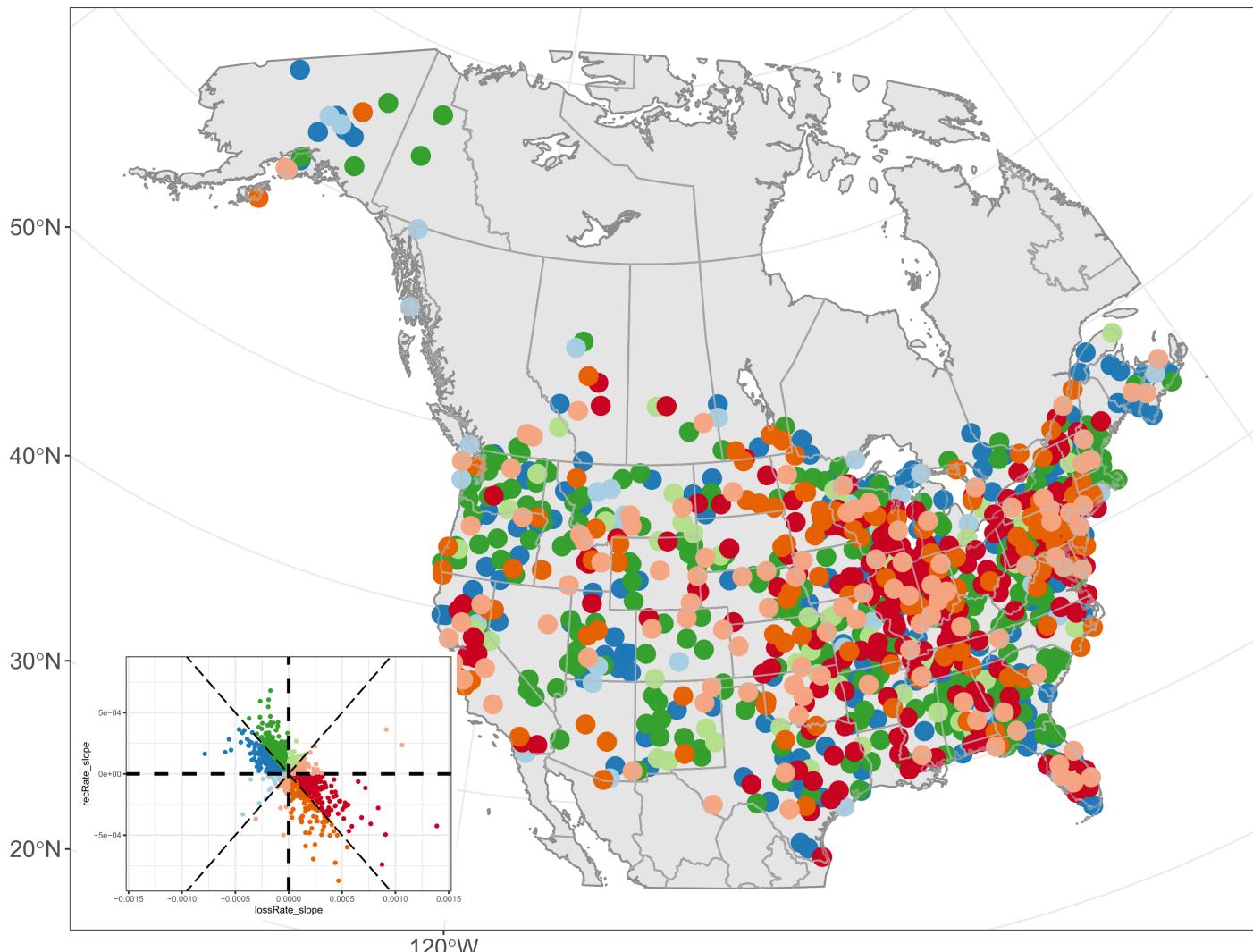
Rec. vs. Loss colored by ab. trend



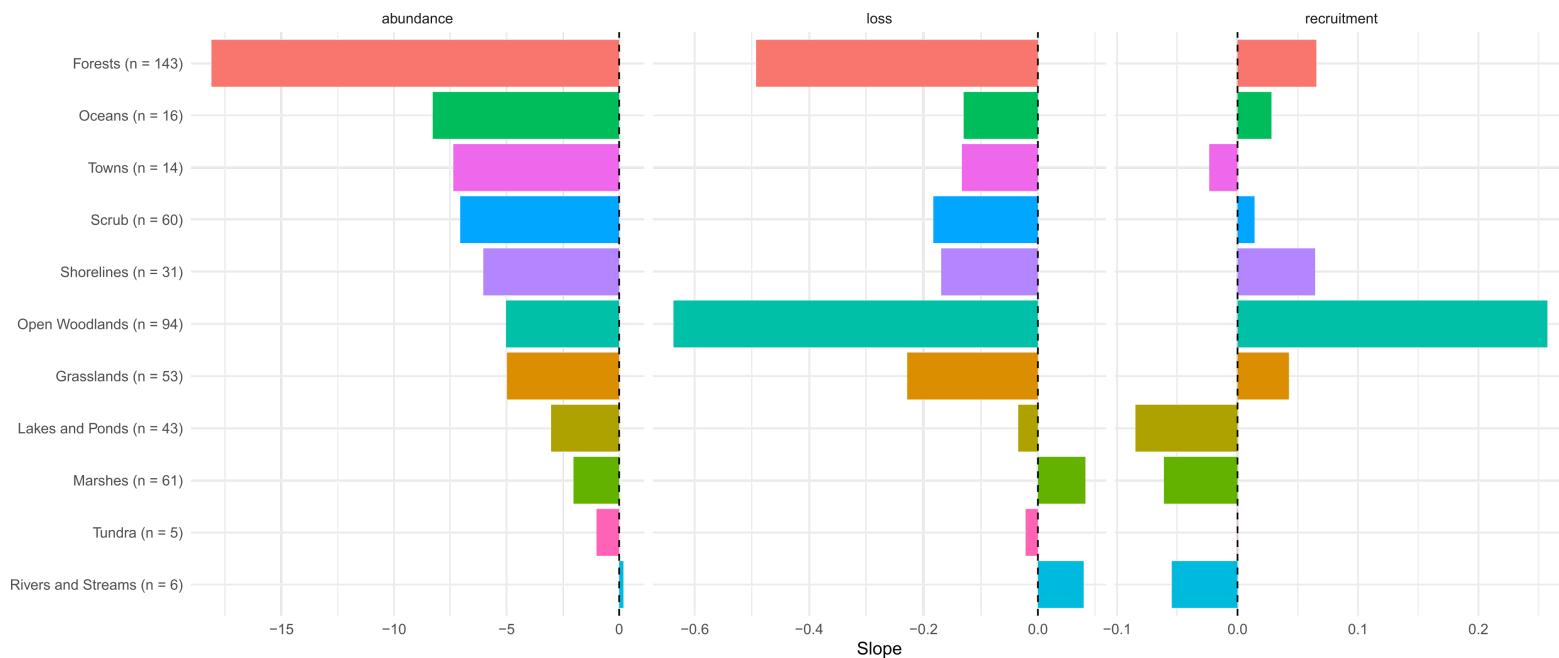
Rec. rate vs. Loss rate colored by growth rate



Recruitment rate vs. Loss rate in space



Species' preferred habitat - Numbers



Species' preferred habitat - Rates

