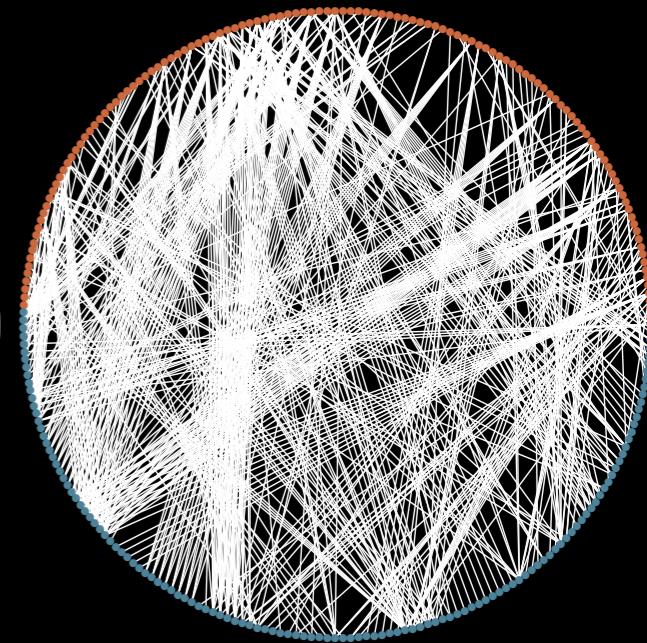
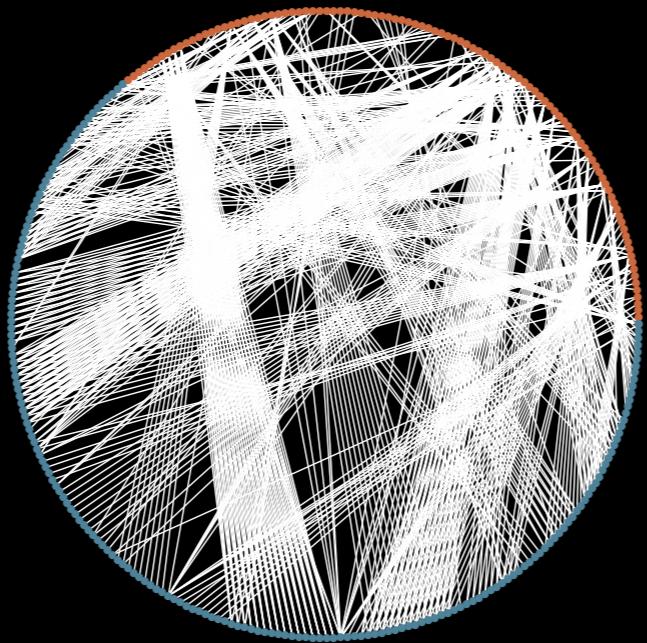
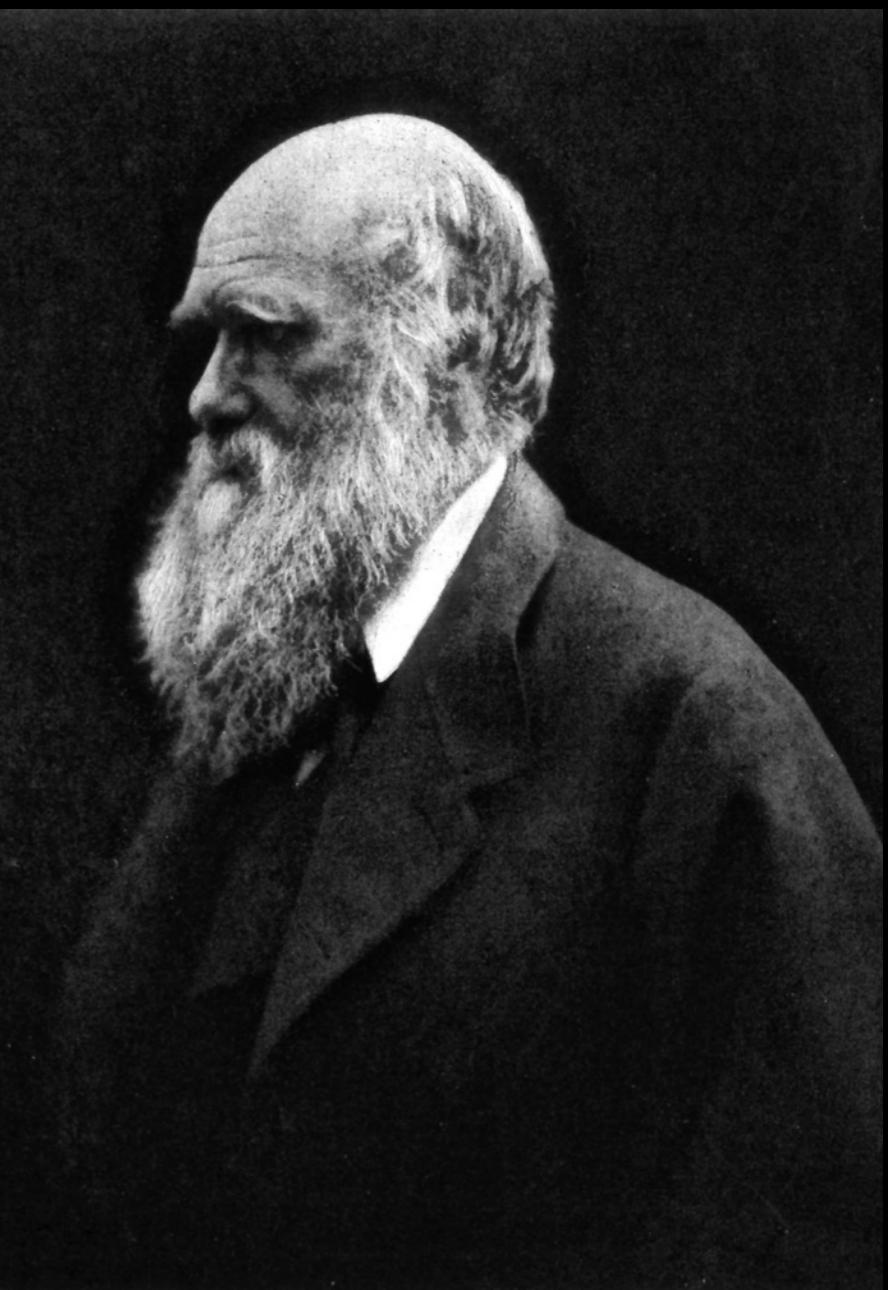


# The statistical mechanics of biodiversity in evolving island communities



Andy Rominger  
[nature.berkeley.edu/~rominger](http://nature.berkeley.edu/~rominger)  
University of Michigan • 12 March 2016

# General biodiversity laws



# General biodiversity laws





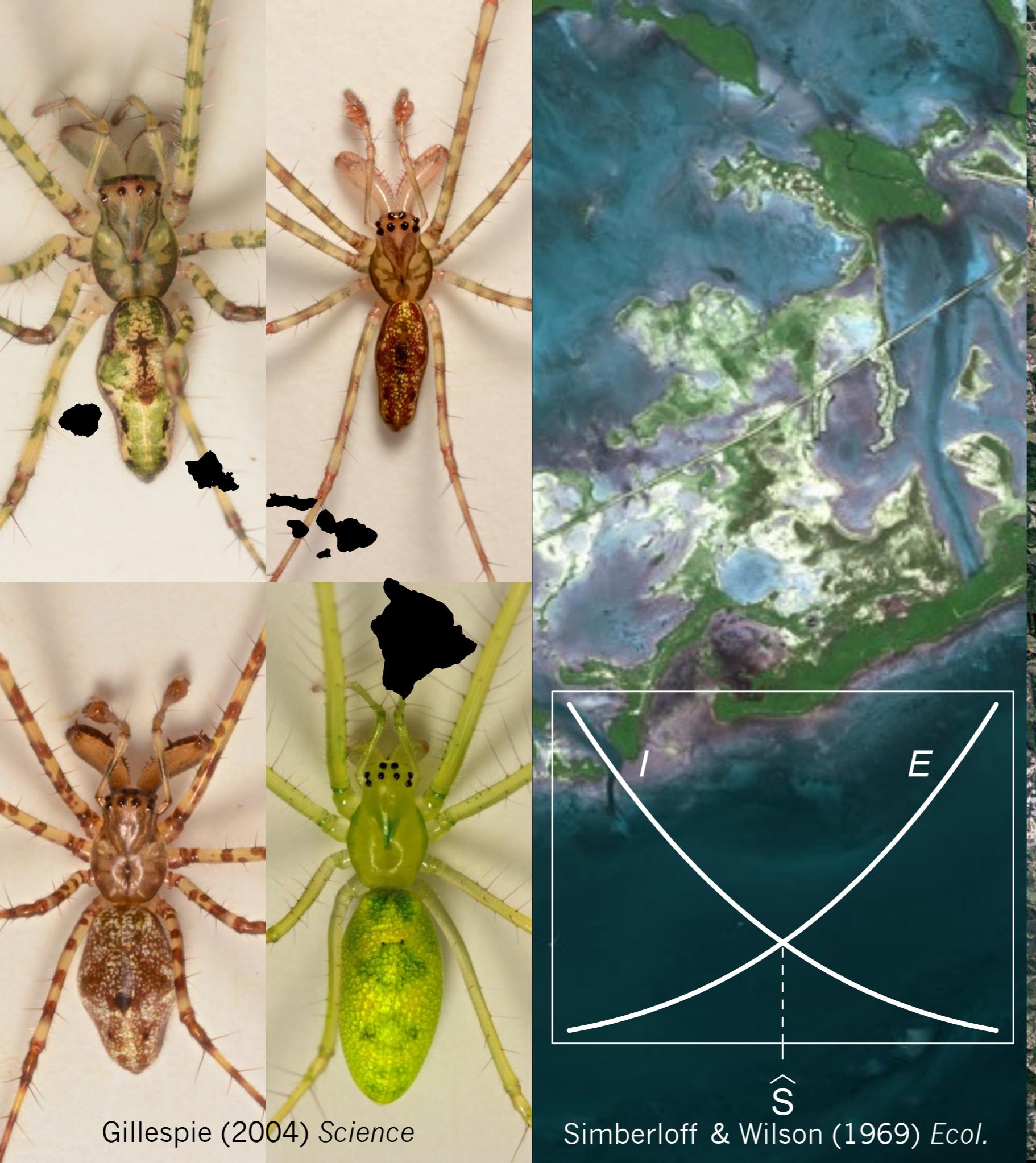
Gillespie (2004) Science



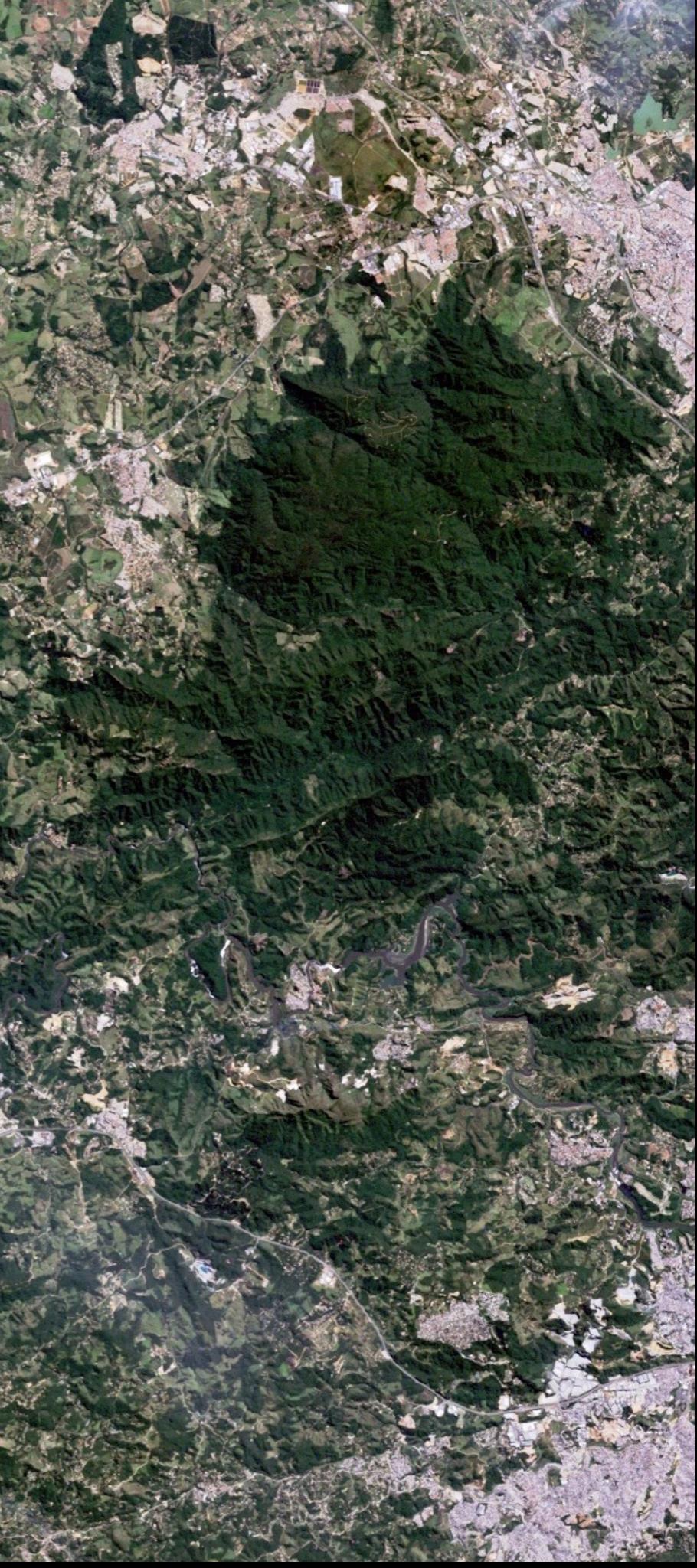
Gillespie (2004) *Science*



Simberloff & Wilson (1969) *Ecol.*

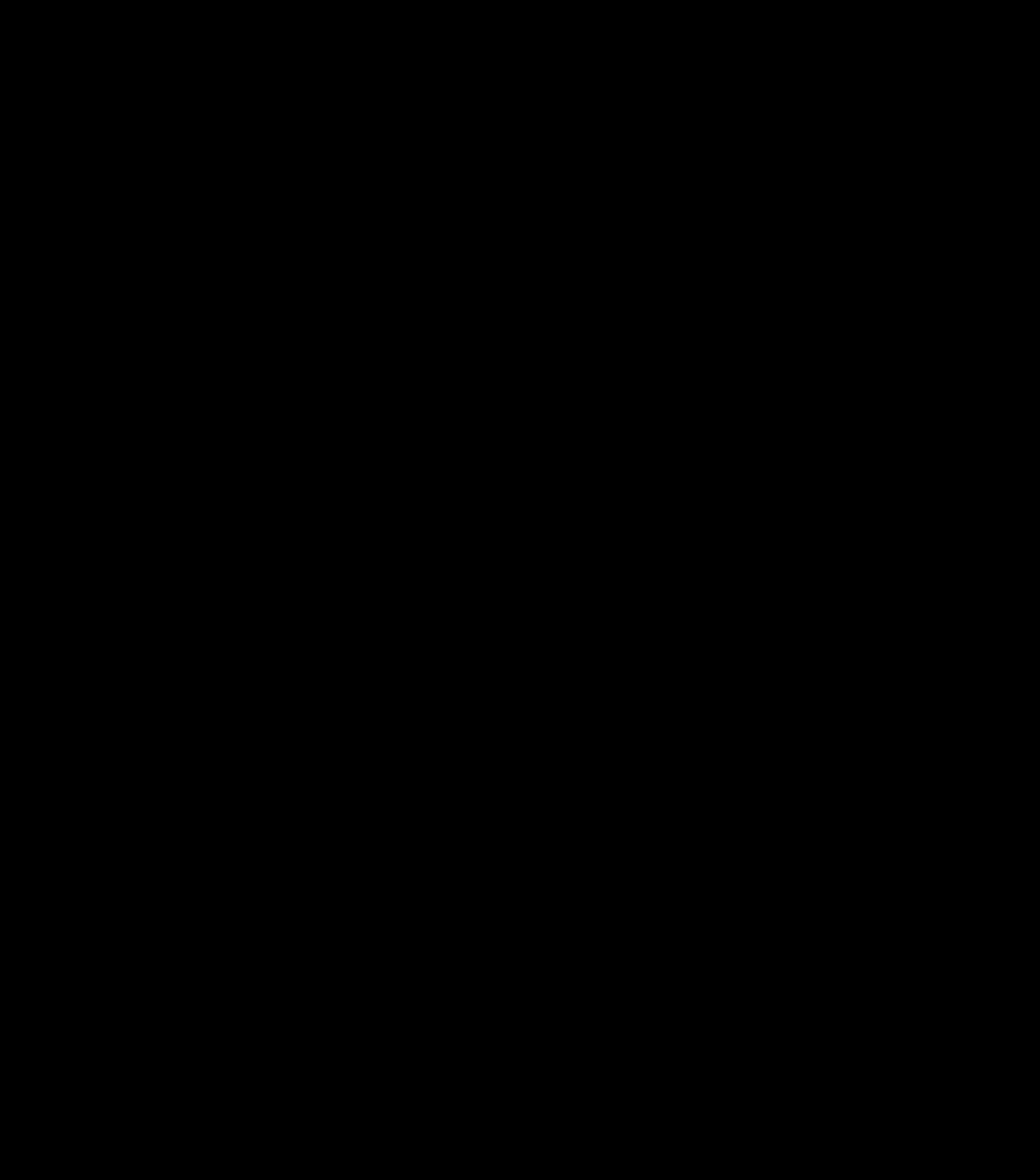


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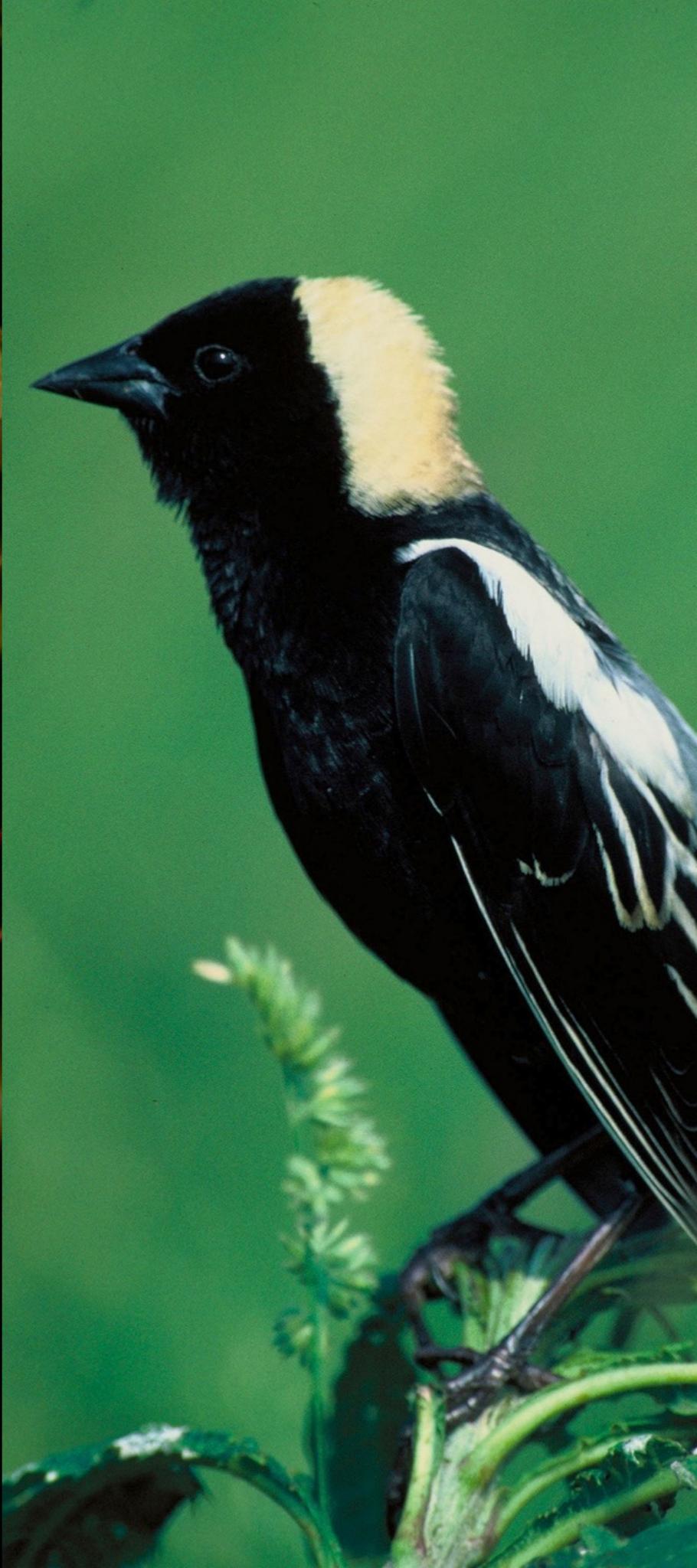


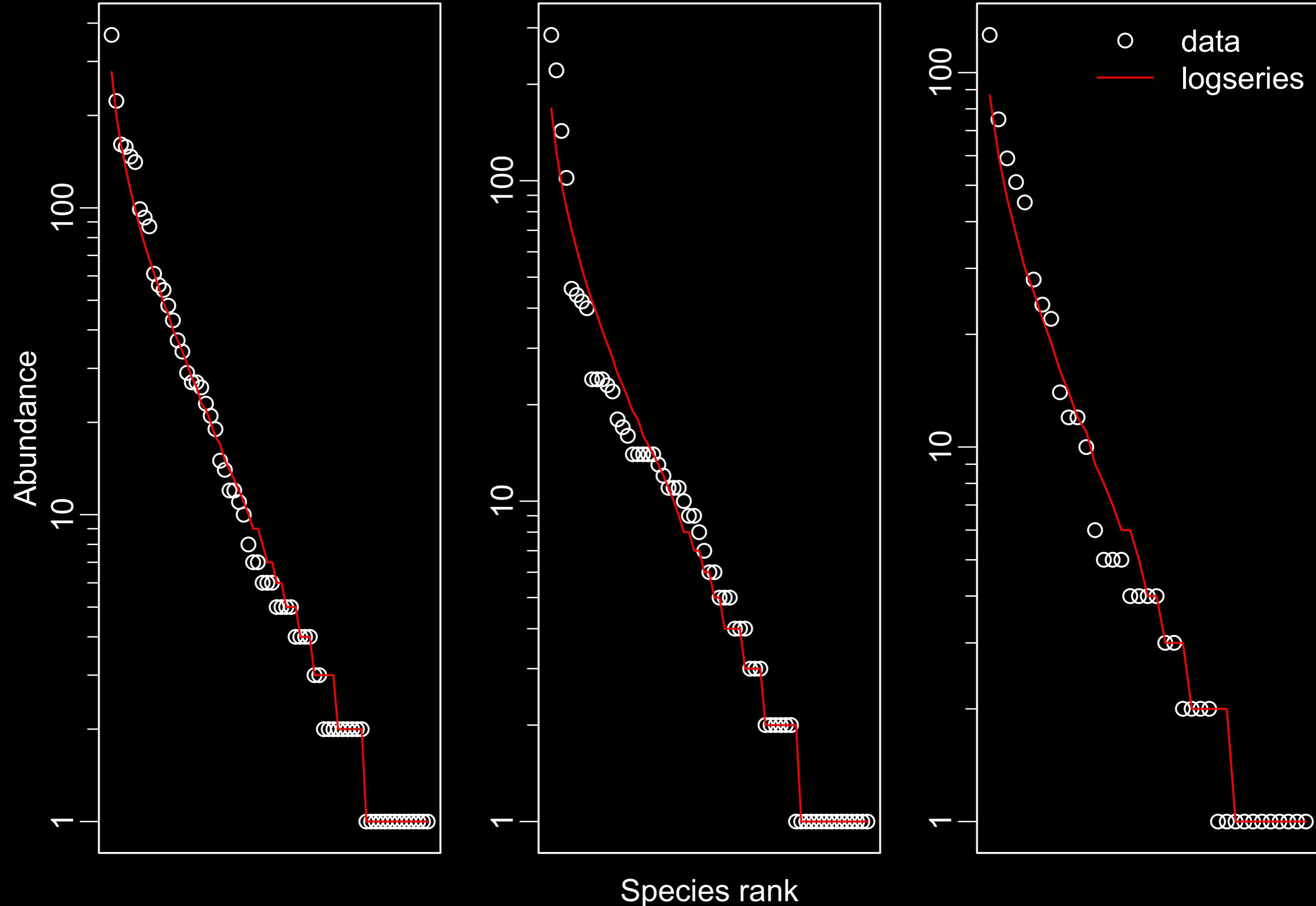
Simberloff & Wilson (1969) *Ecol.*

# Emergent similarity







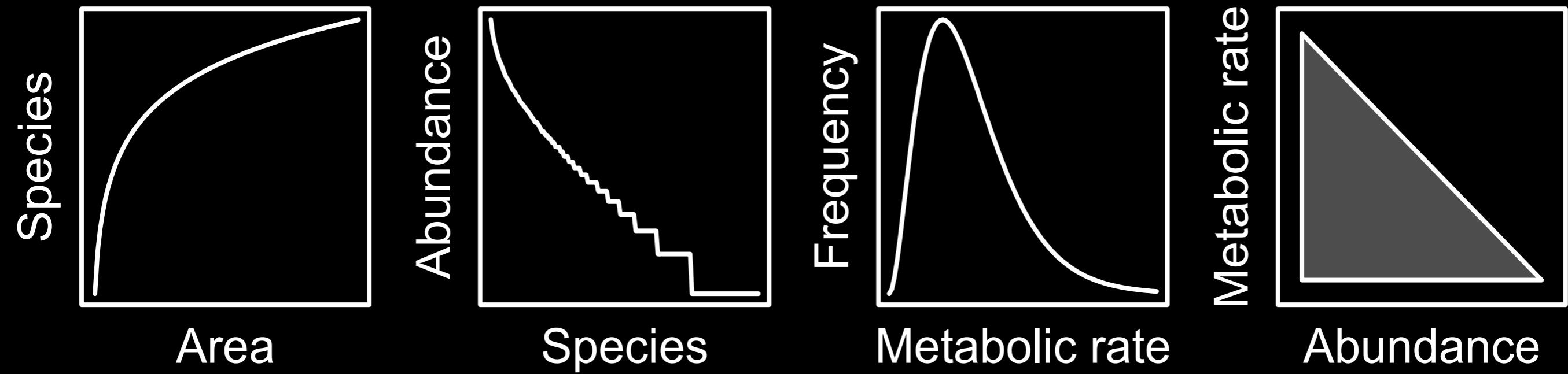


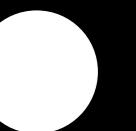
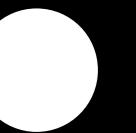
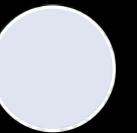
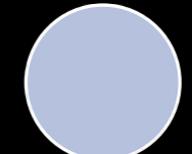
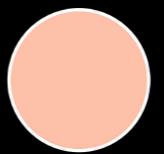
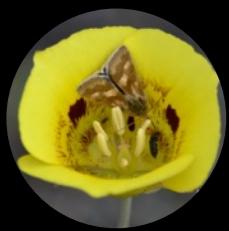
data from: [urbanforestmap.org](http://urbanforestmap.org)

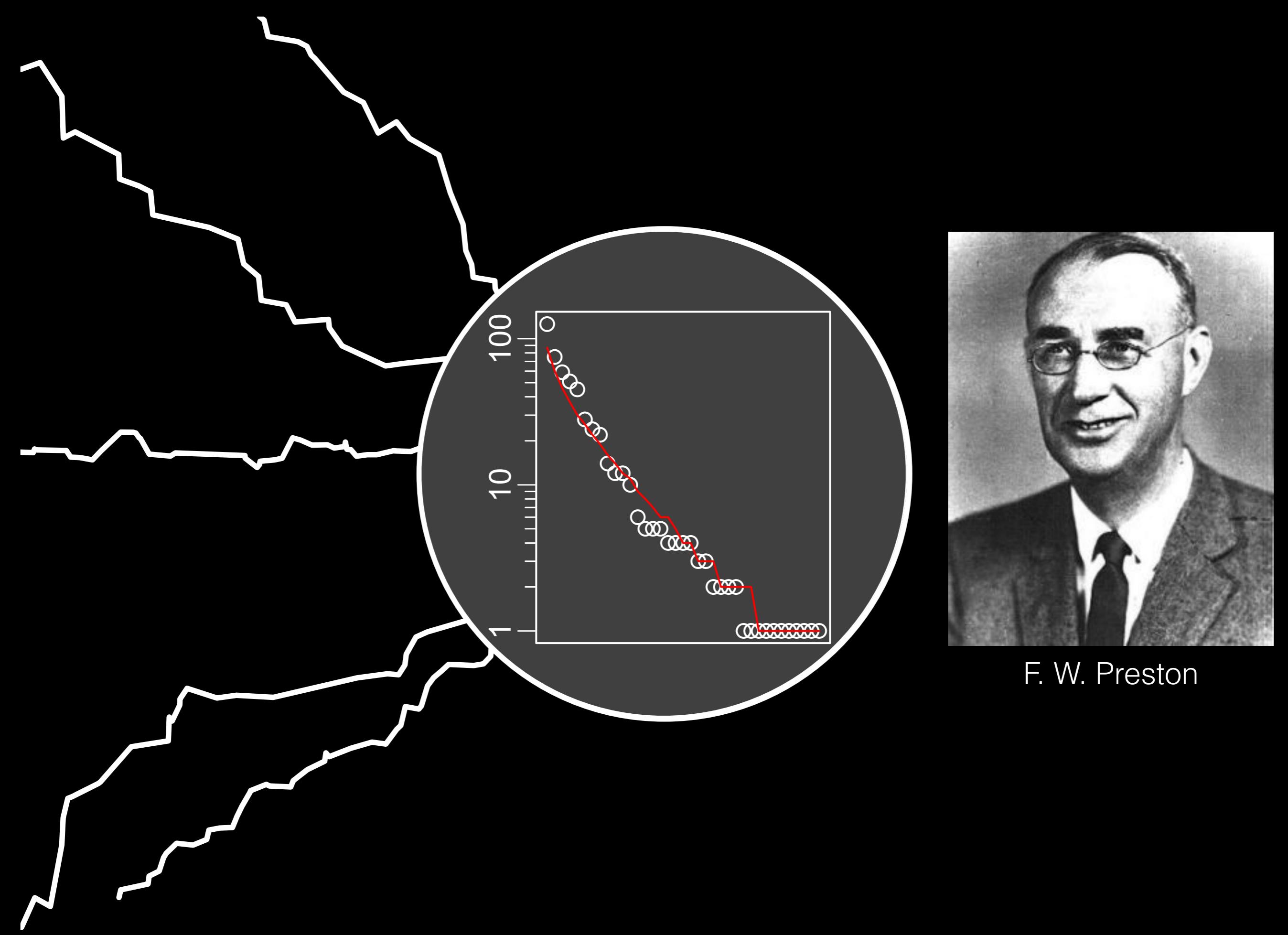
Gruner (2007) *Biol. J. Linn. Soc.*

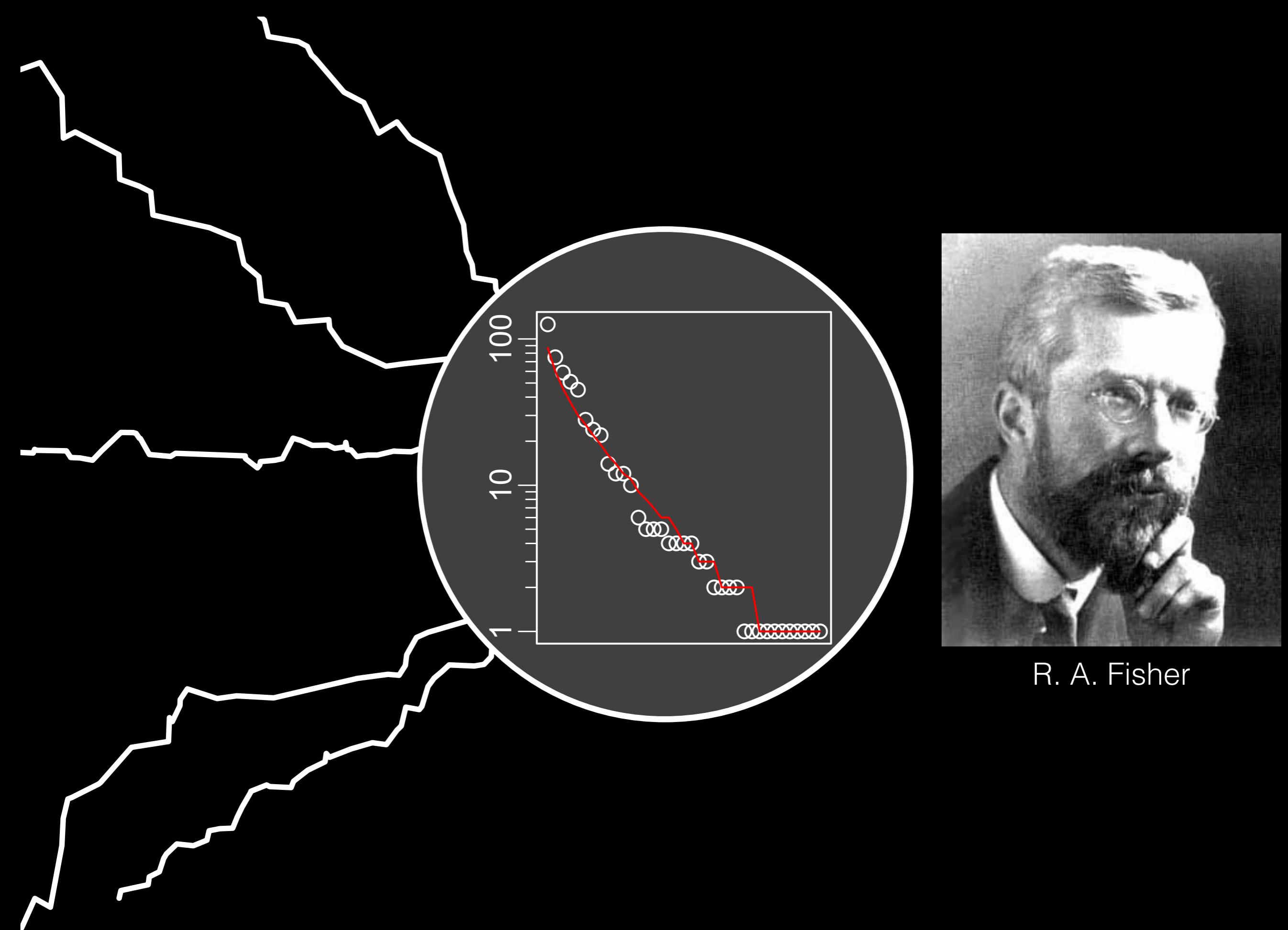
US Breeding Bird Survey

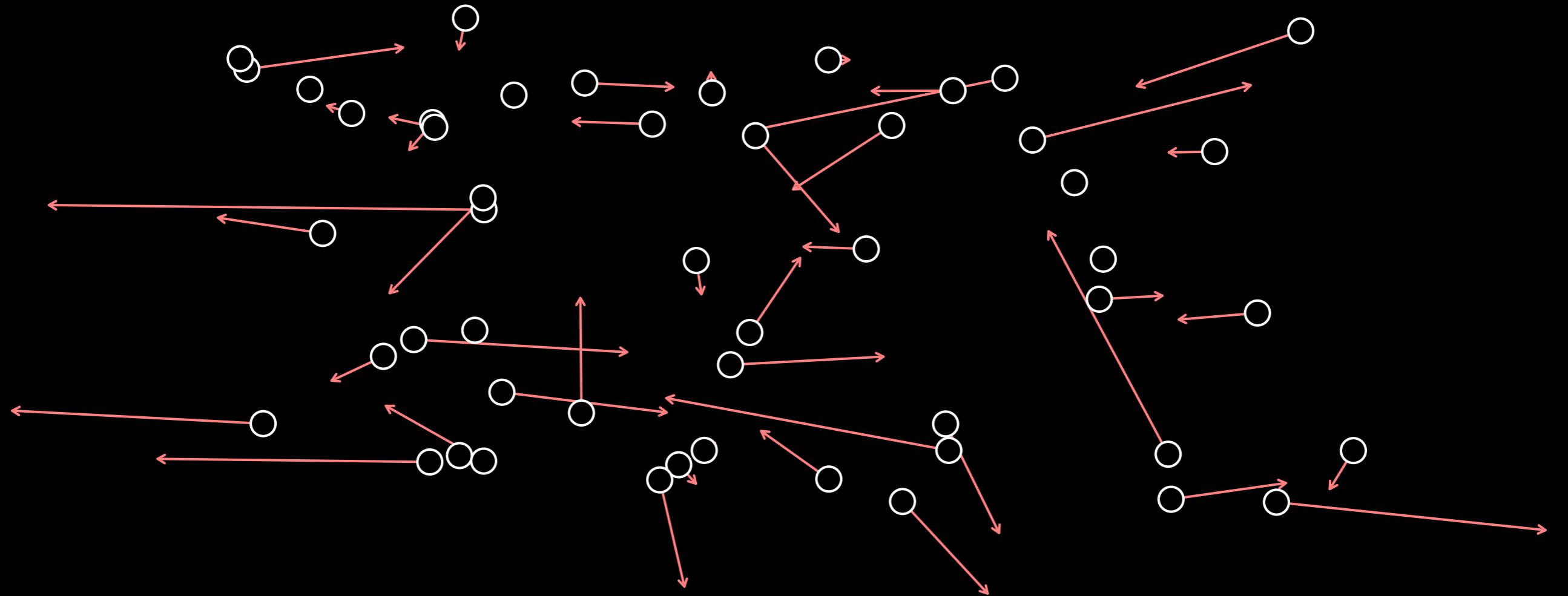
# General biodiversity laws



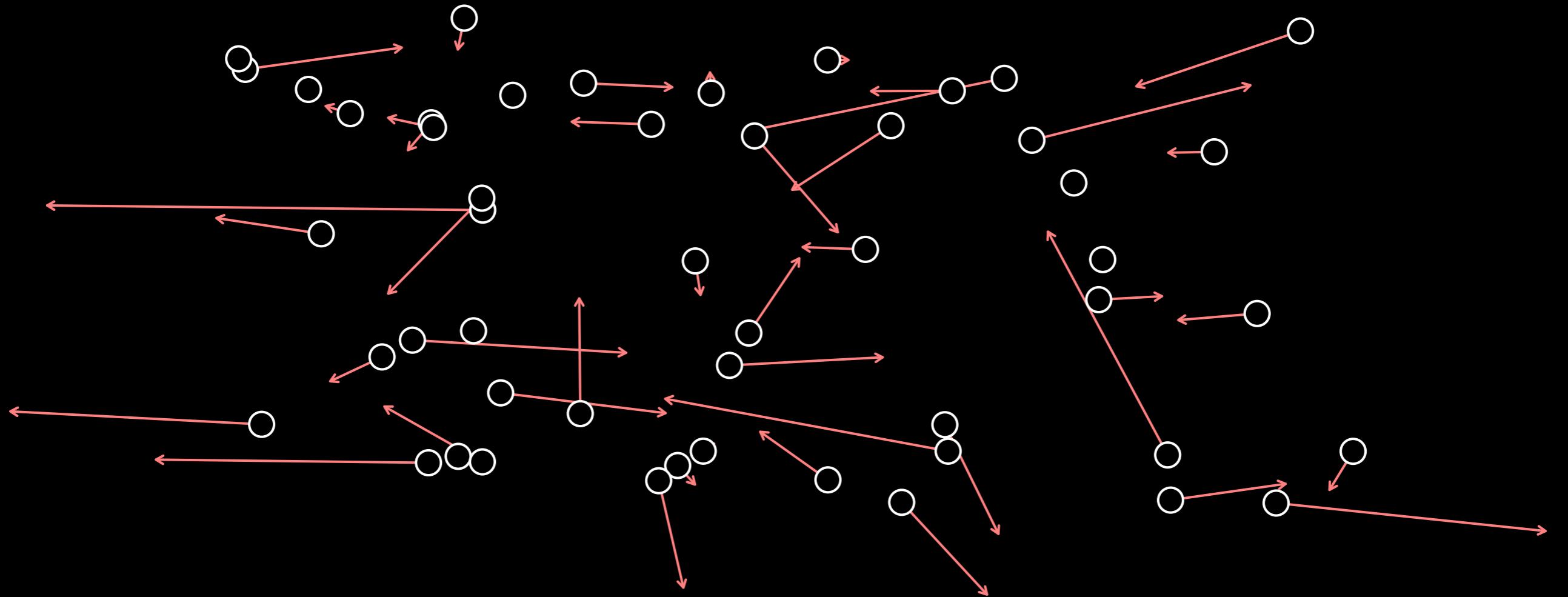




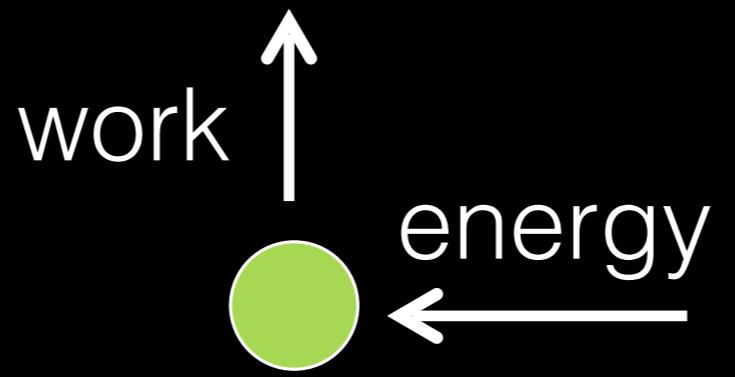


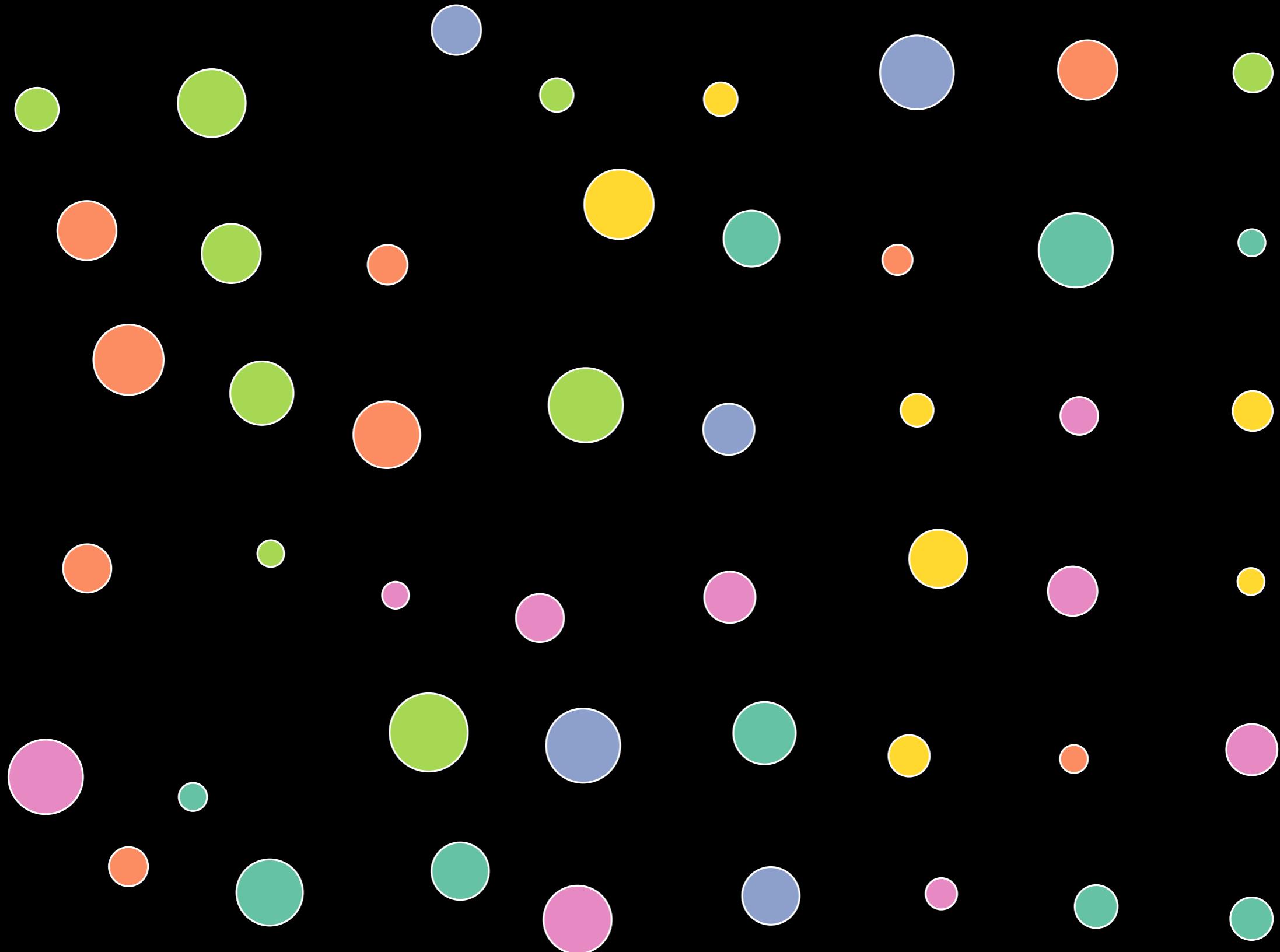


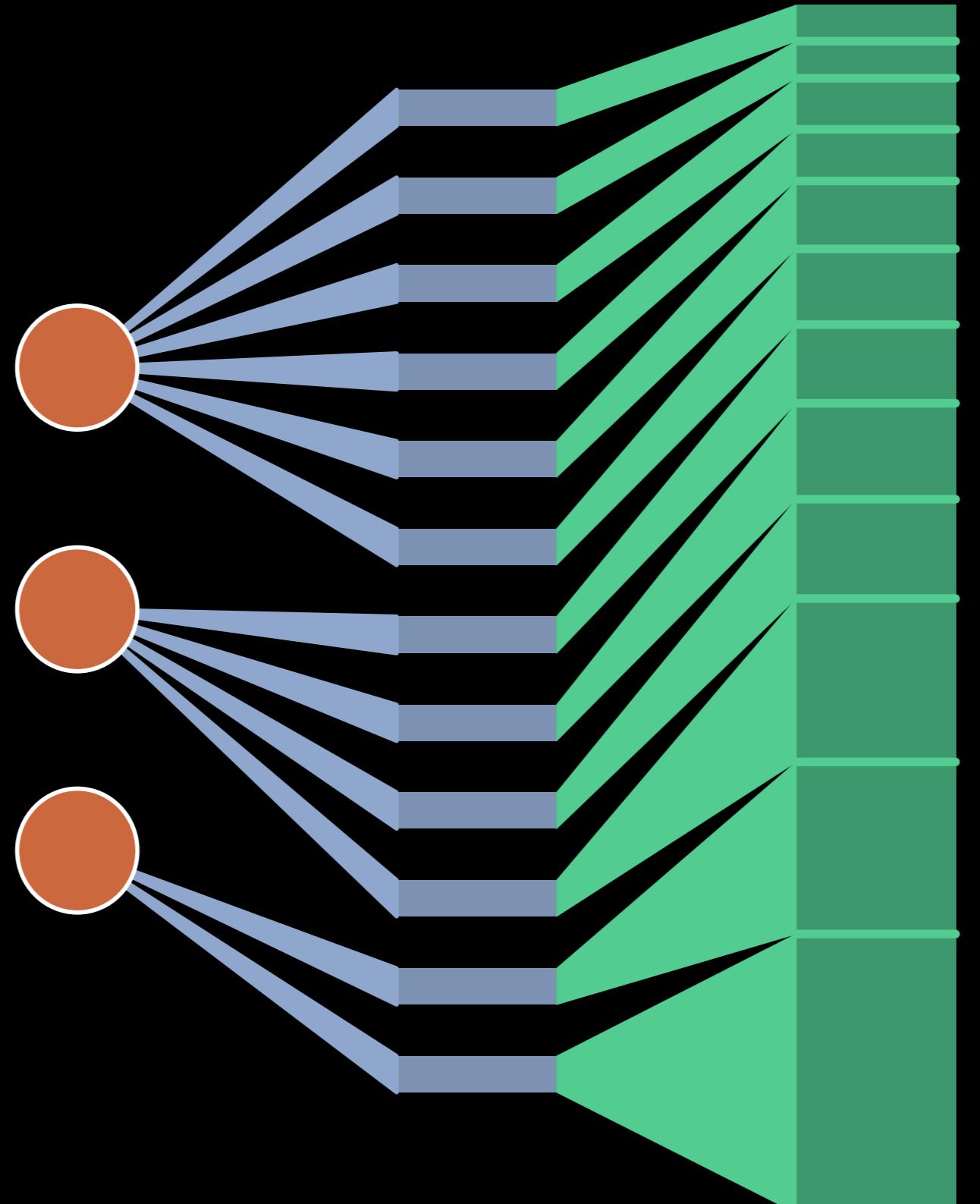
# Statistical constraint



~~t-test~~





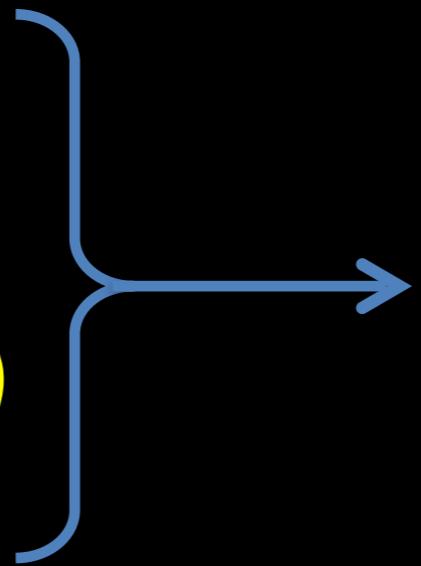


Species Individuals Energy

# Principle of Maximum Information Entropy

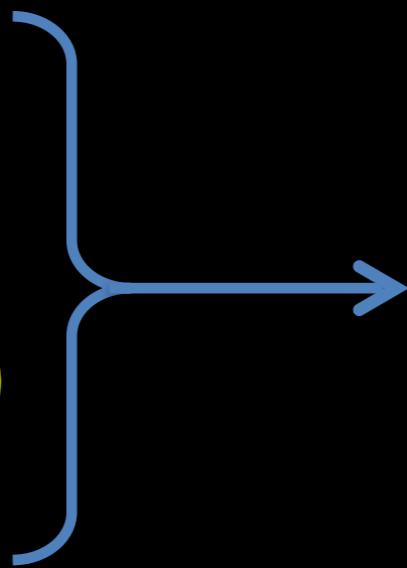
Known info  
(‘*state variables*’)

Known info  
(‘*state variables*’)



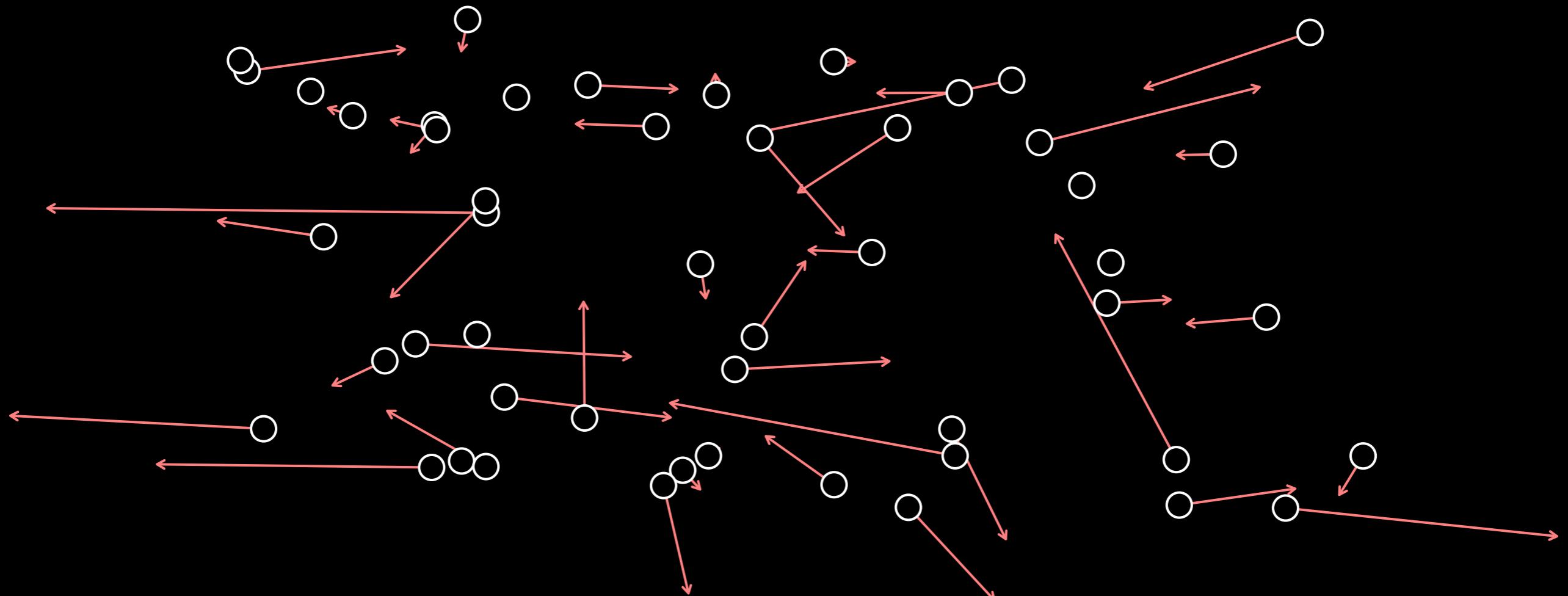
System  
probability  
distributions

Known info  
(‘*state variables*’)

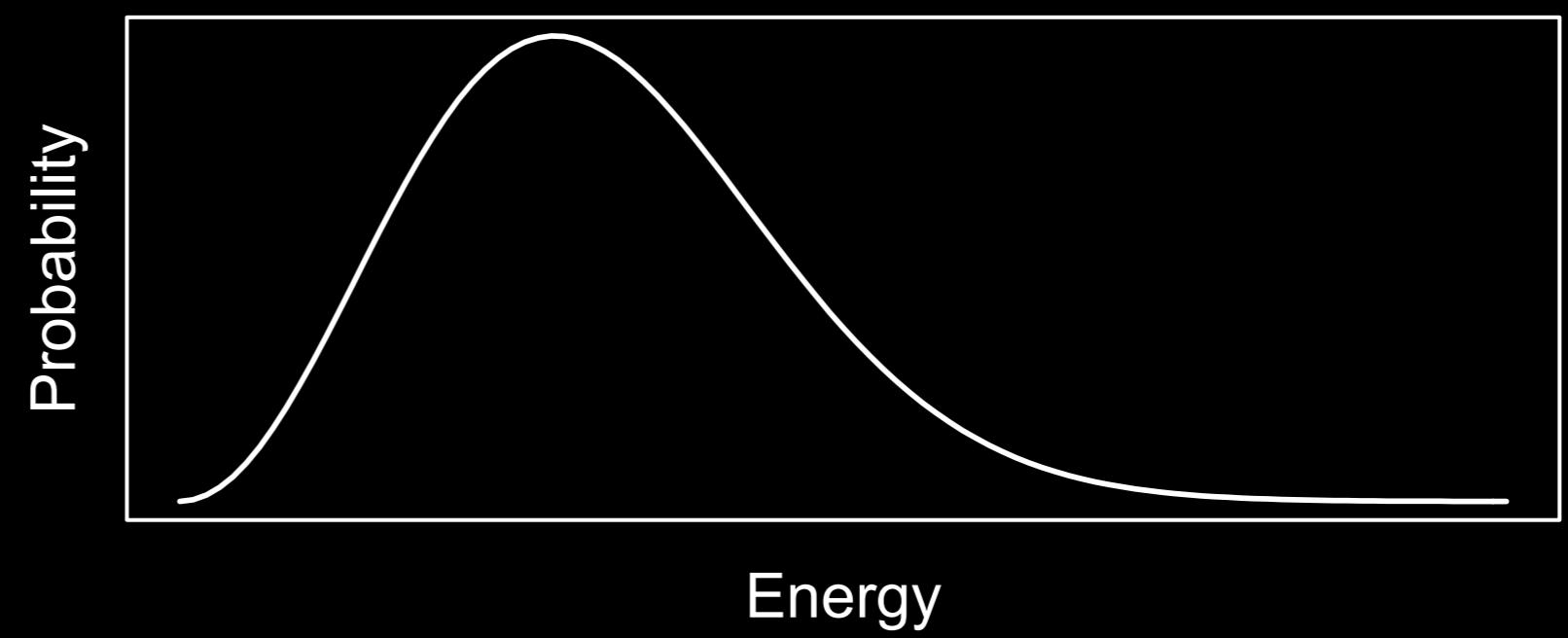


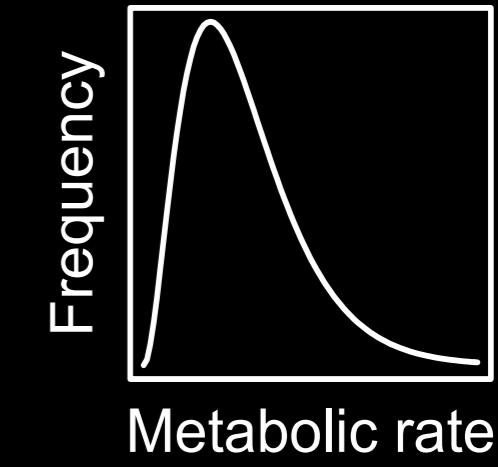
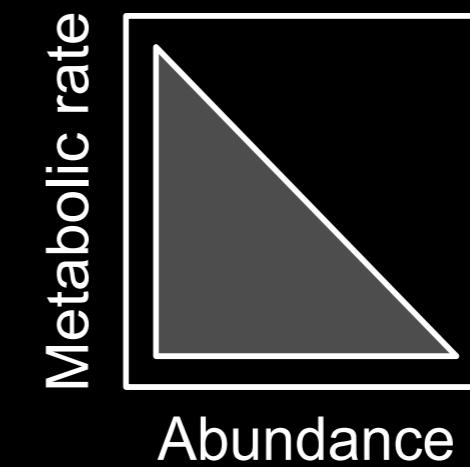
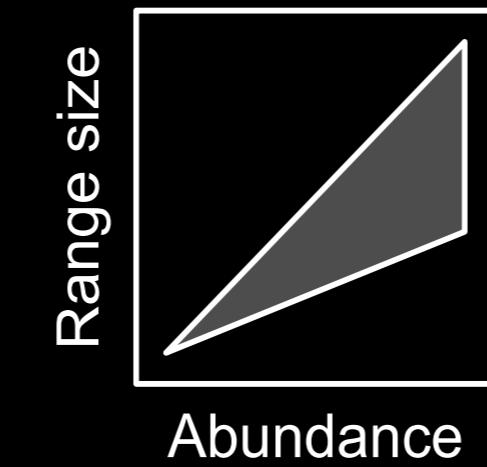
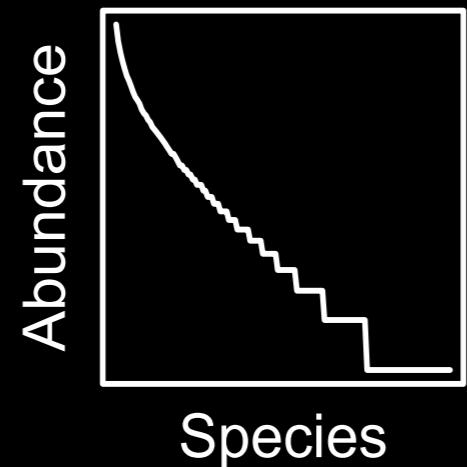
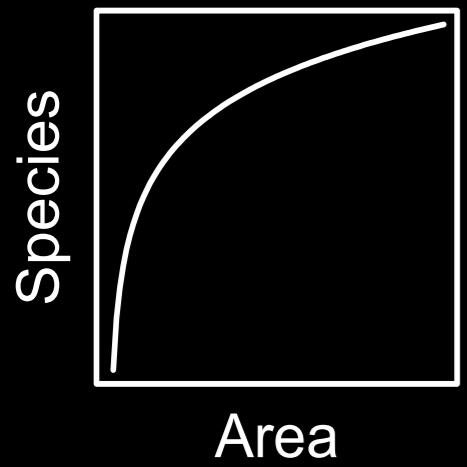
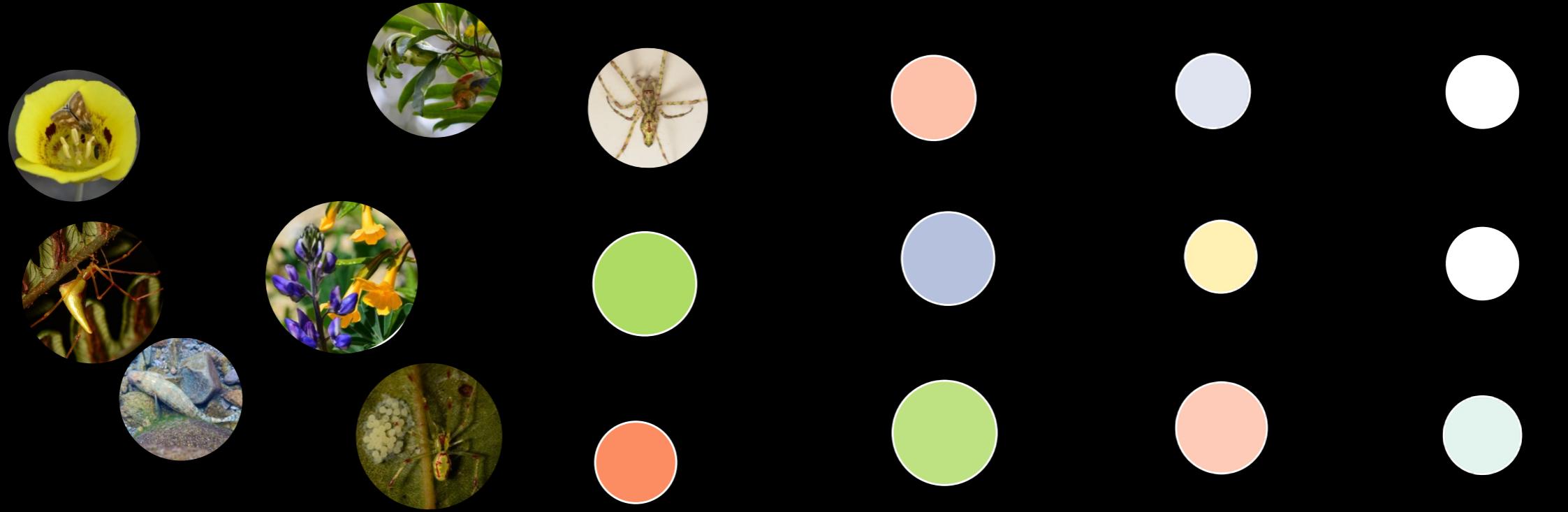
System  
probability  
distributions





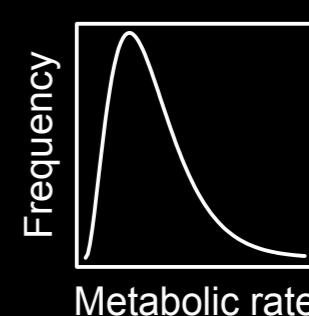
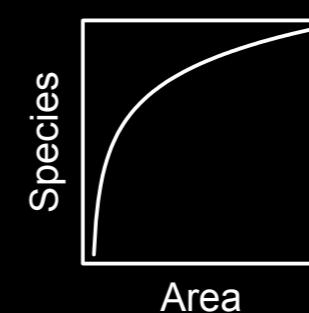
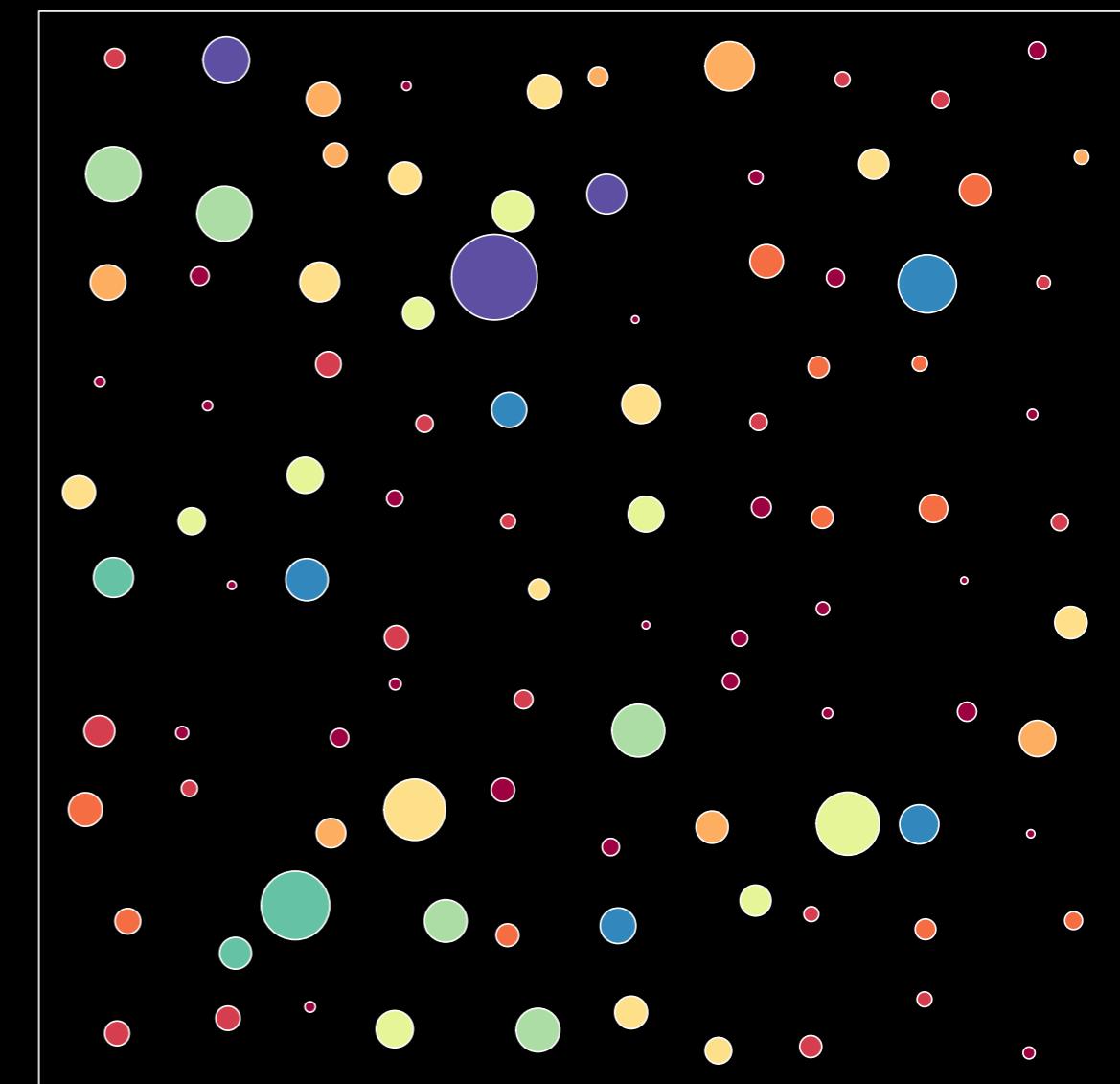
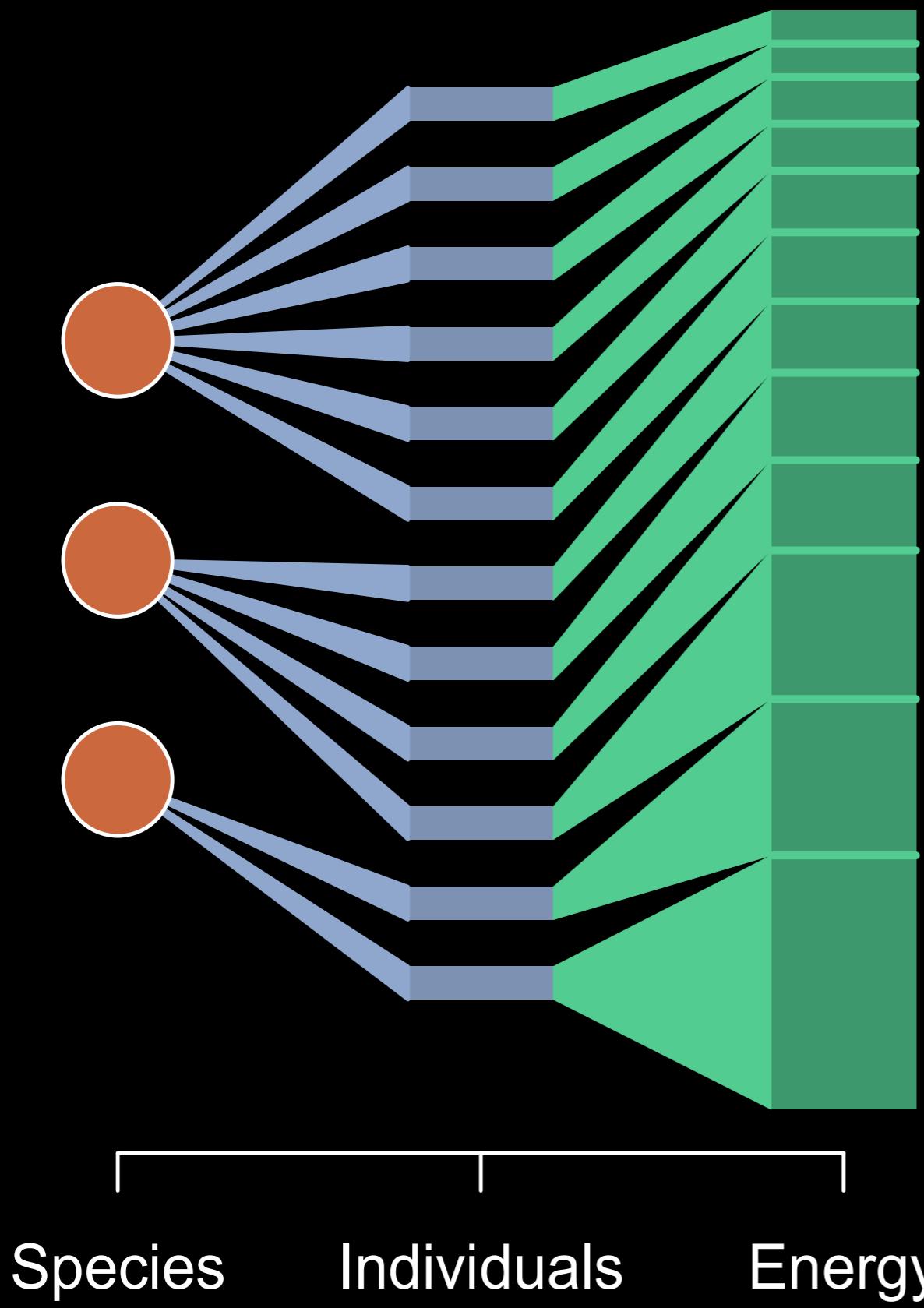
E. T. Jaynes





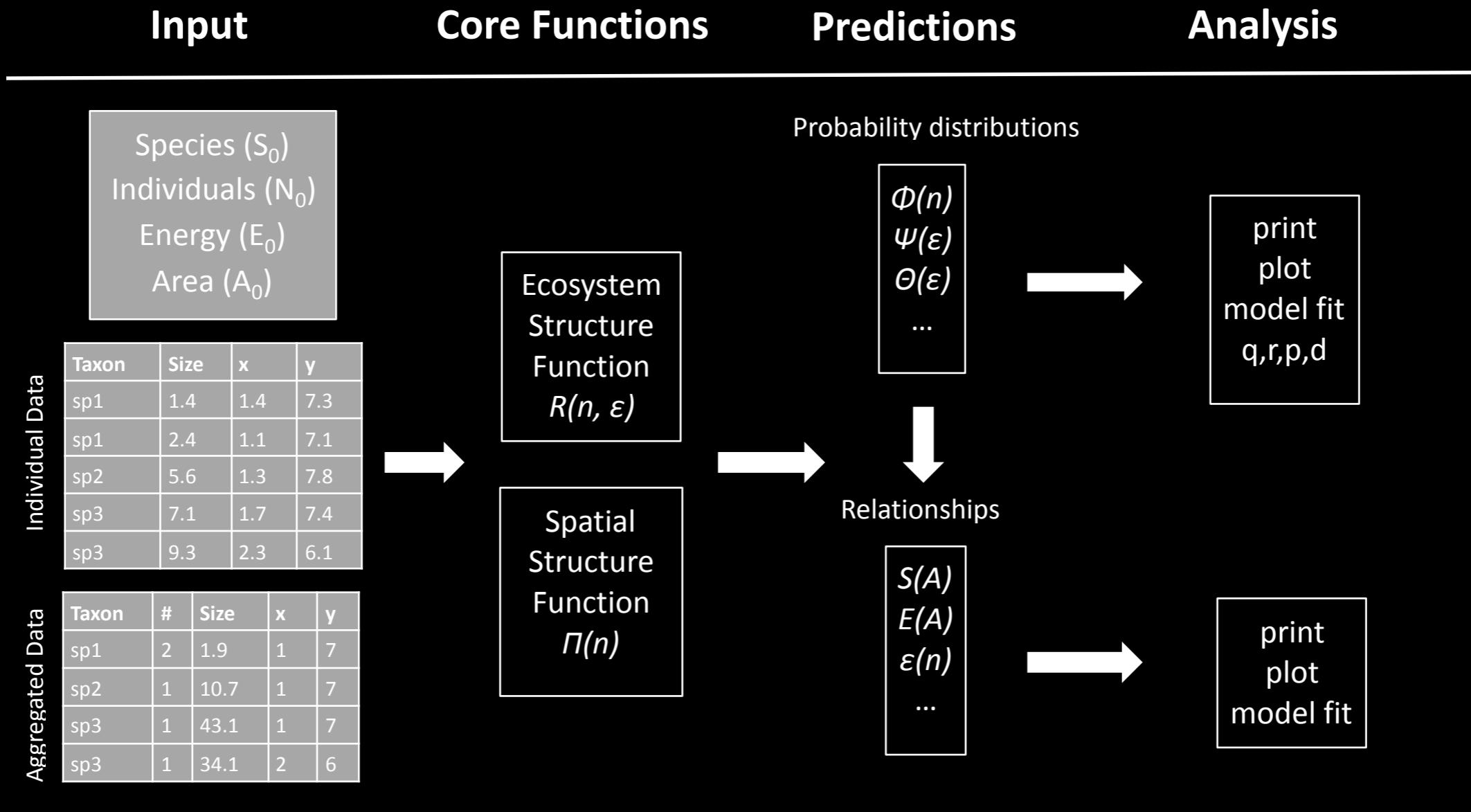
# Maximum Entropy Theory of Ecology

(Harte 2011)





# R package: meterR



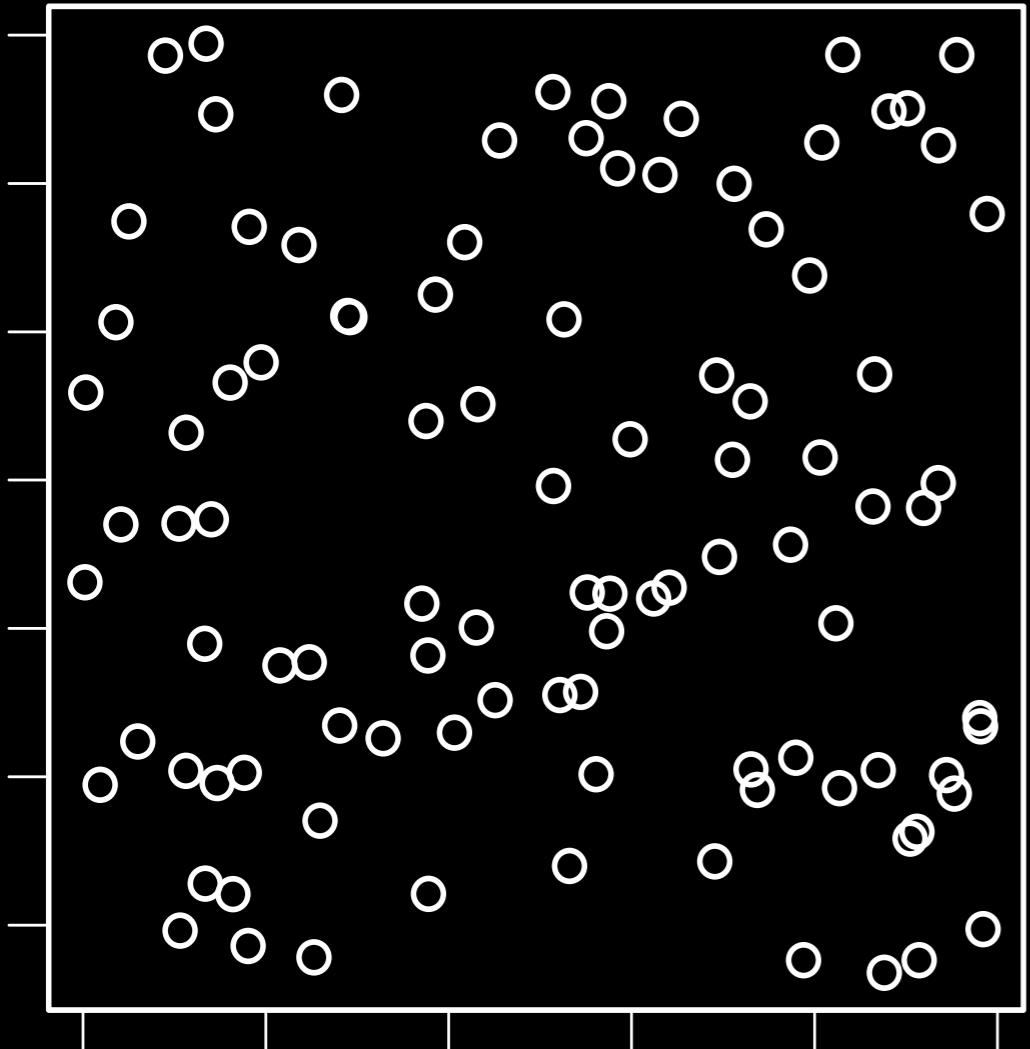
```
data(arth)  
data(anbo)
```

```
esf<-meteESF(spp,  
                abund,  
                power)  
ssf<-meteSSF(spp,  
                abund,  
                coords)
```

```
sad<-sad(esf)  
ipd<-ipd(esf)  
sipd<-sipd(esf)  
sar1<-downscaleSAR(esf)  
sar2<-  
      meteSAR(spp,abund,  
              x,y)  
etc.
```

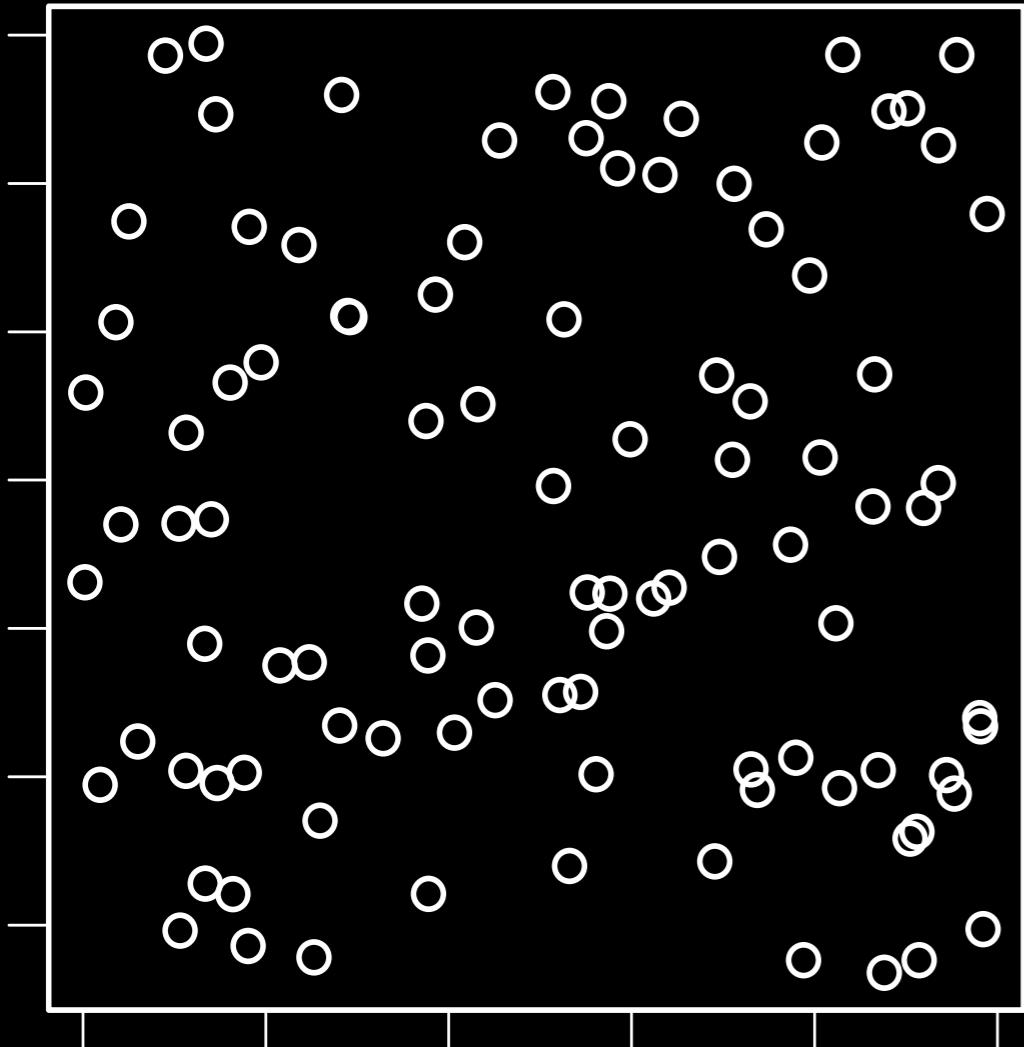
```
plot(sad)  
logLik(sad)  
mse(sad)  
sad$r()  
#simulation  
sad$q() #quantiles  
etc.
```

# Why test theory?

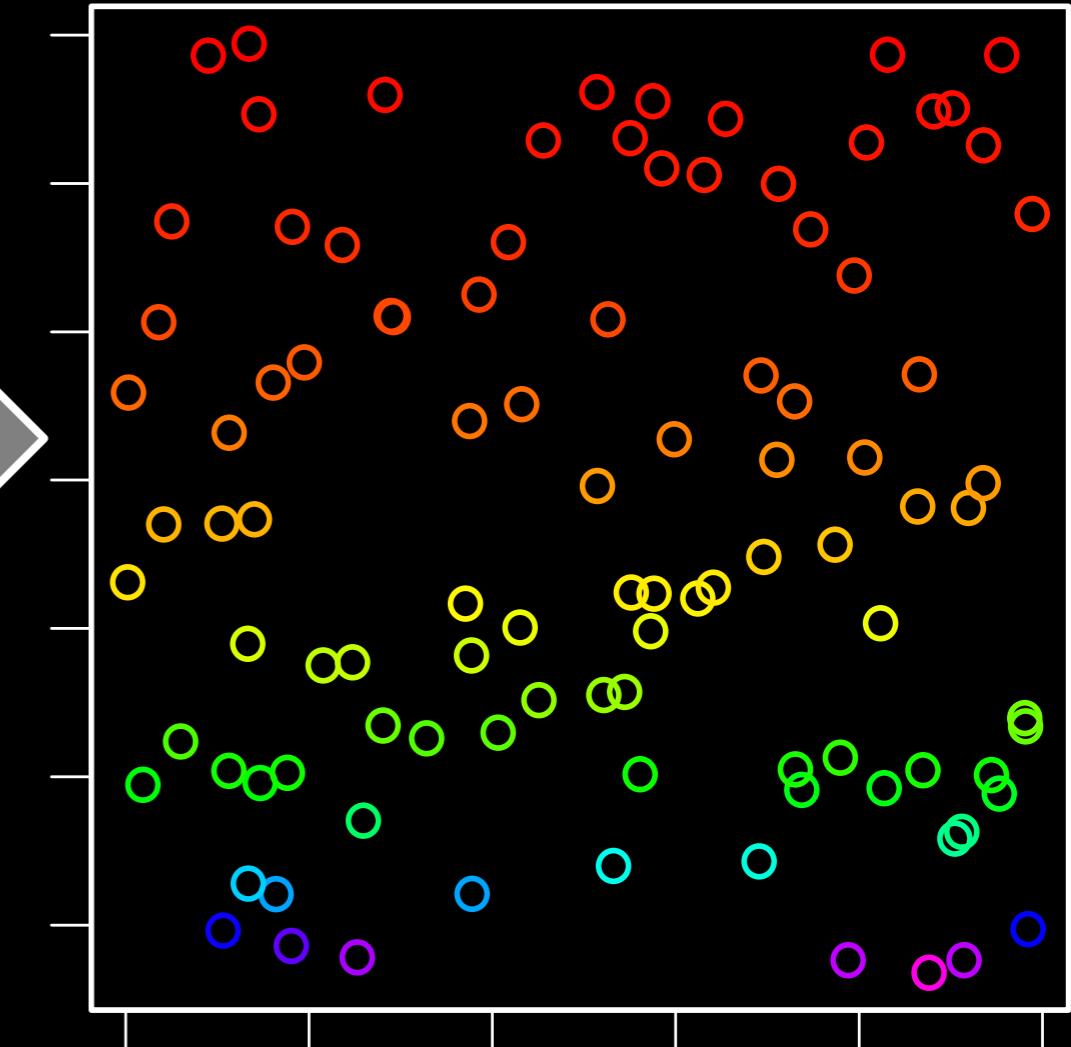
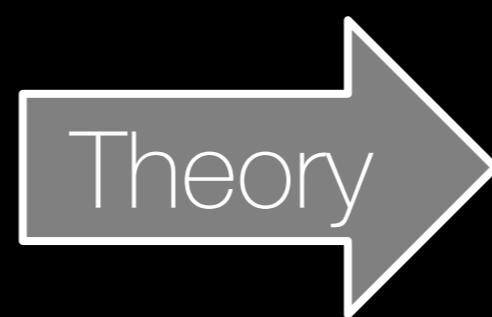


Mechanism AWOL

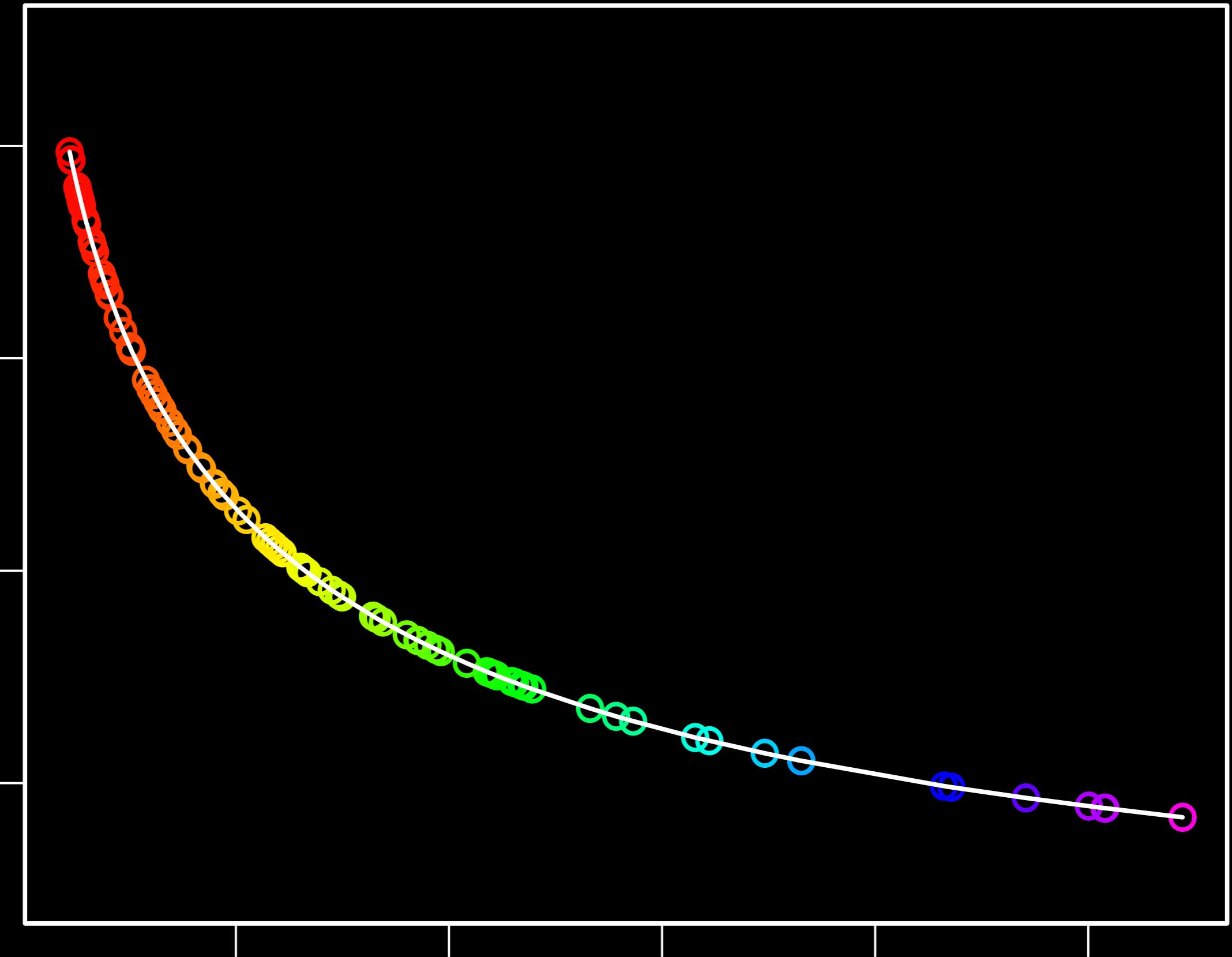
# Why test theory?

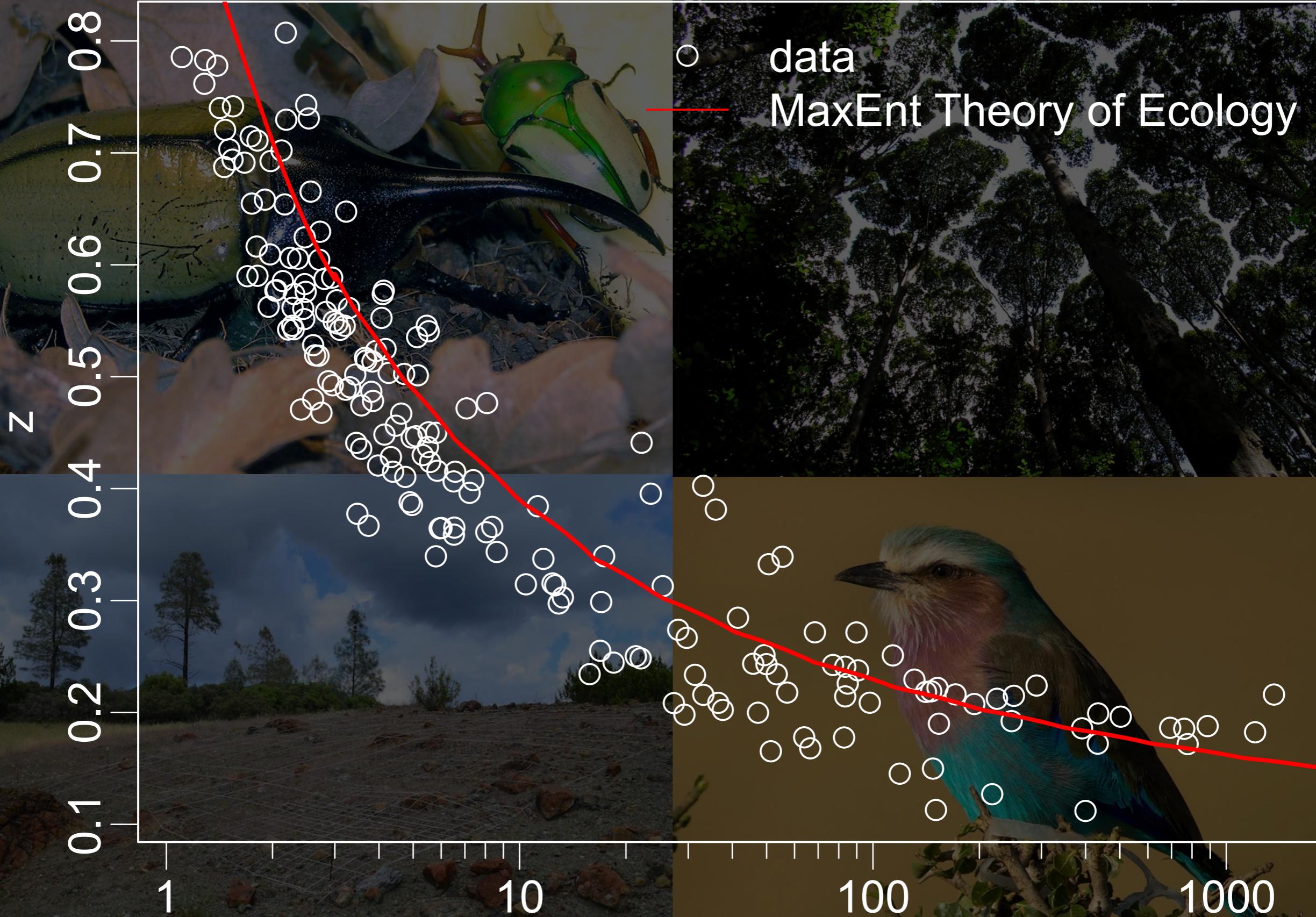


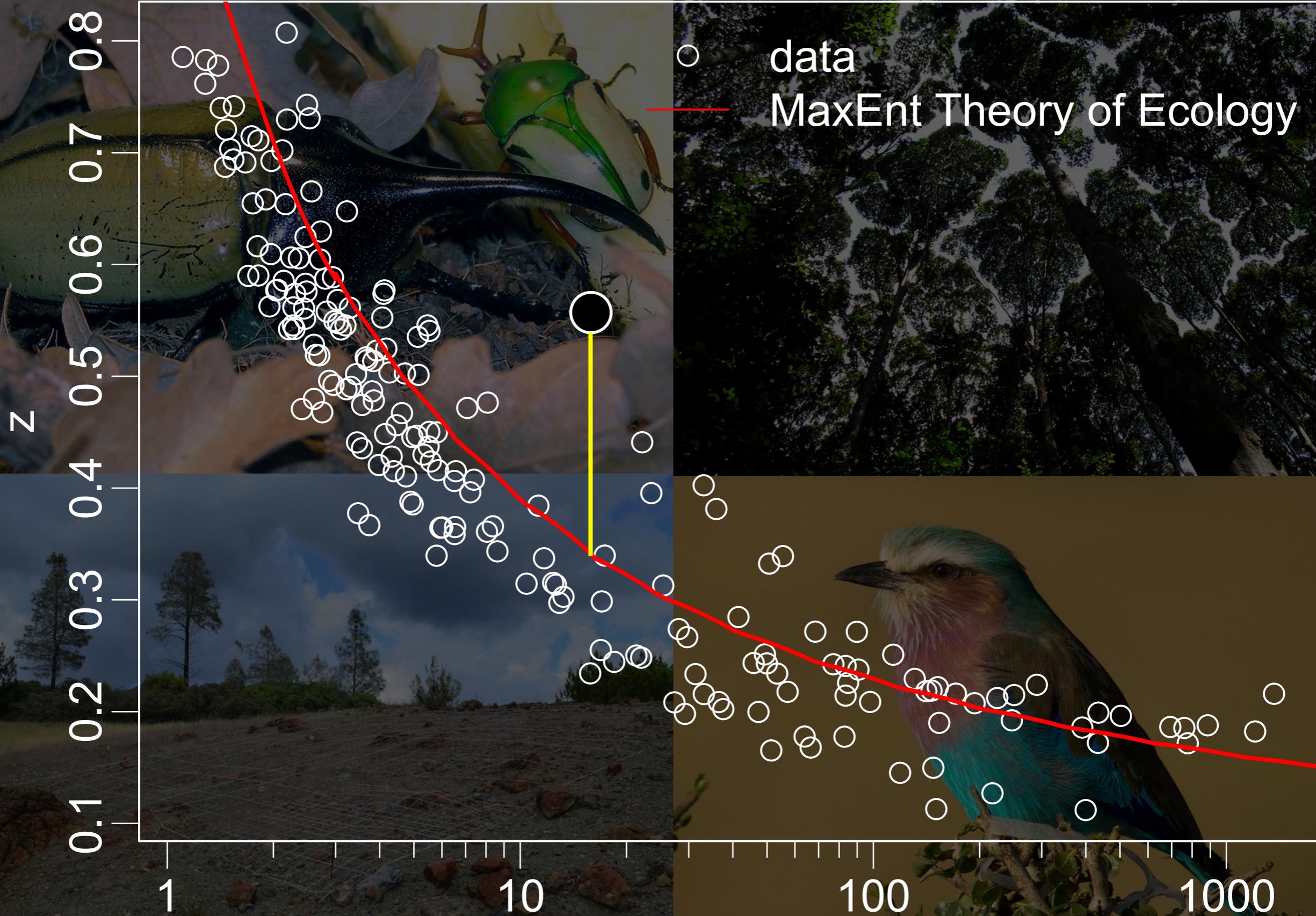
Mechanism AWOL

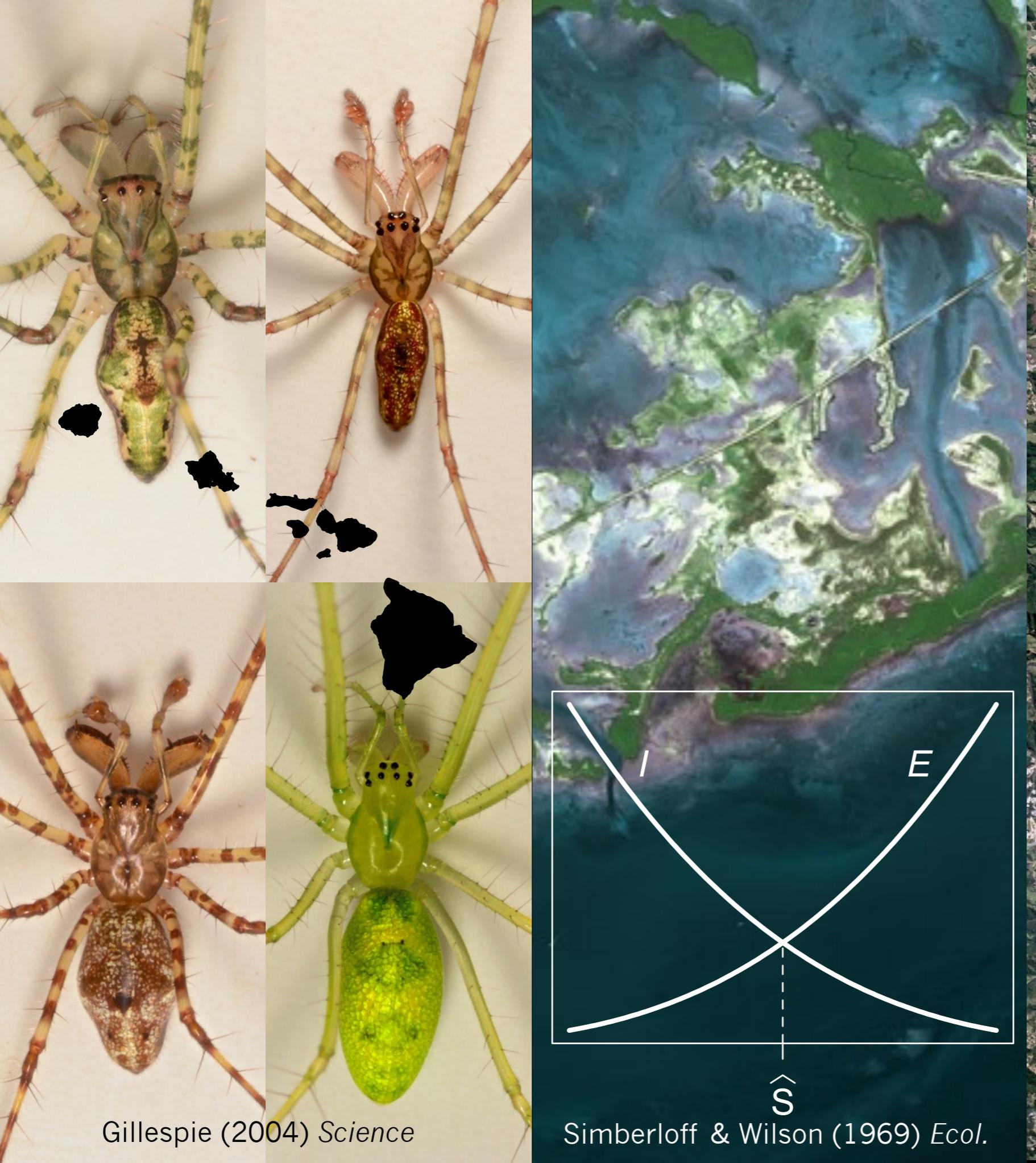


New insights





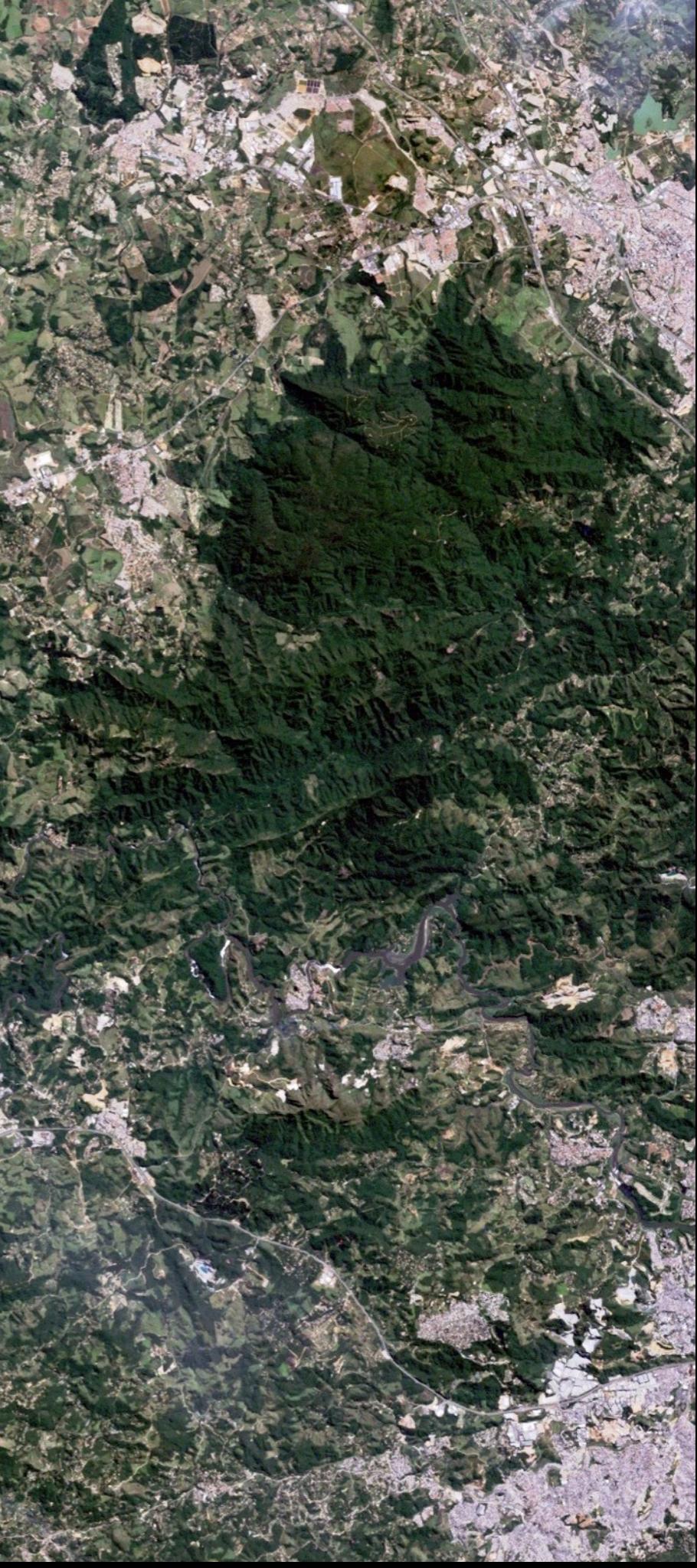


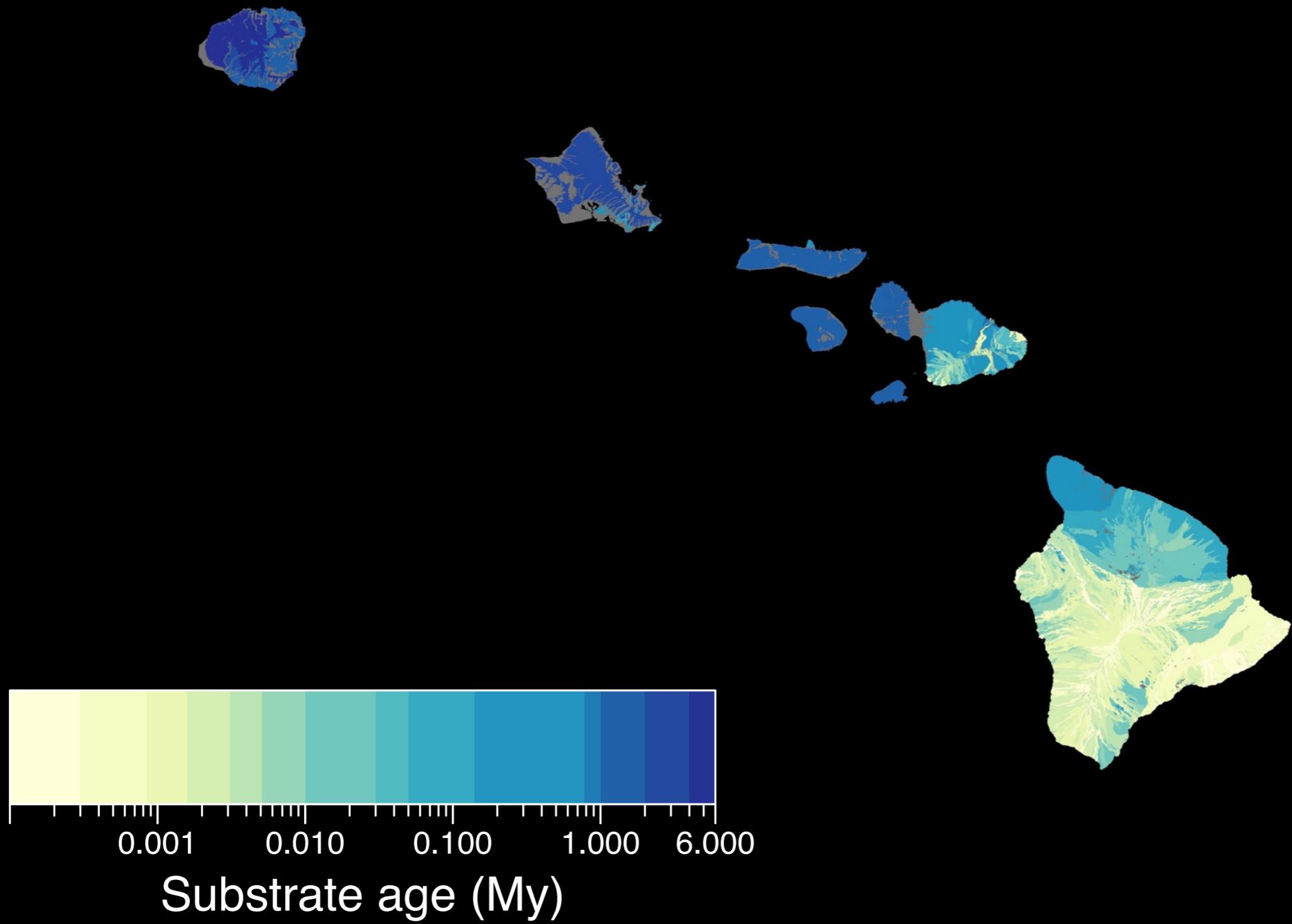


Gillespie (2004) *Science*



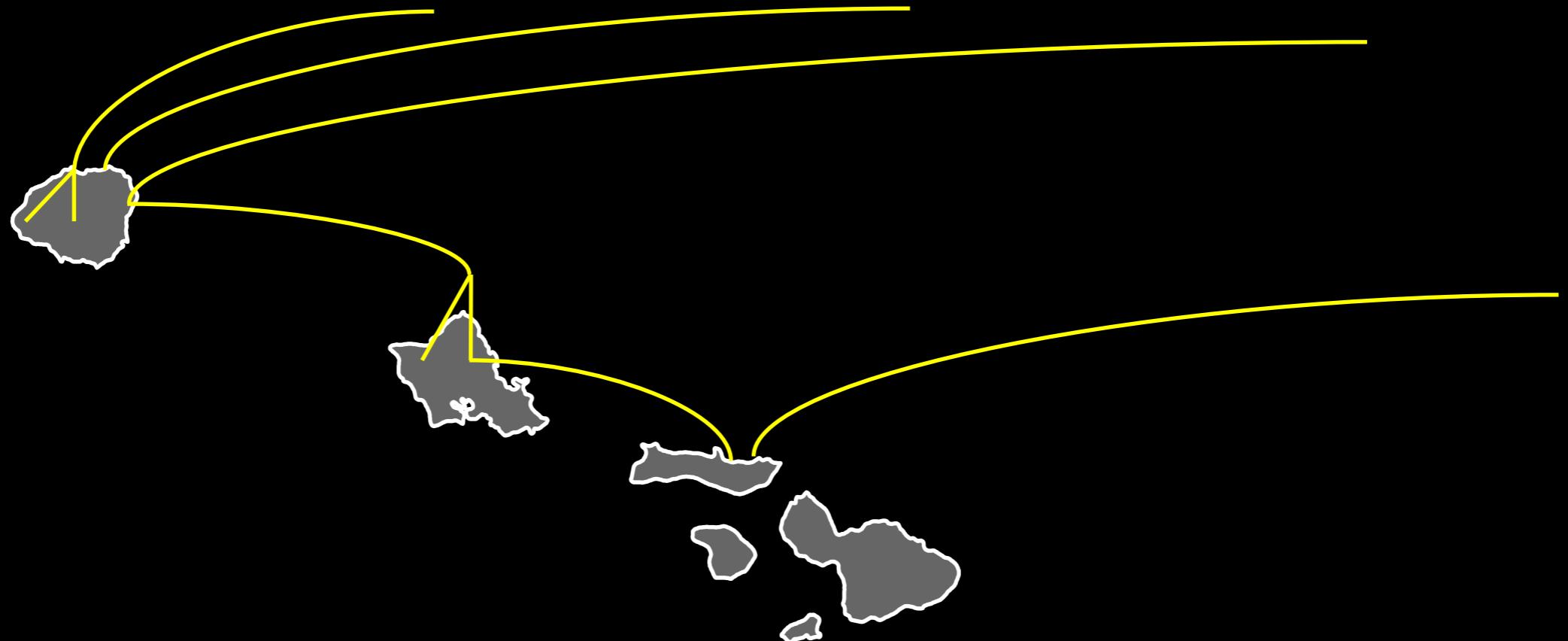
Simberloff & Wilson (1969) *Ecol.*

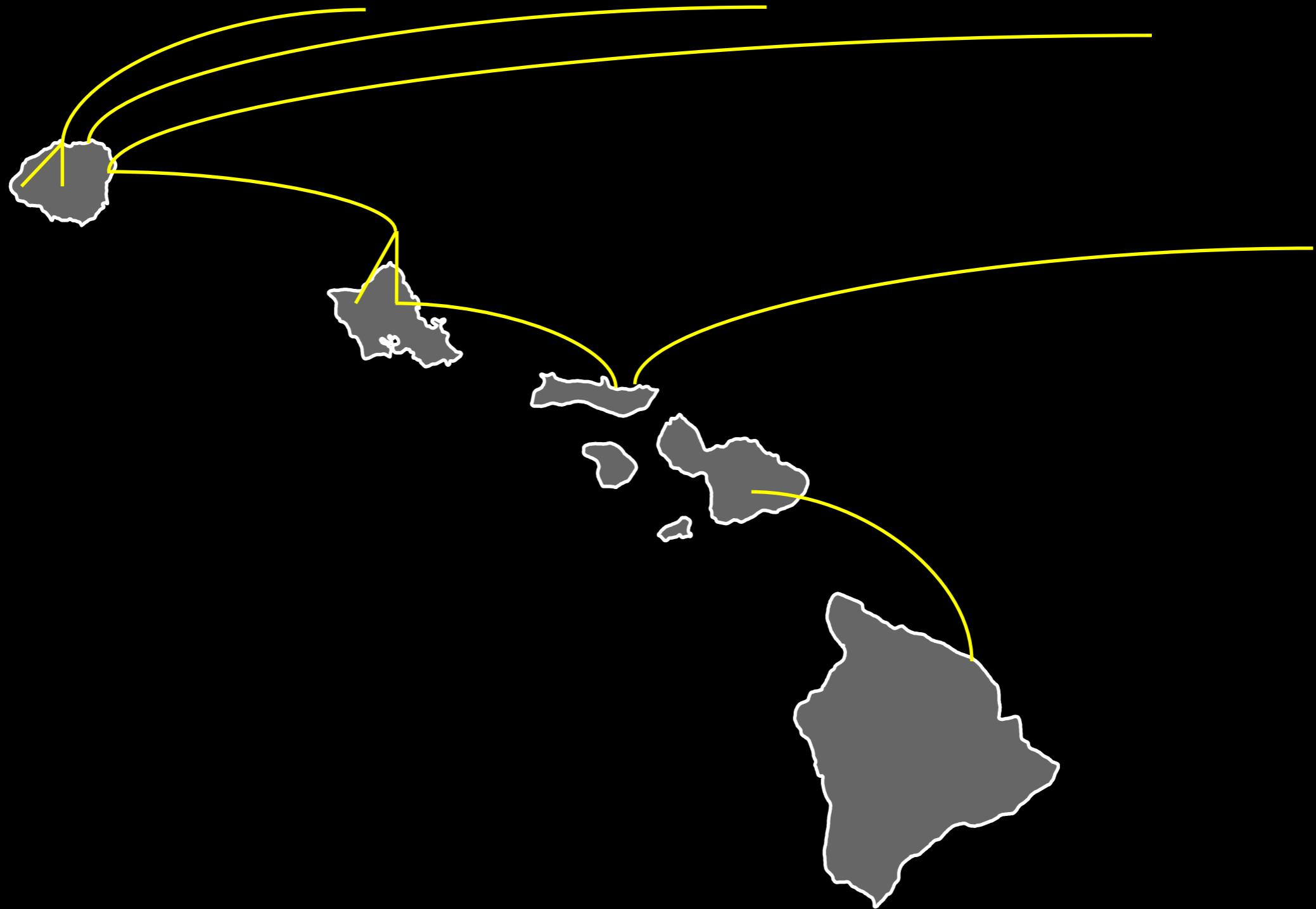


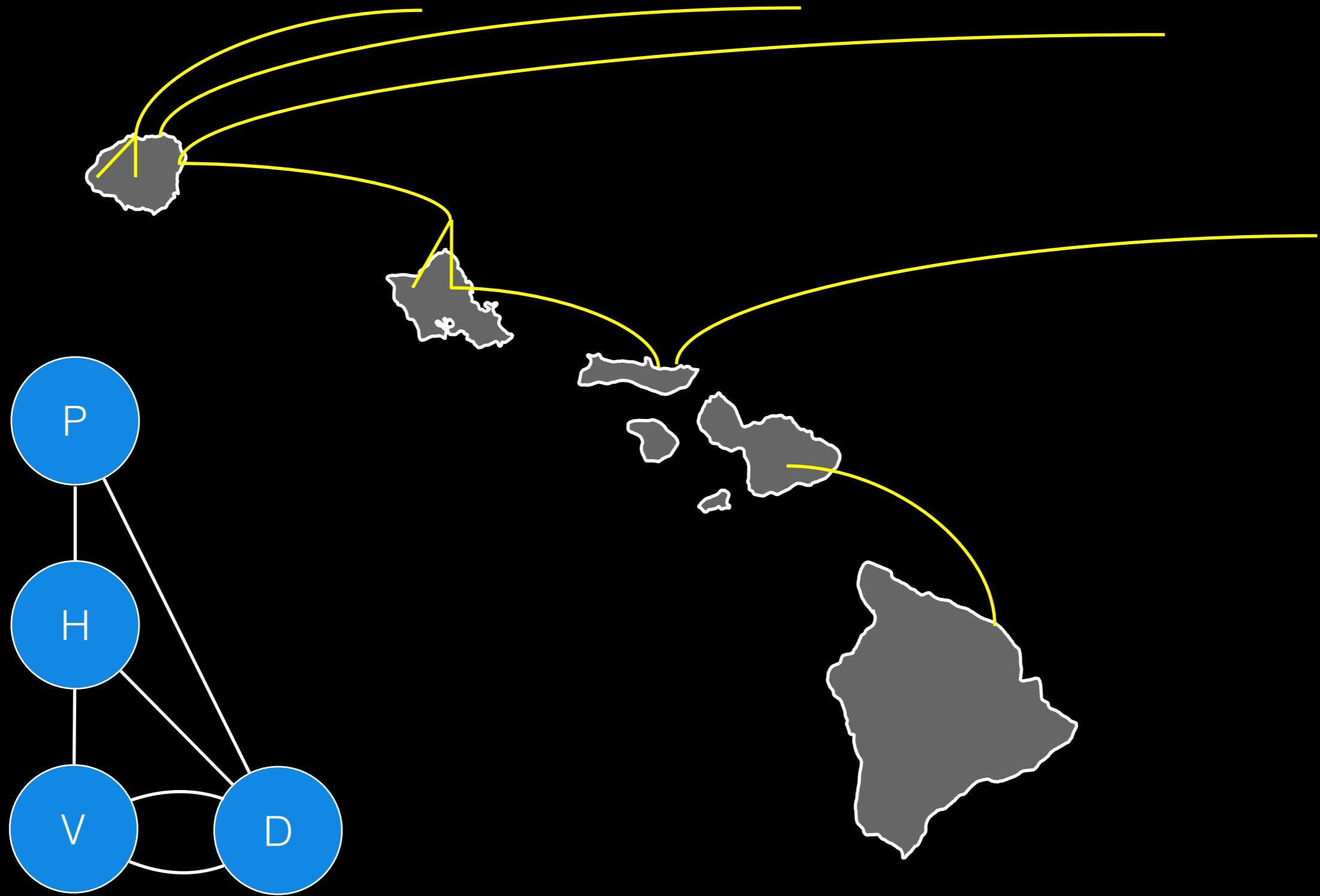






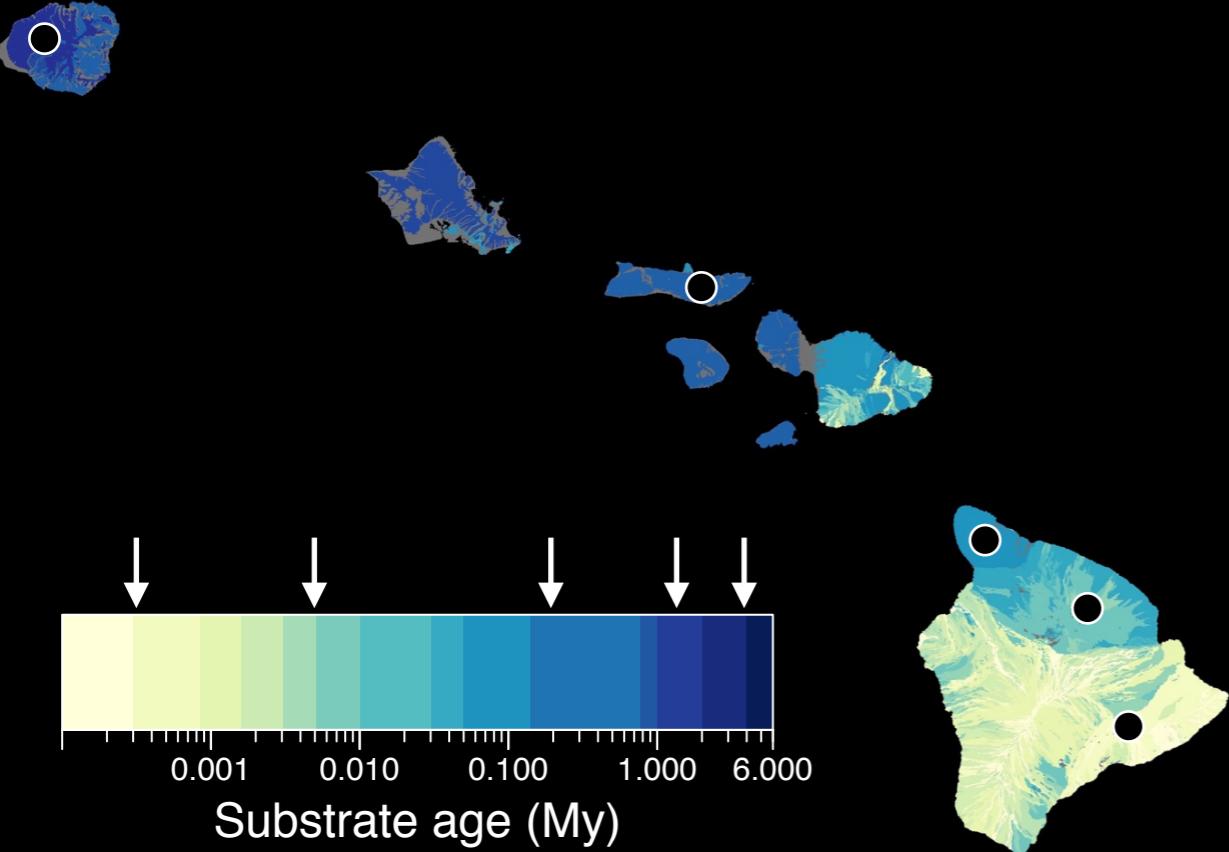








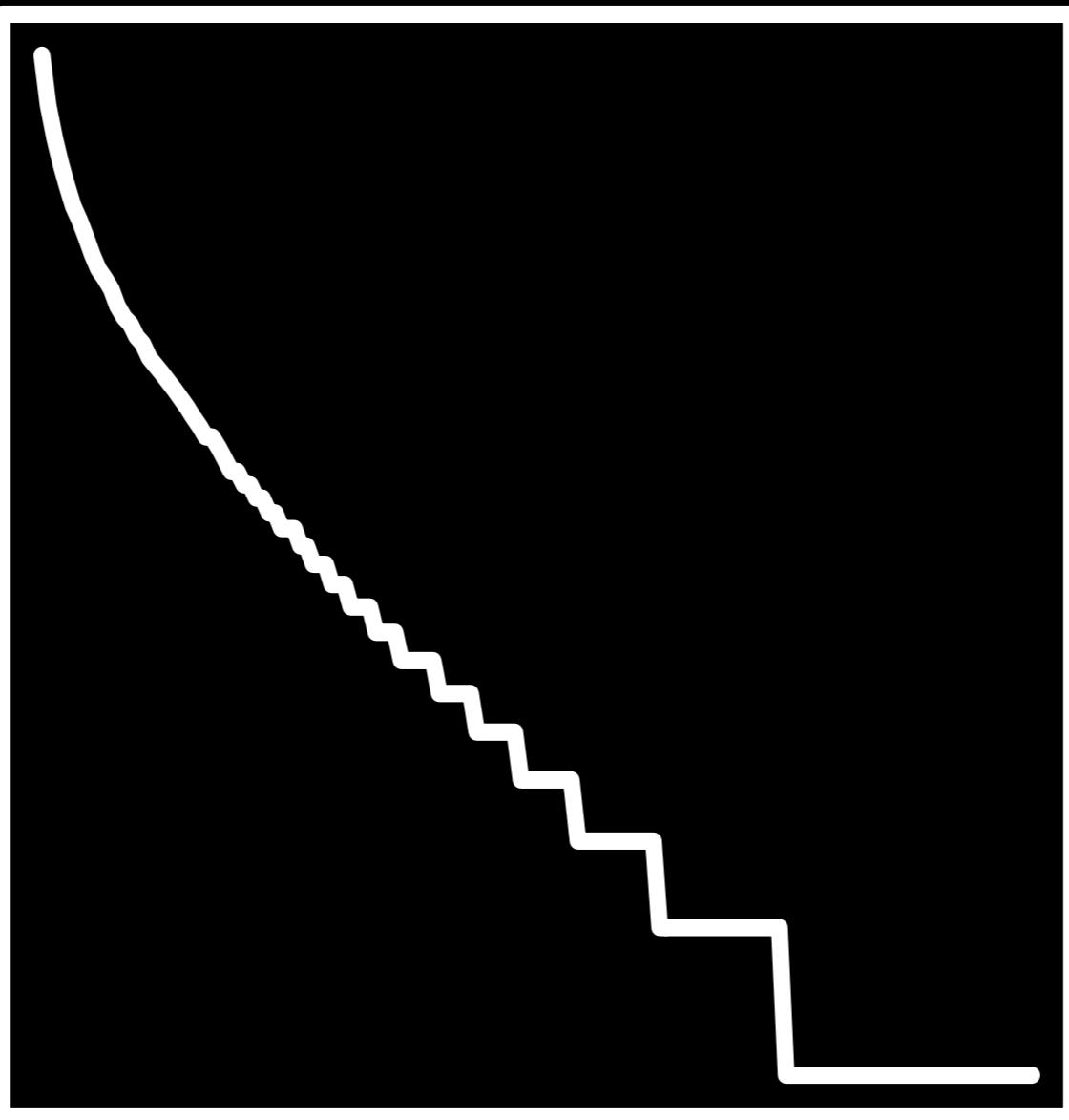
# Capturing evolving communities



15,997 arthropods collected

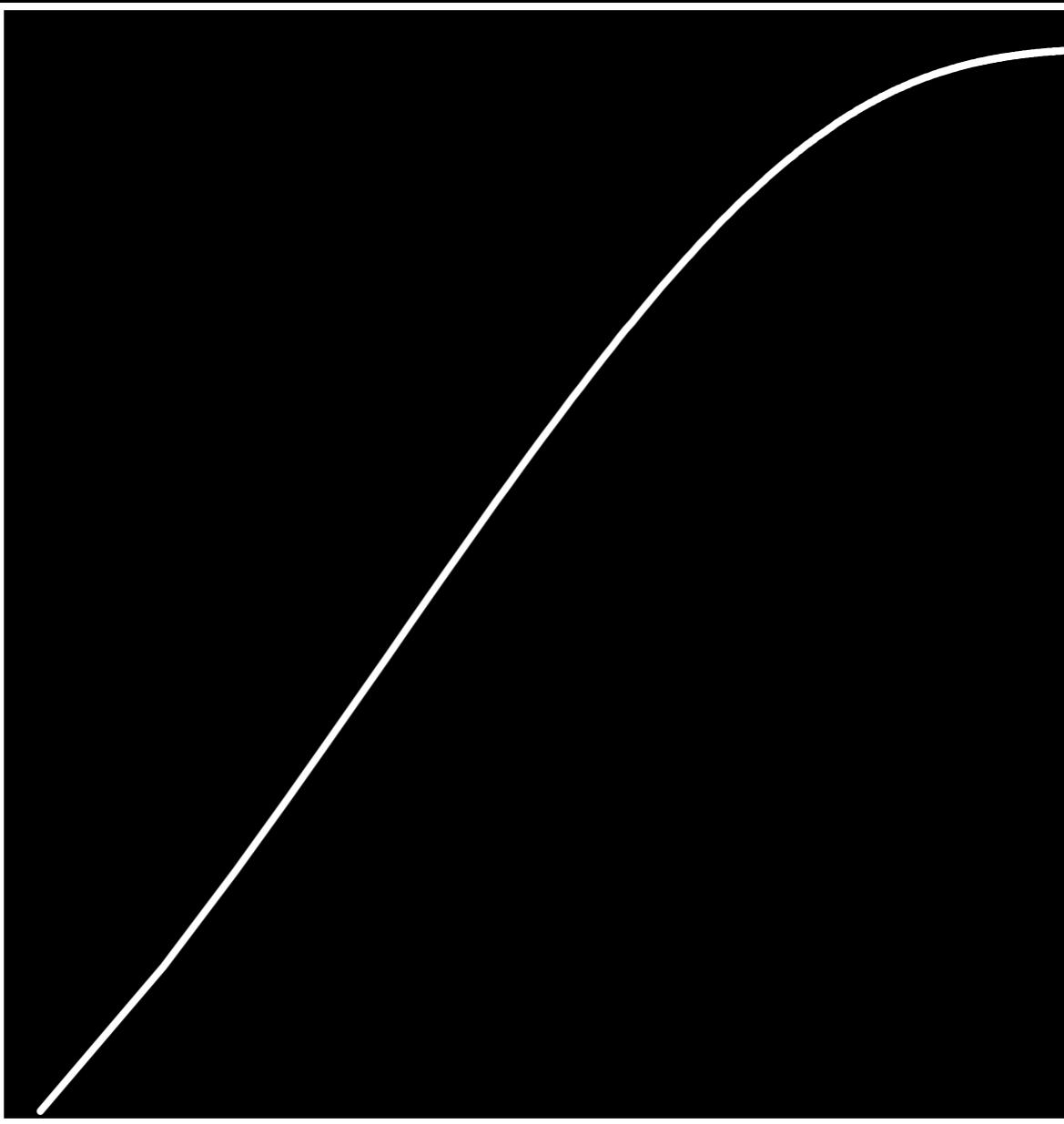


Abundance



Species

Cumulative density

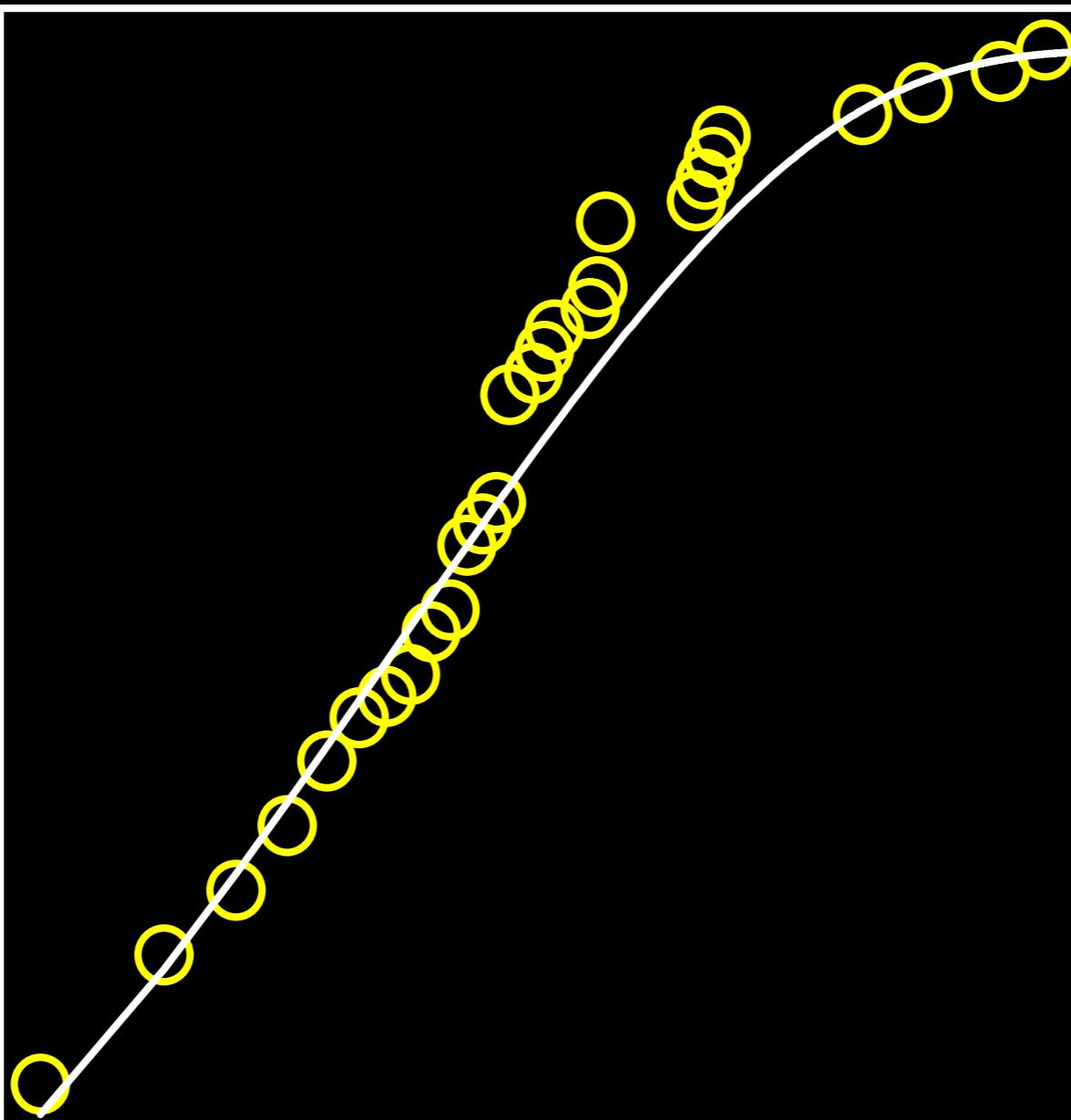


Abundance

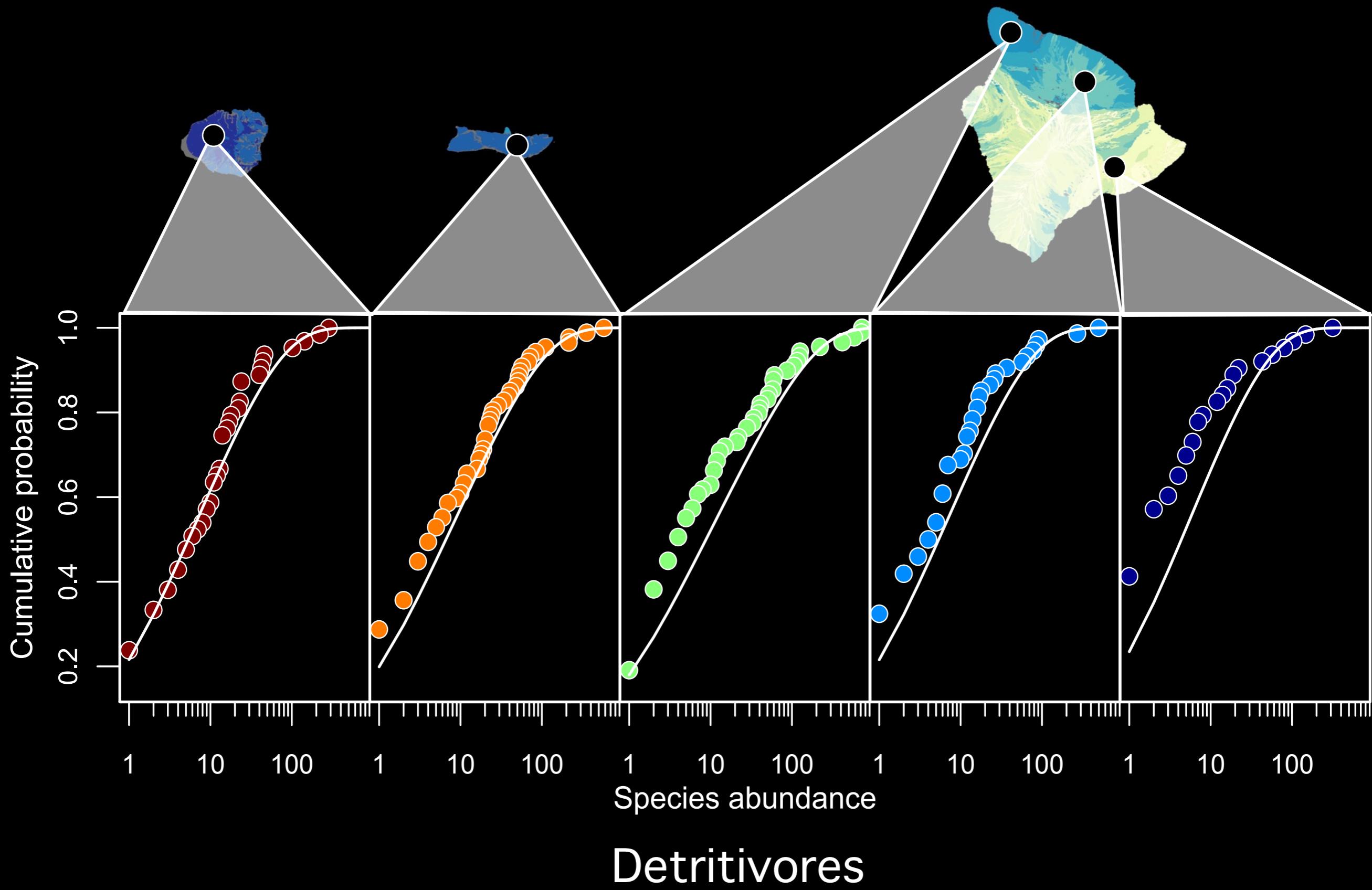
Theory

Cumulative density

Abundance



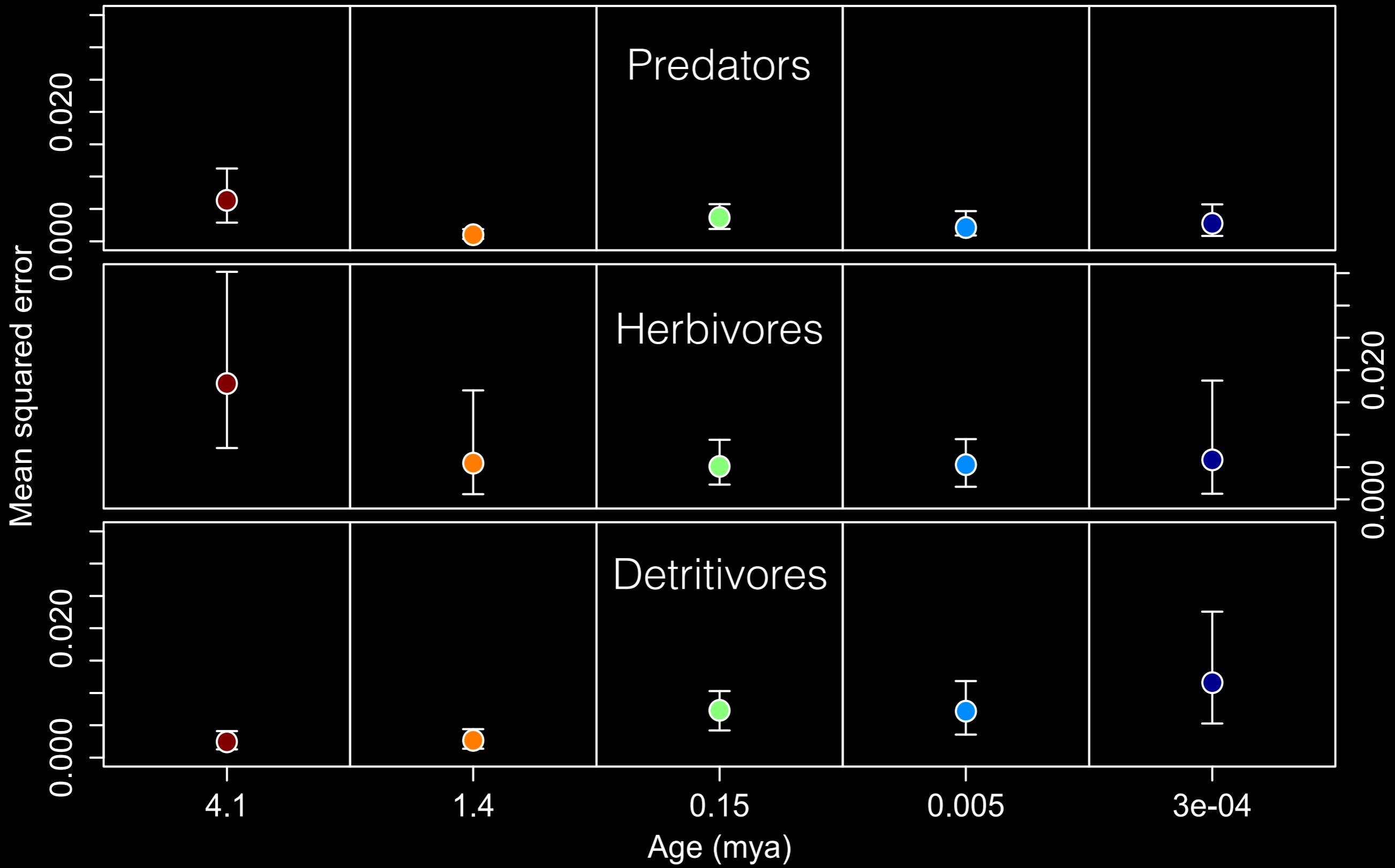
Theory  
Data



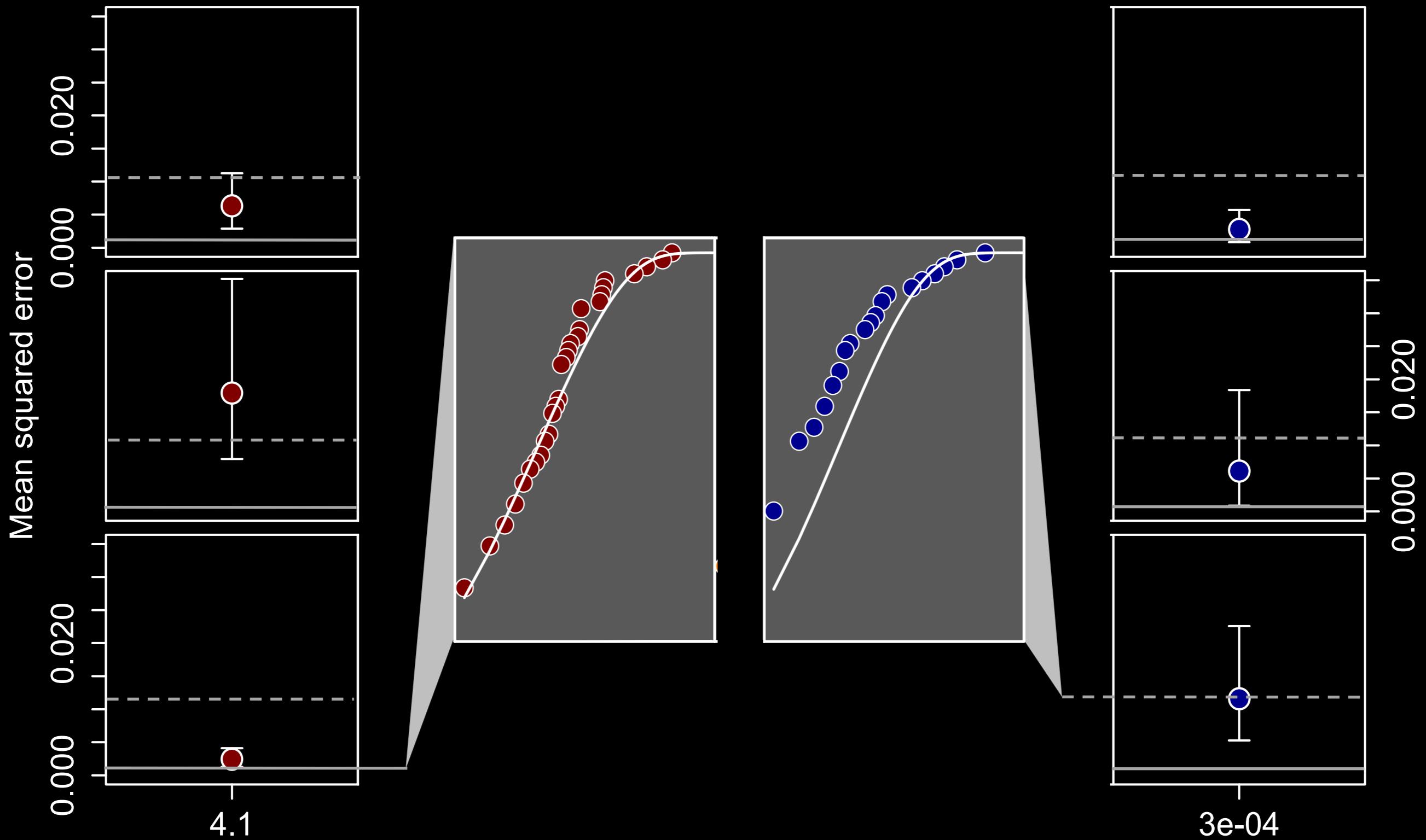
# Species abundance



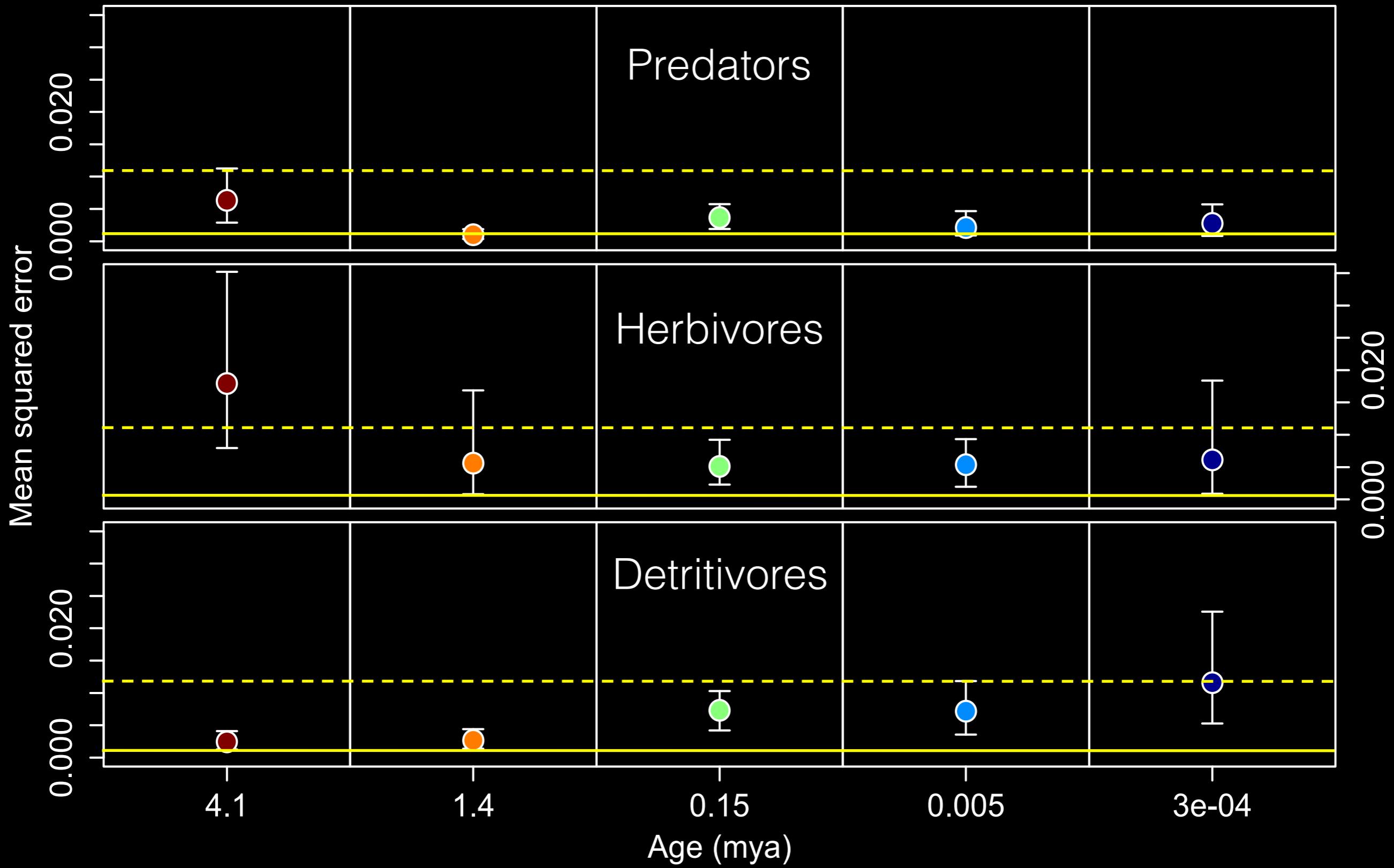
# Species abundance



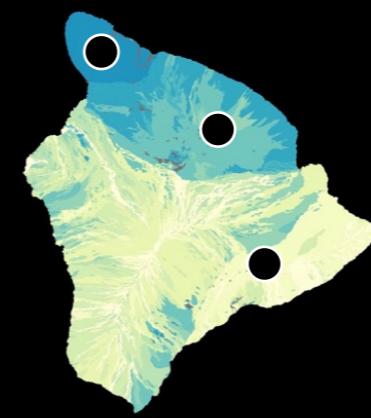
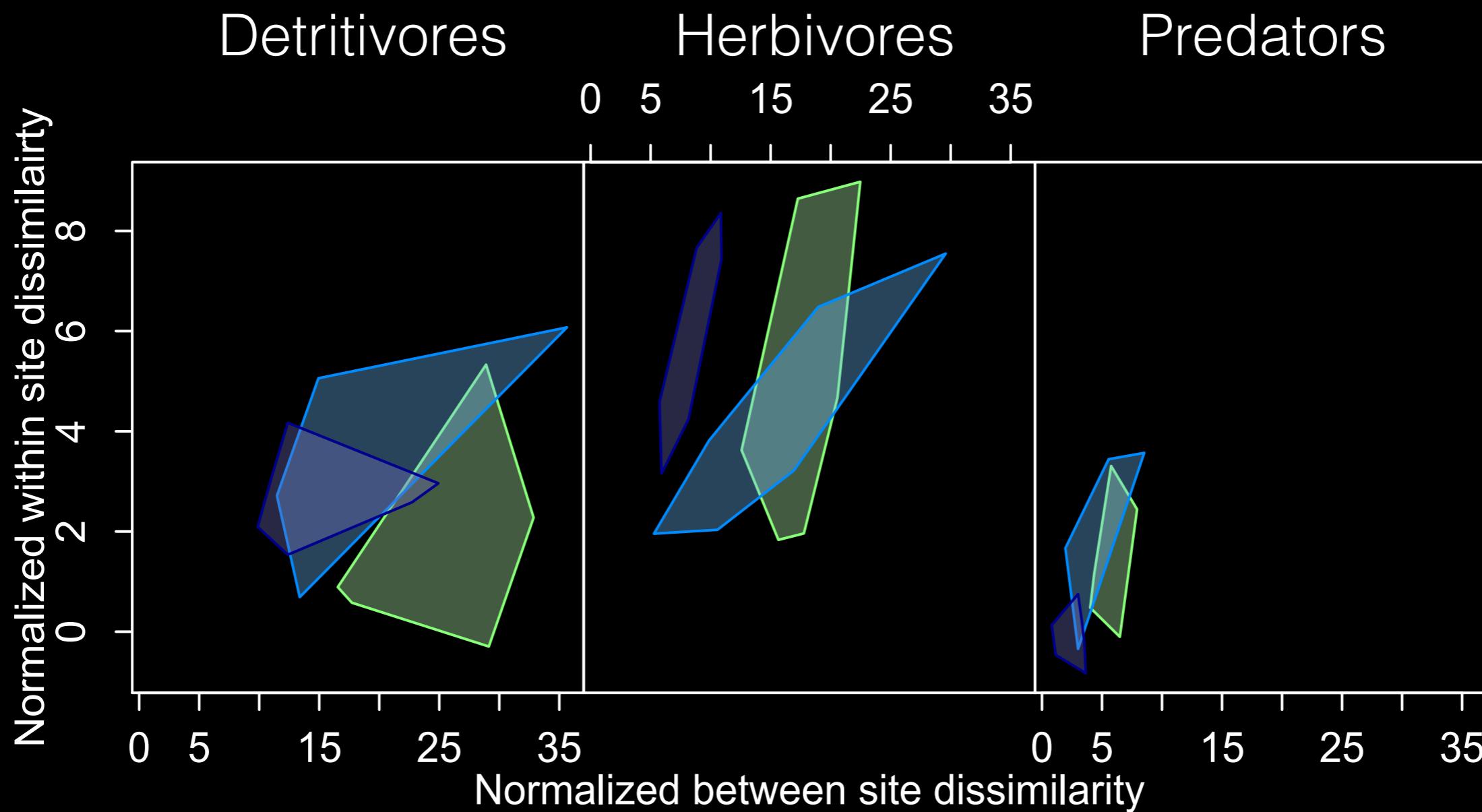
# Species abundance



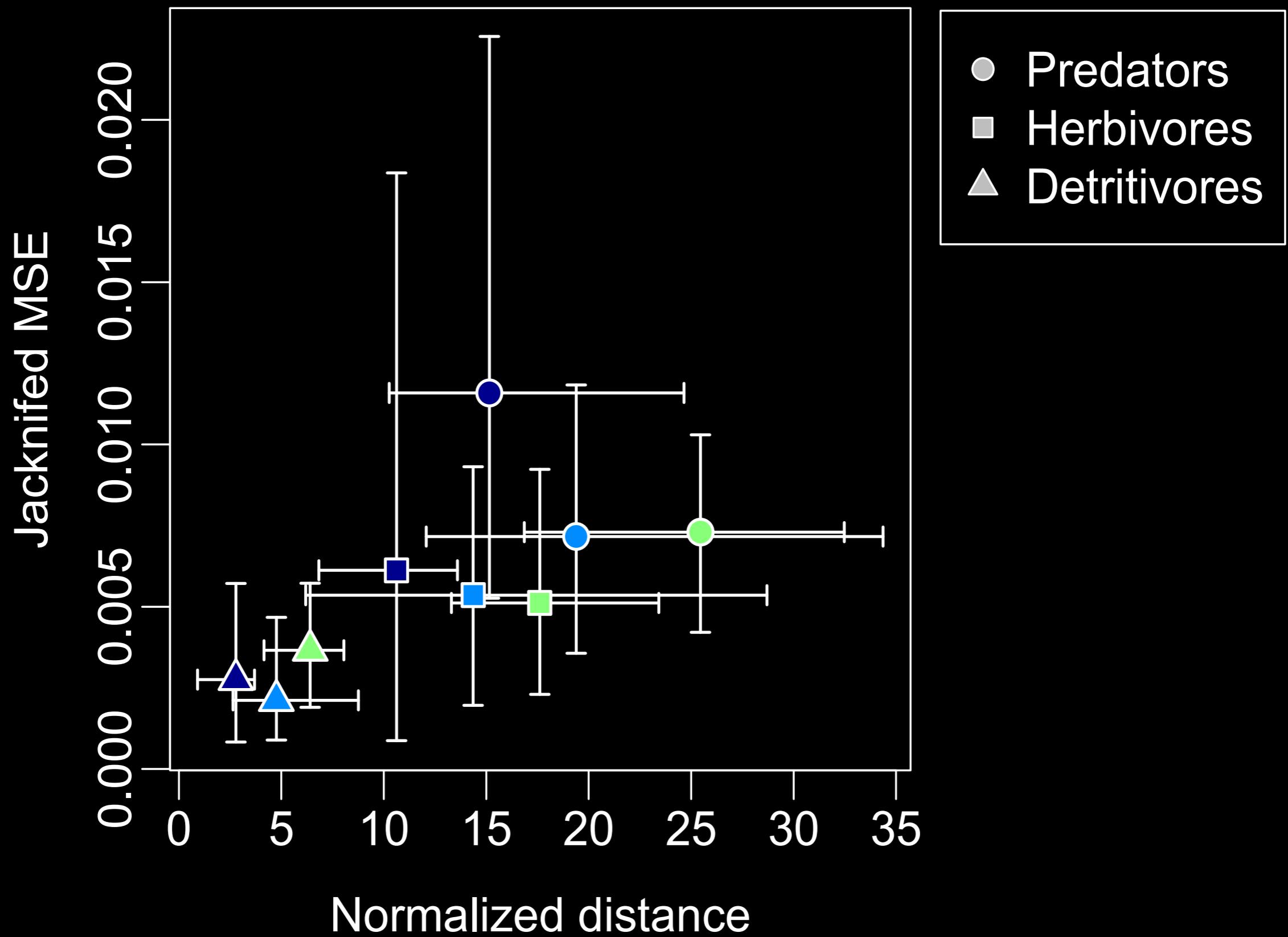
# Species abundance



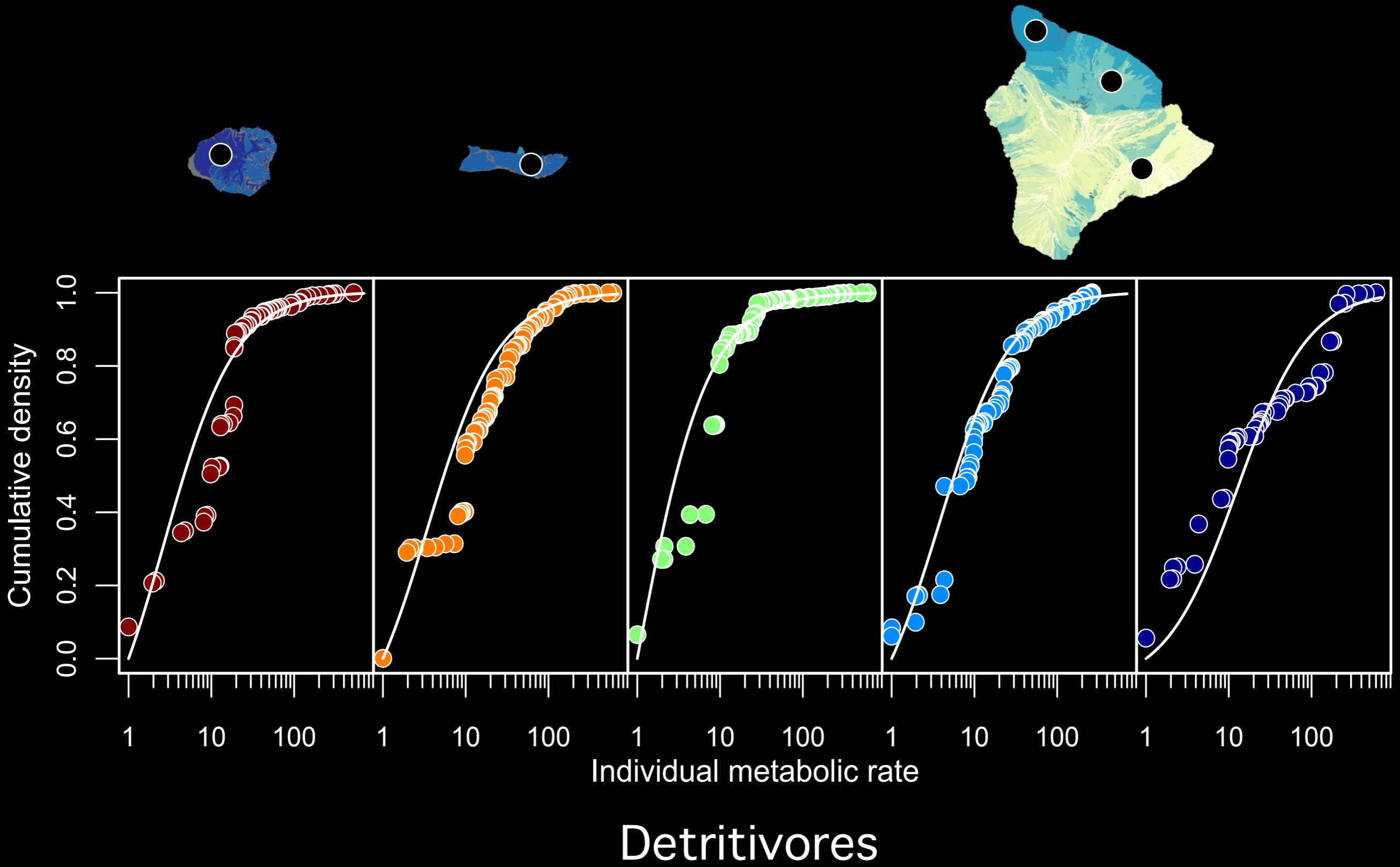
# Incomplete assembly



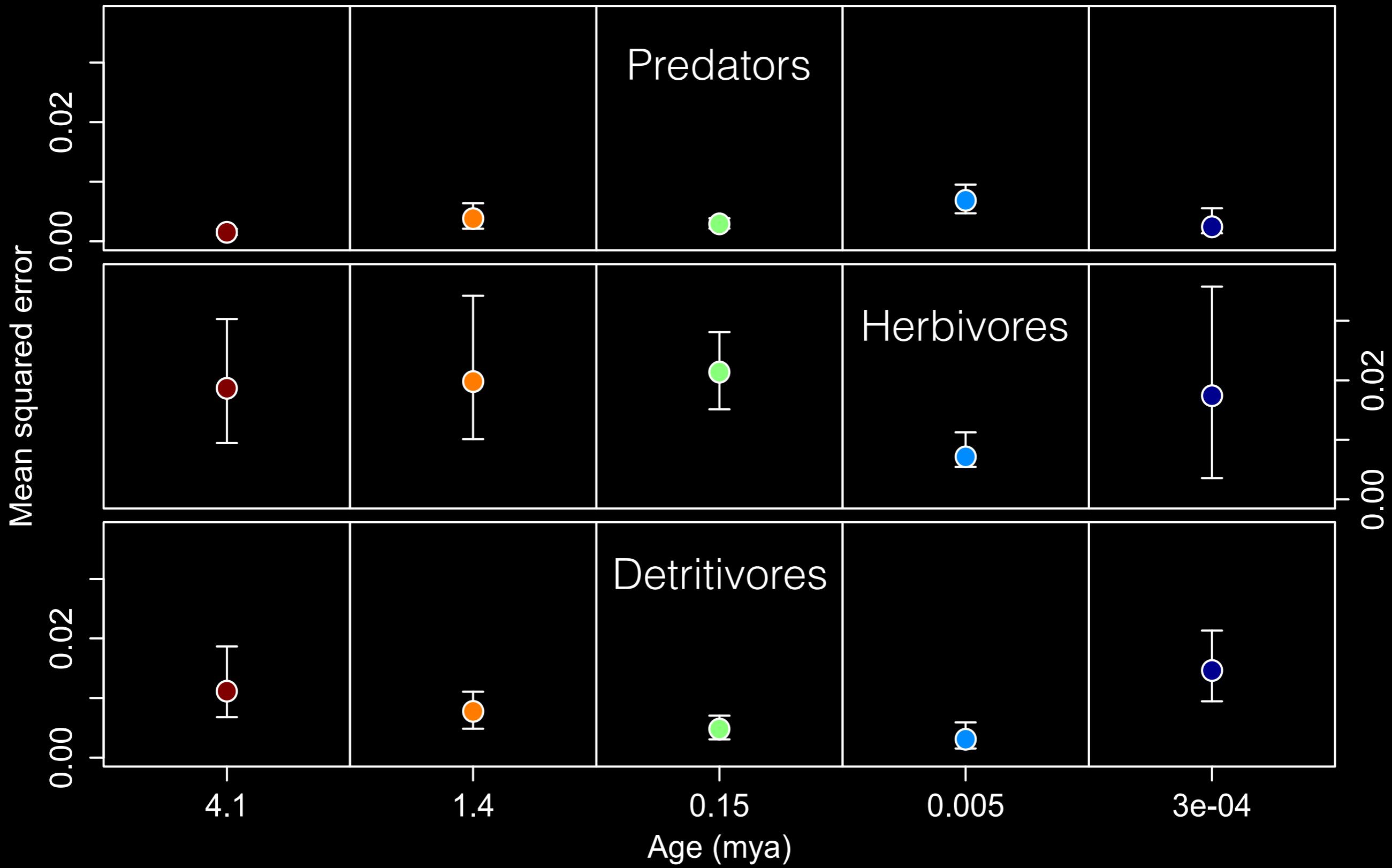
# Incomplete assembly



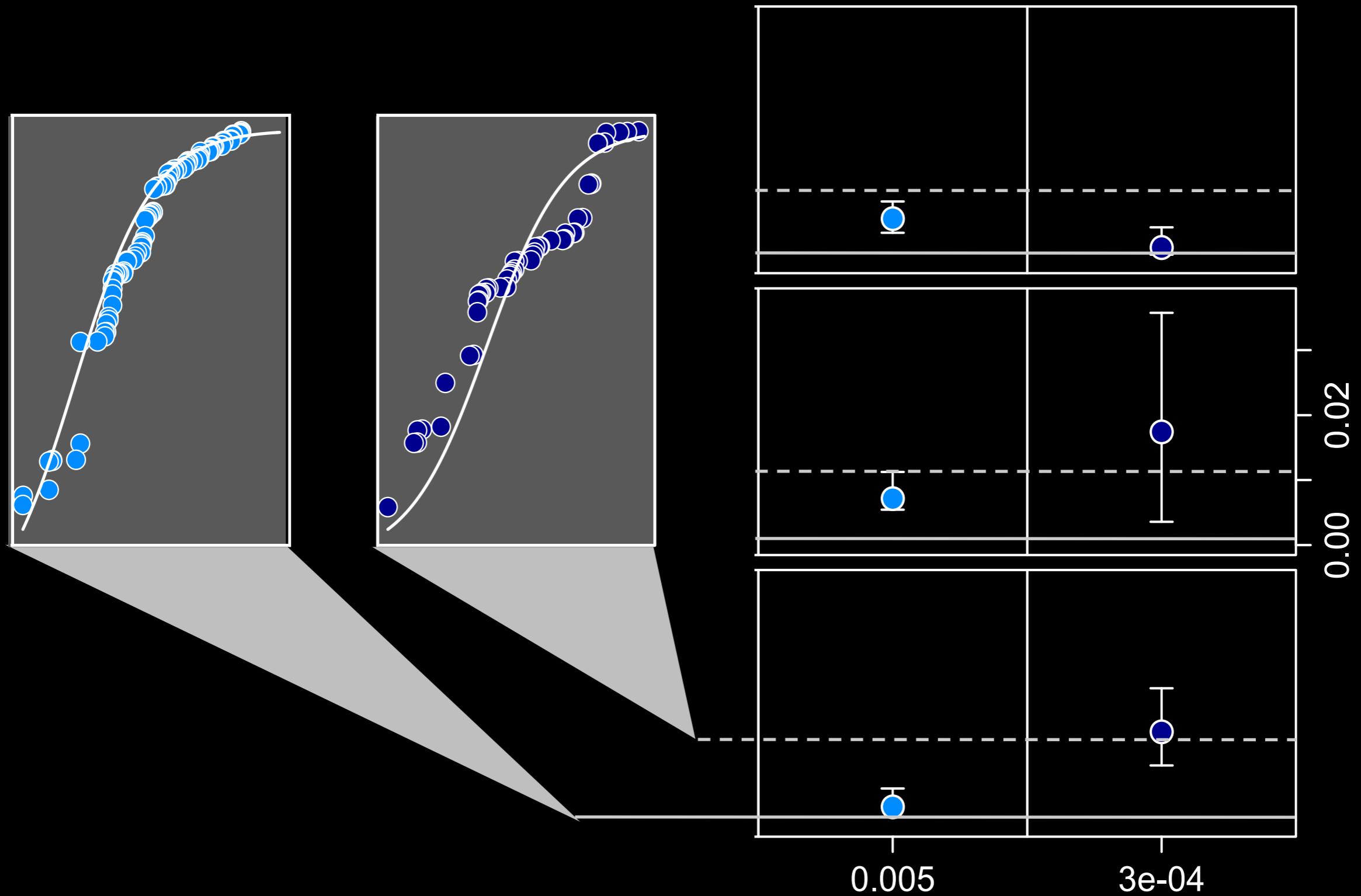
# Individual metabolic rate



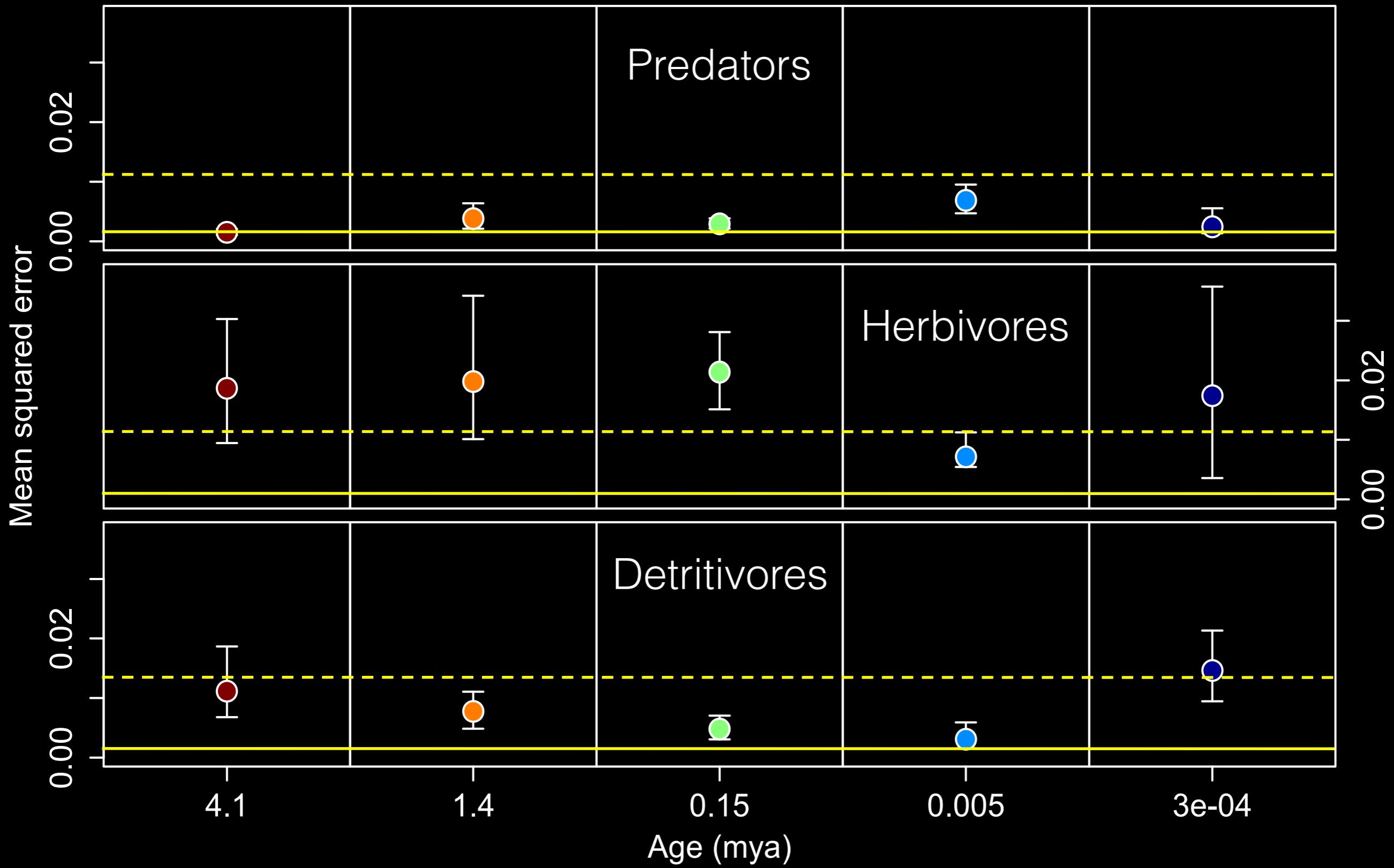
# Individual metabolic rate



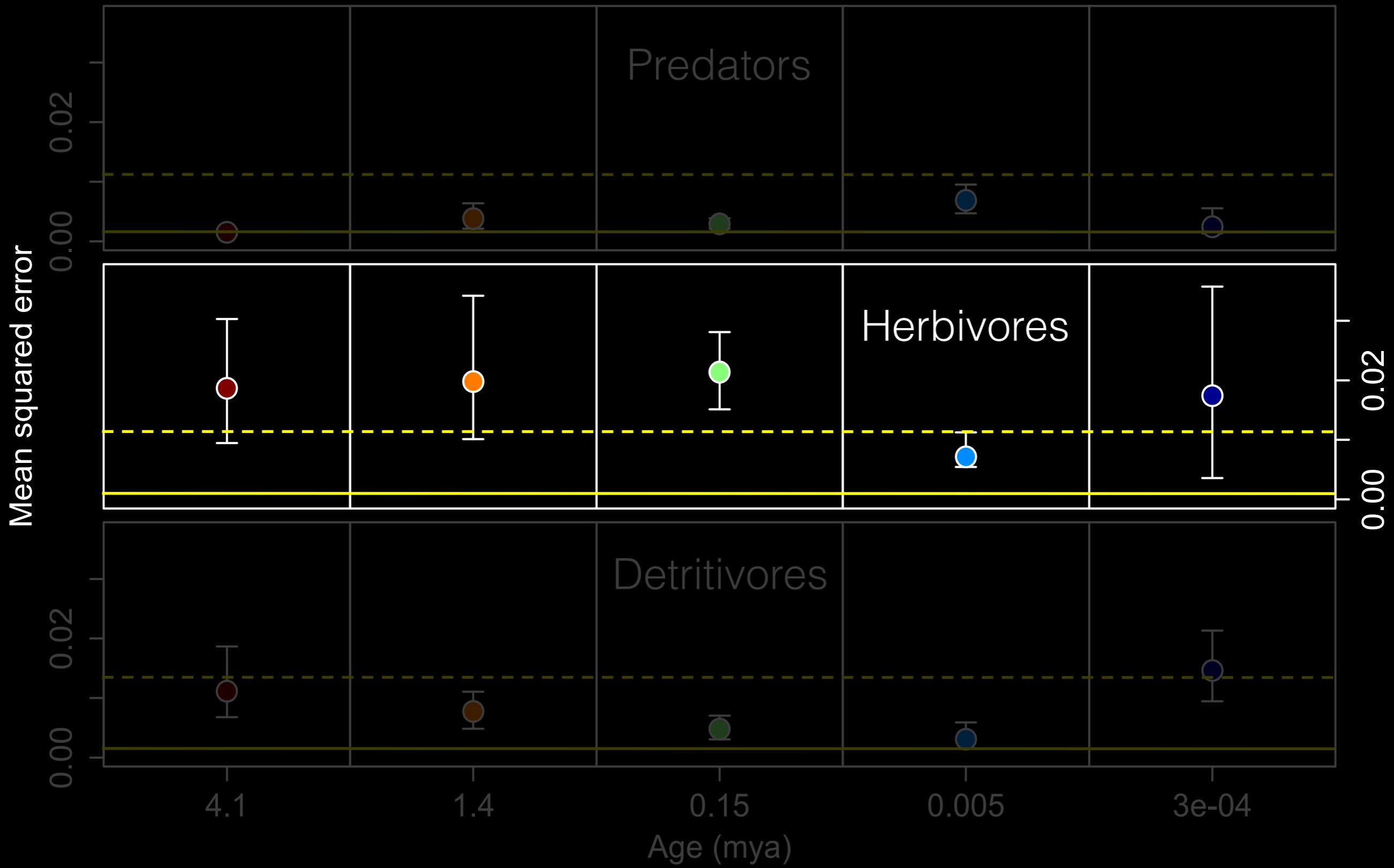
# Individual metabolic rate

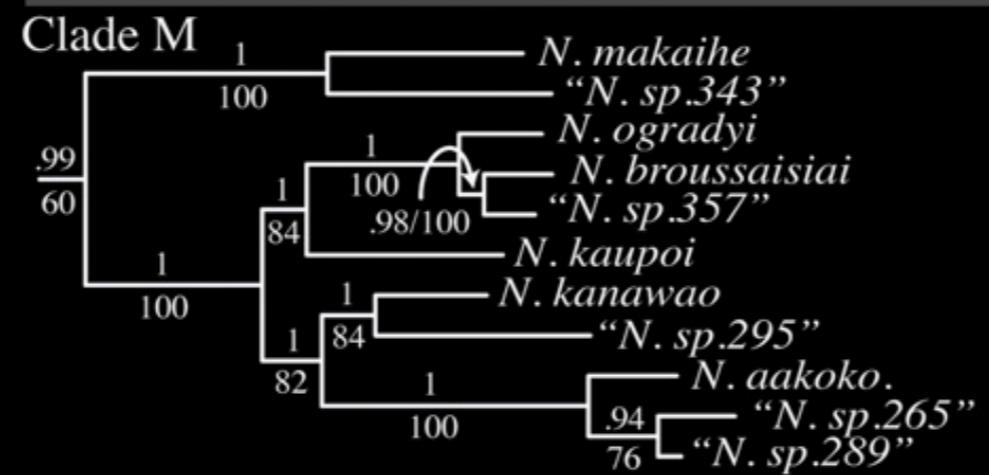
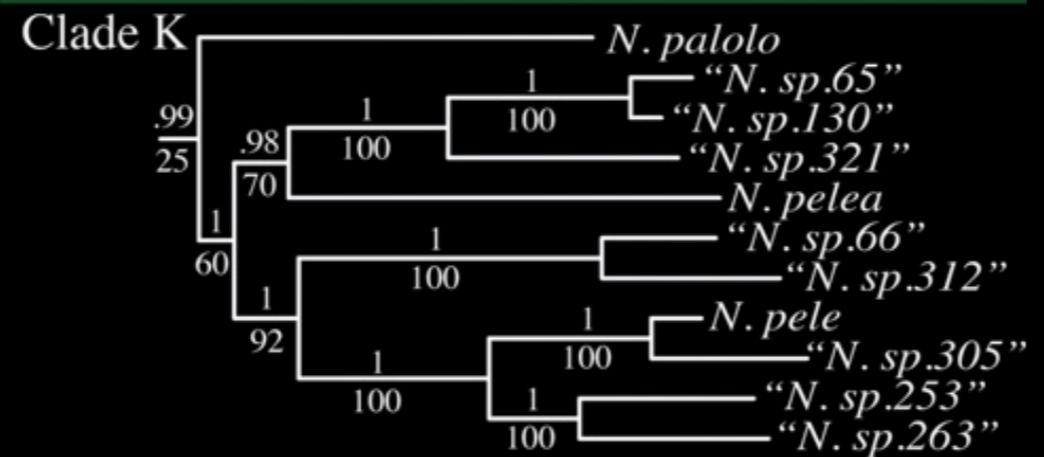
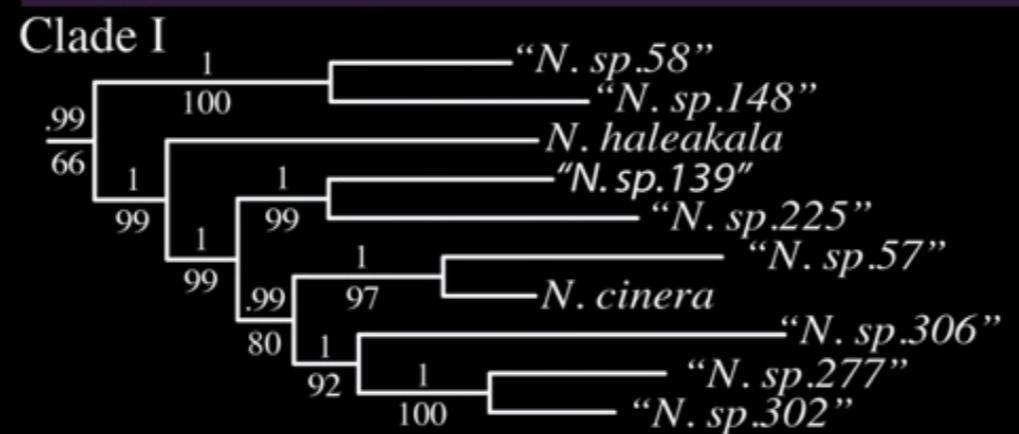
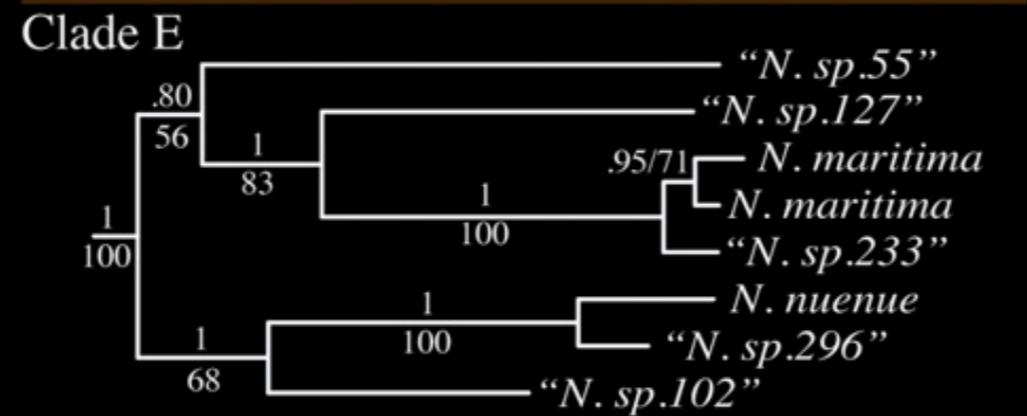


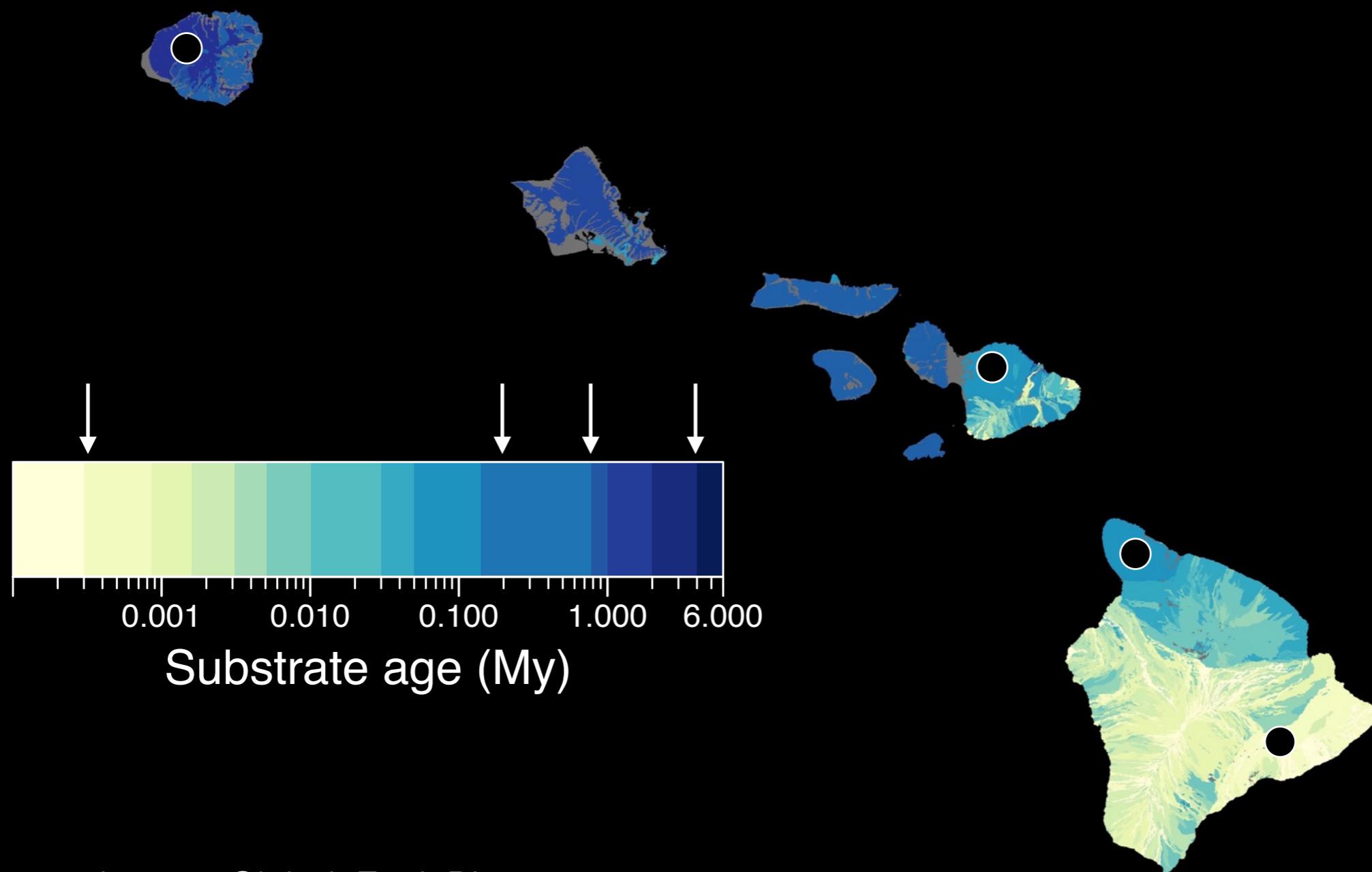
# Individual metabolic rate

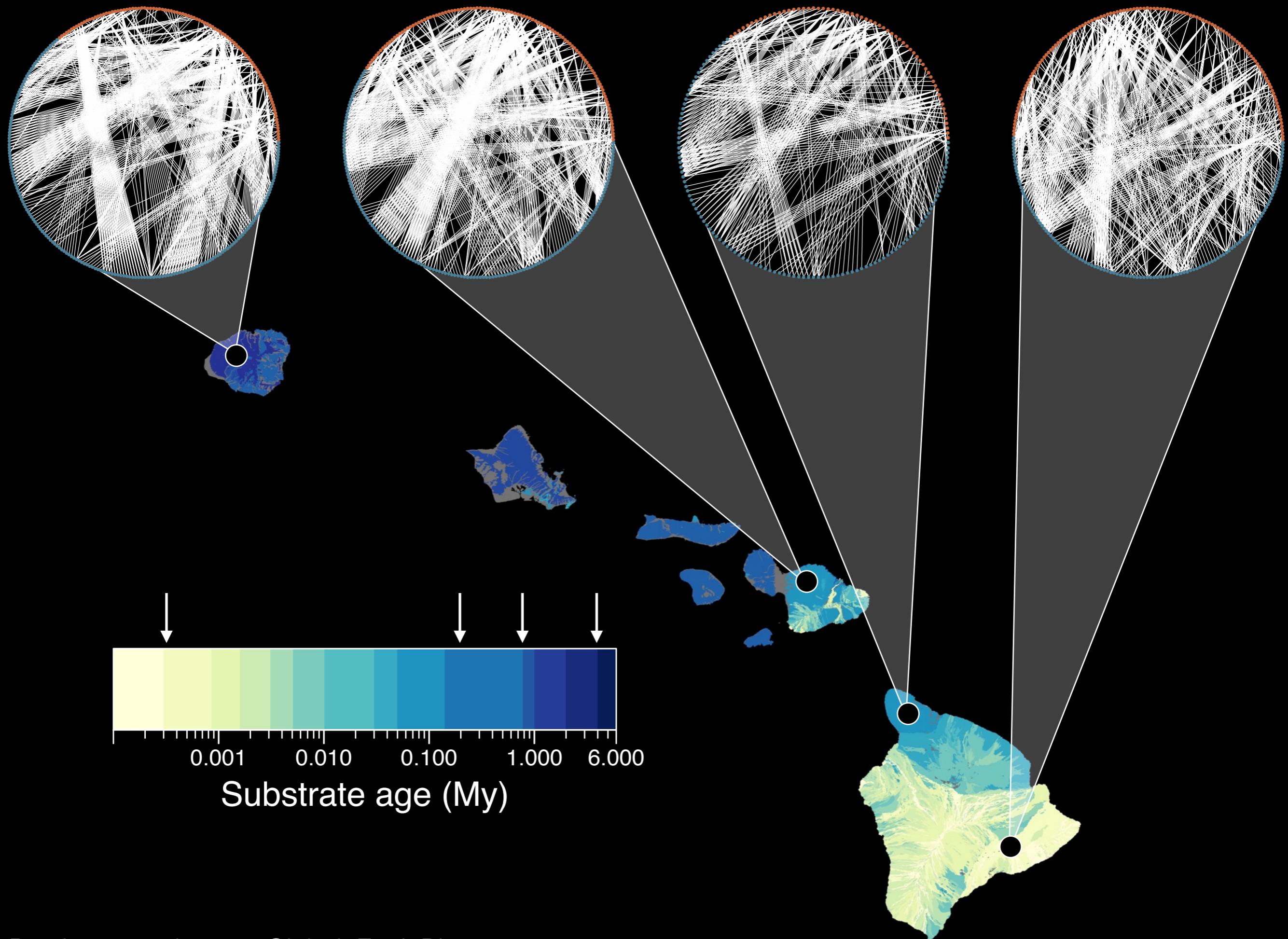


# Individual metabolic rate

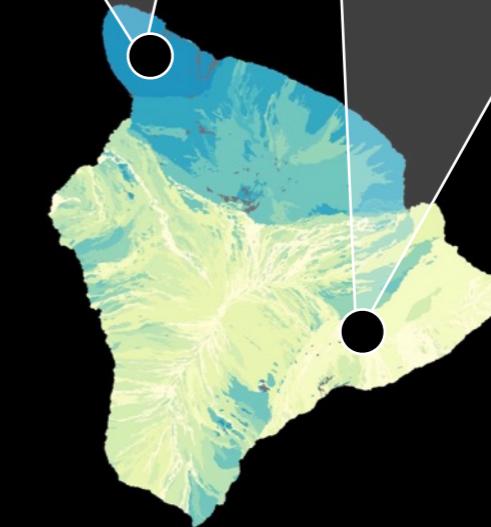
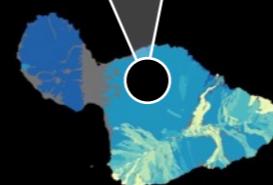
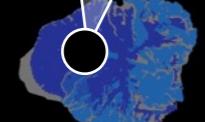
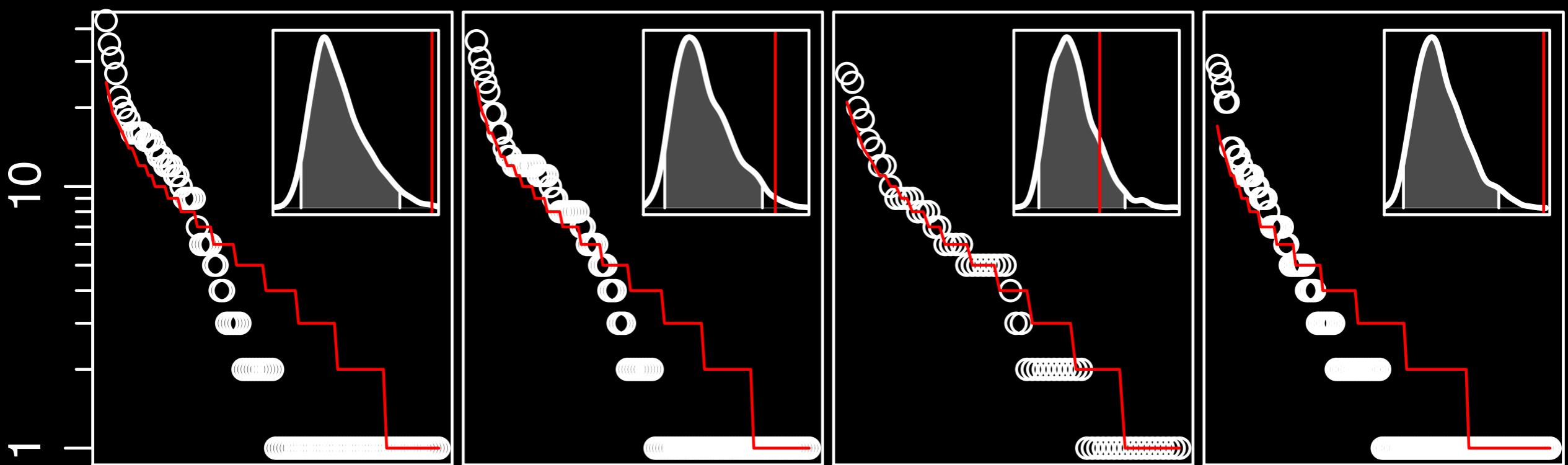


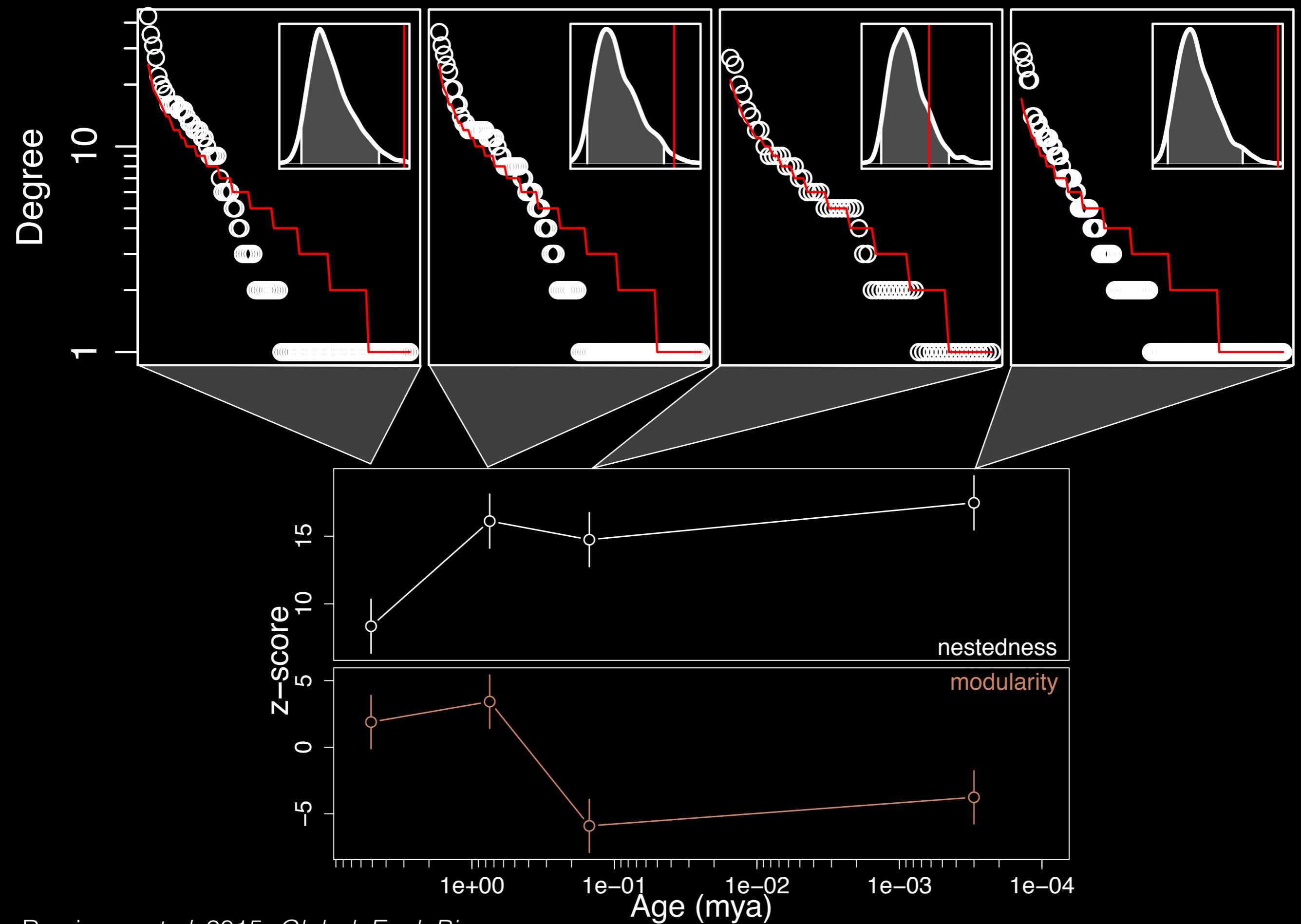




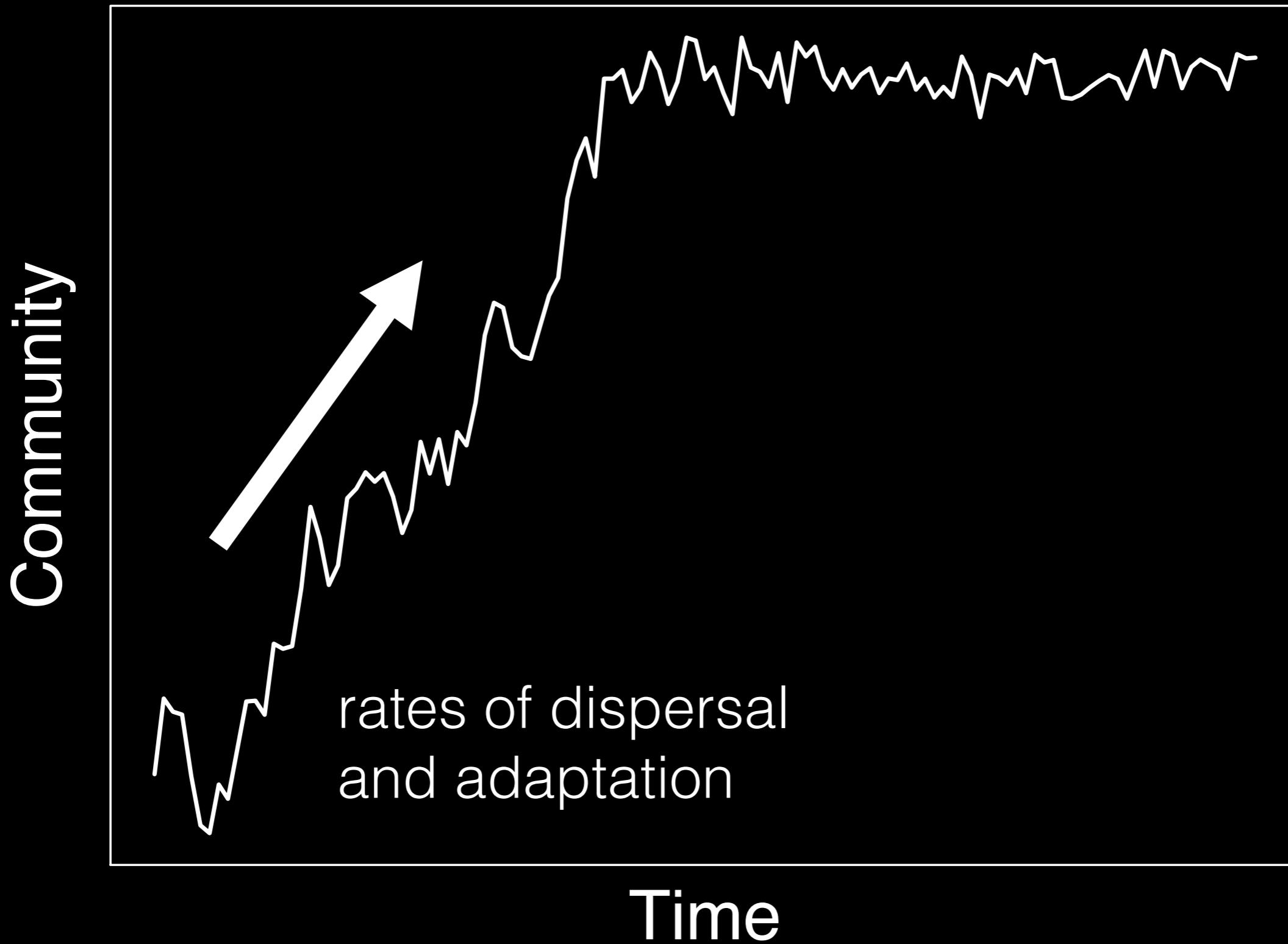


Degree

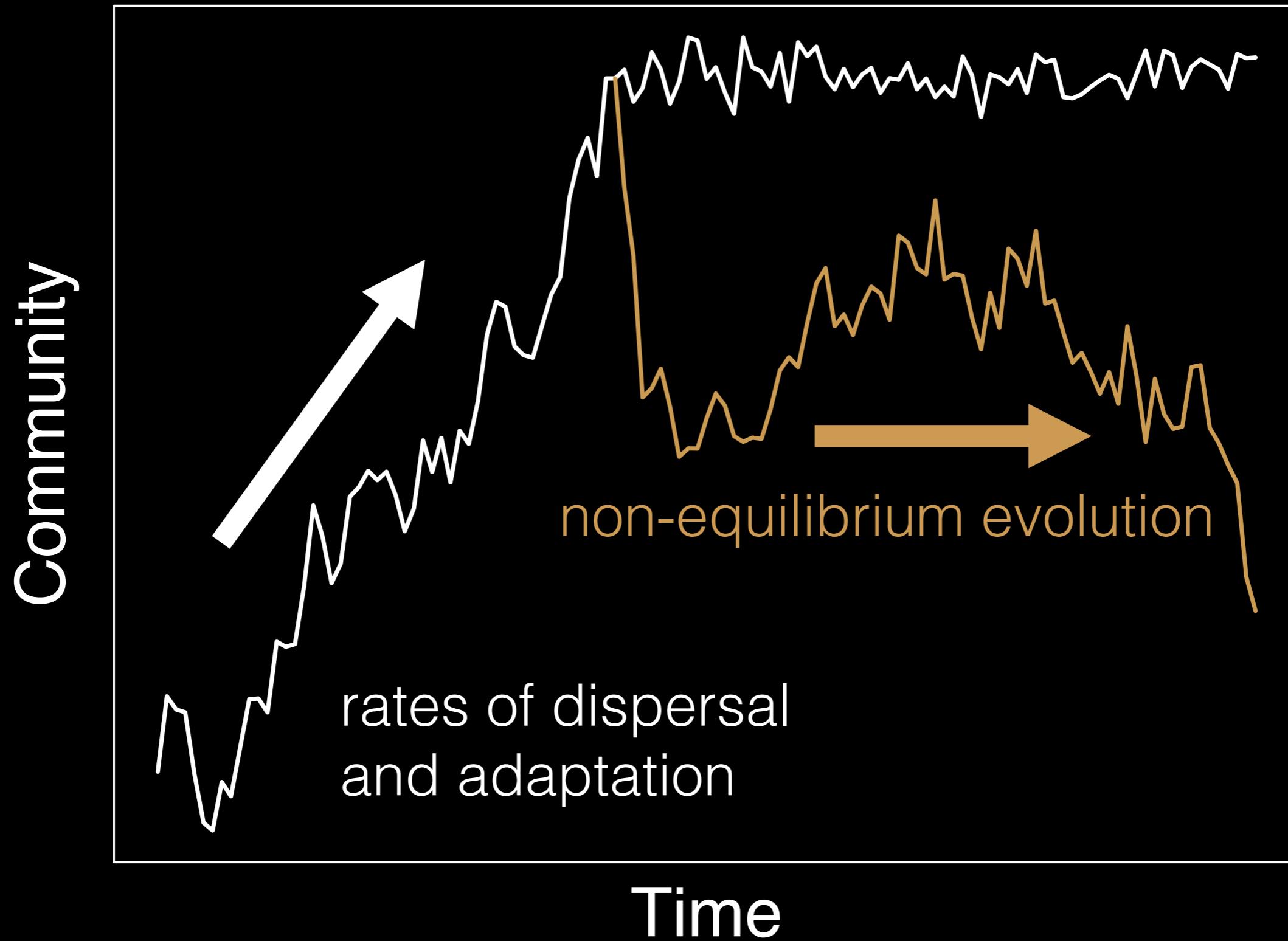




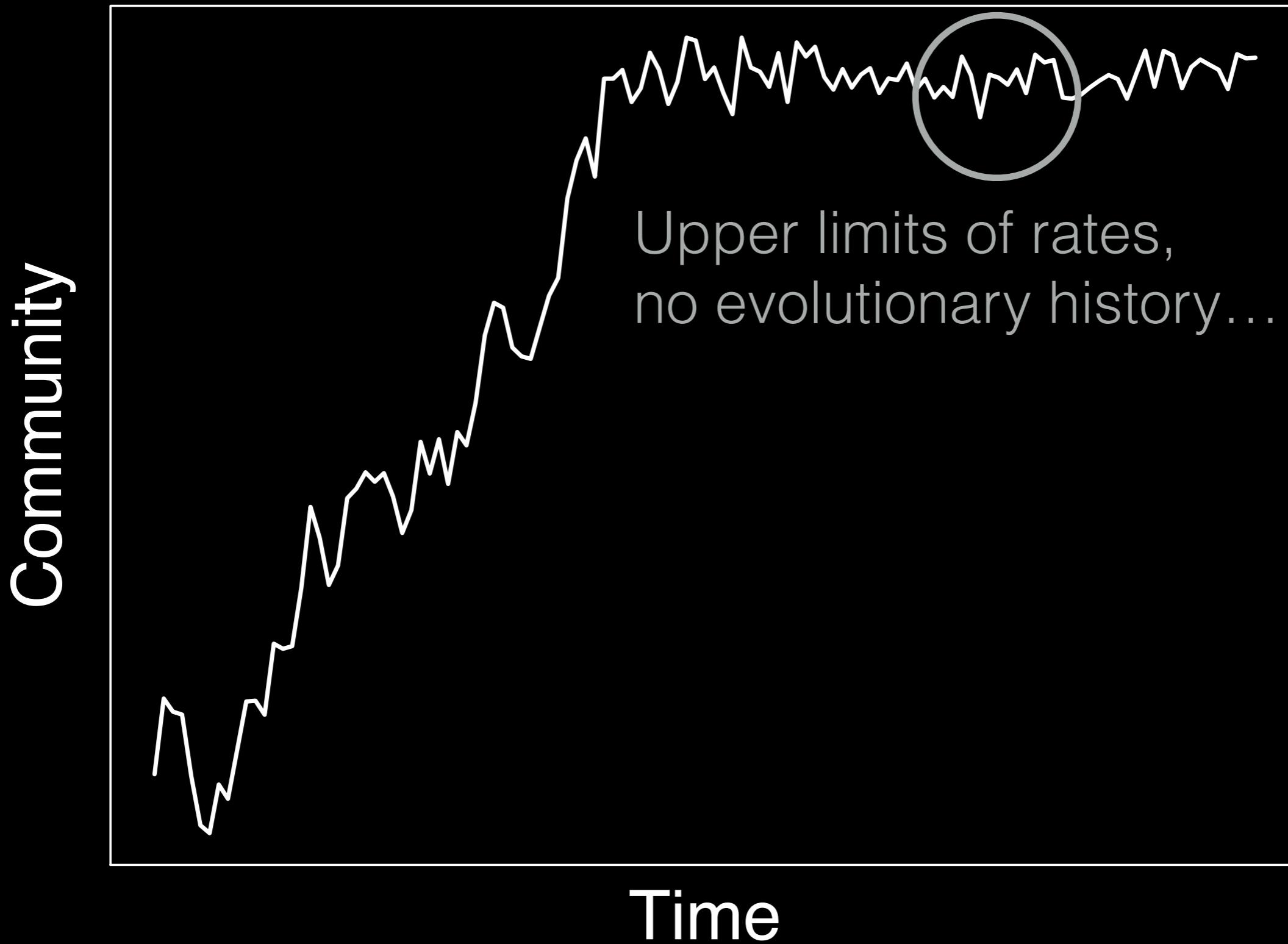
# Importance of memory



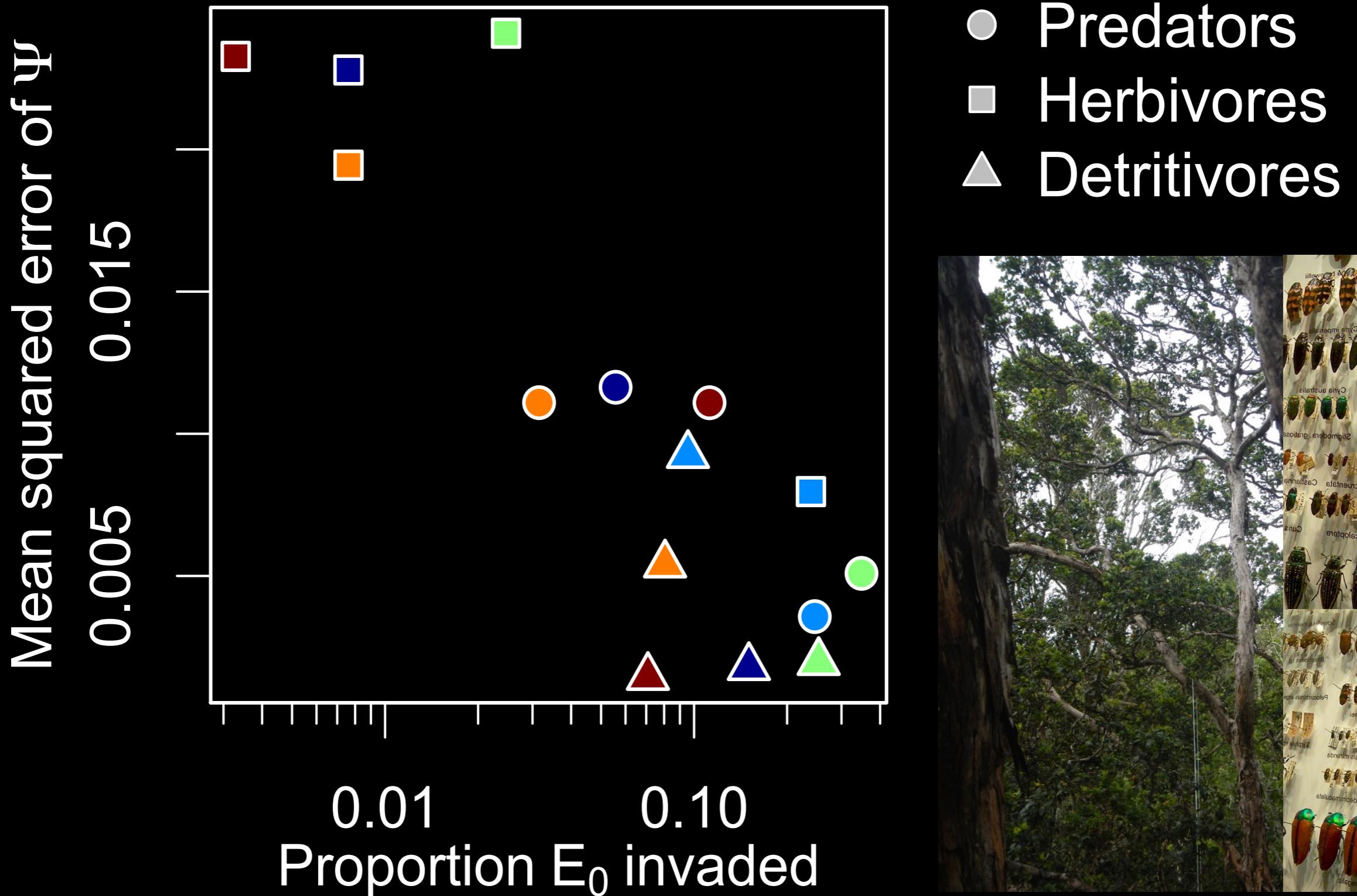
# Importance of memory



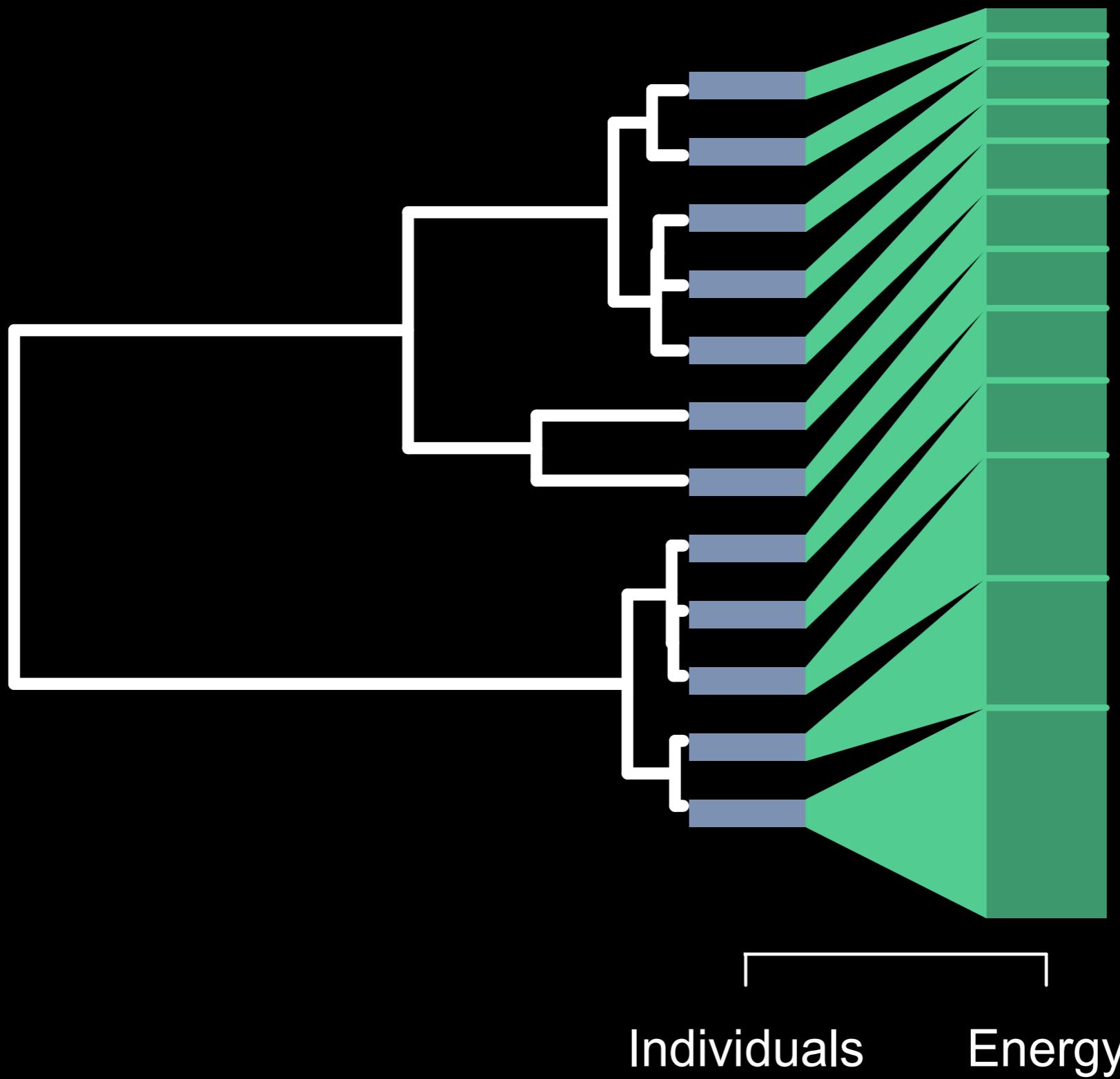
# Importance of memory



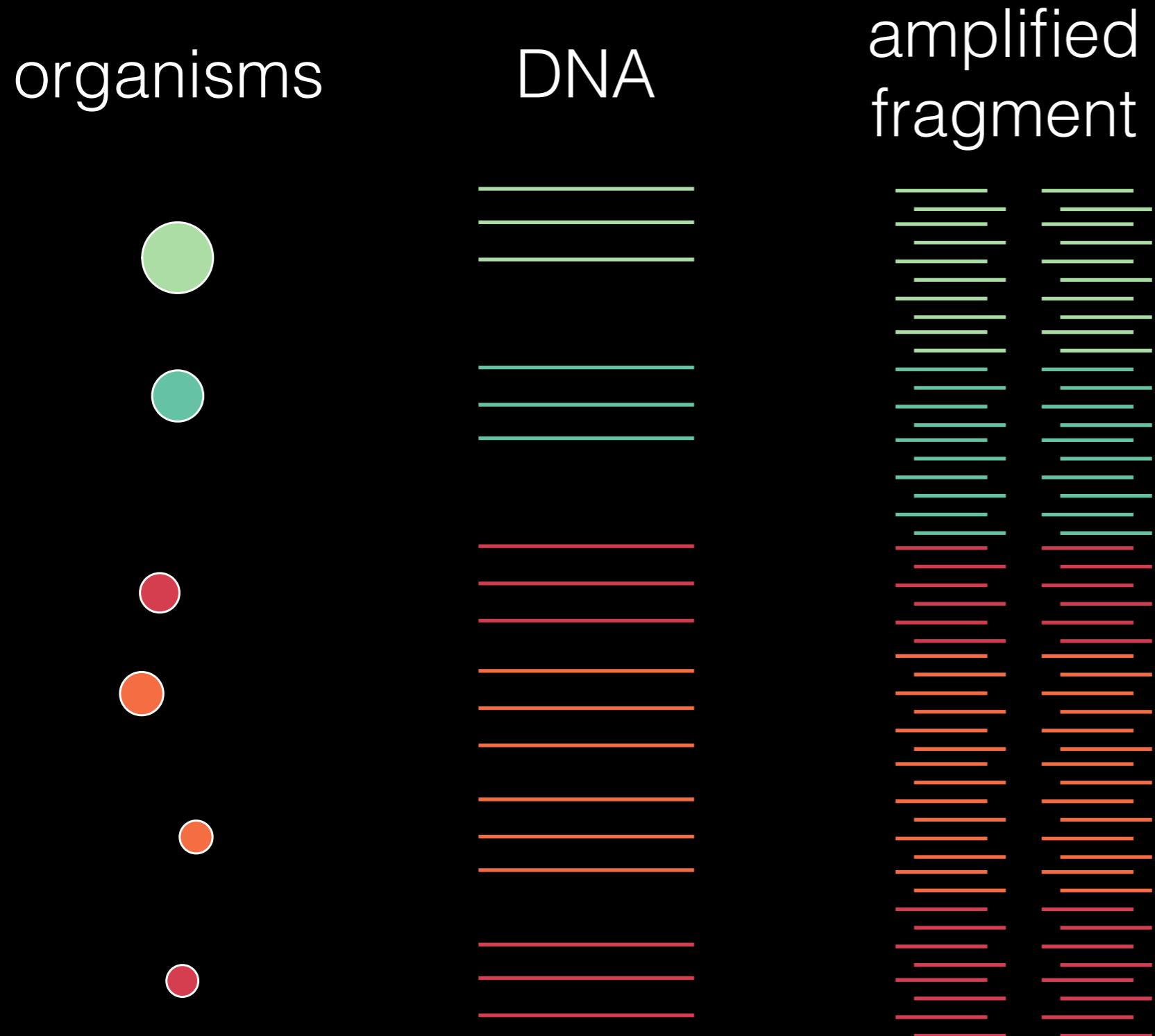
# Importance of history



# Importance of history



# High throughput ecology



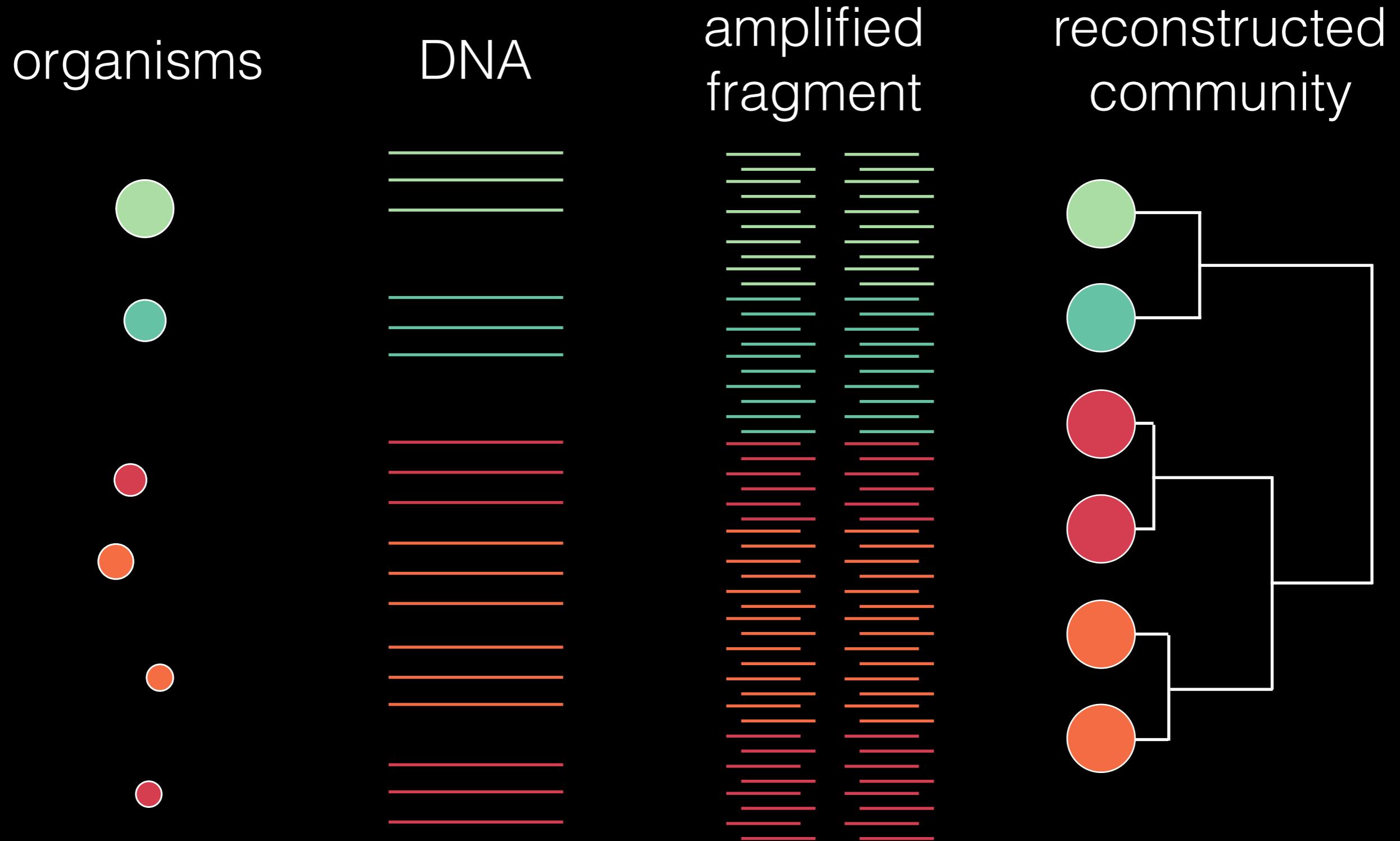
# High throughput ecology



$$\mathbb{P}(\text{comm} \mid \text{data}) =$$

$$\int_{\text{samp}} \frac{\mathbb{P}(\text{real data} \mid \text{sampling, ideal data}) \mathbb{P}(\text{ideal data} \mid \text{comm}) \mathbb{P}(\text{comm, sampling})}{\mathbb{P}(\text{data})} d\theta_{\text{samp}}$$

# High throughput ecology



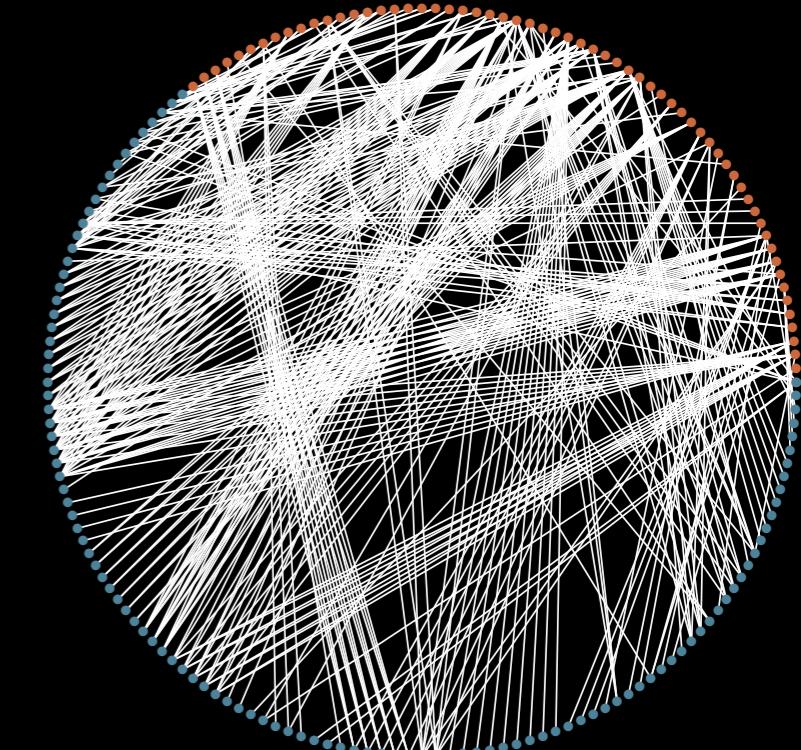
# High throughput ecology

organisms

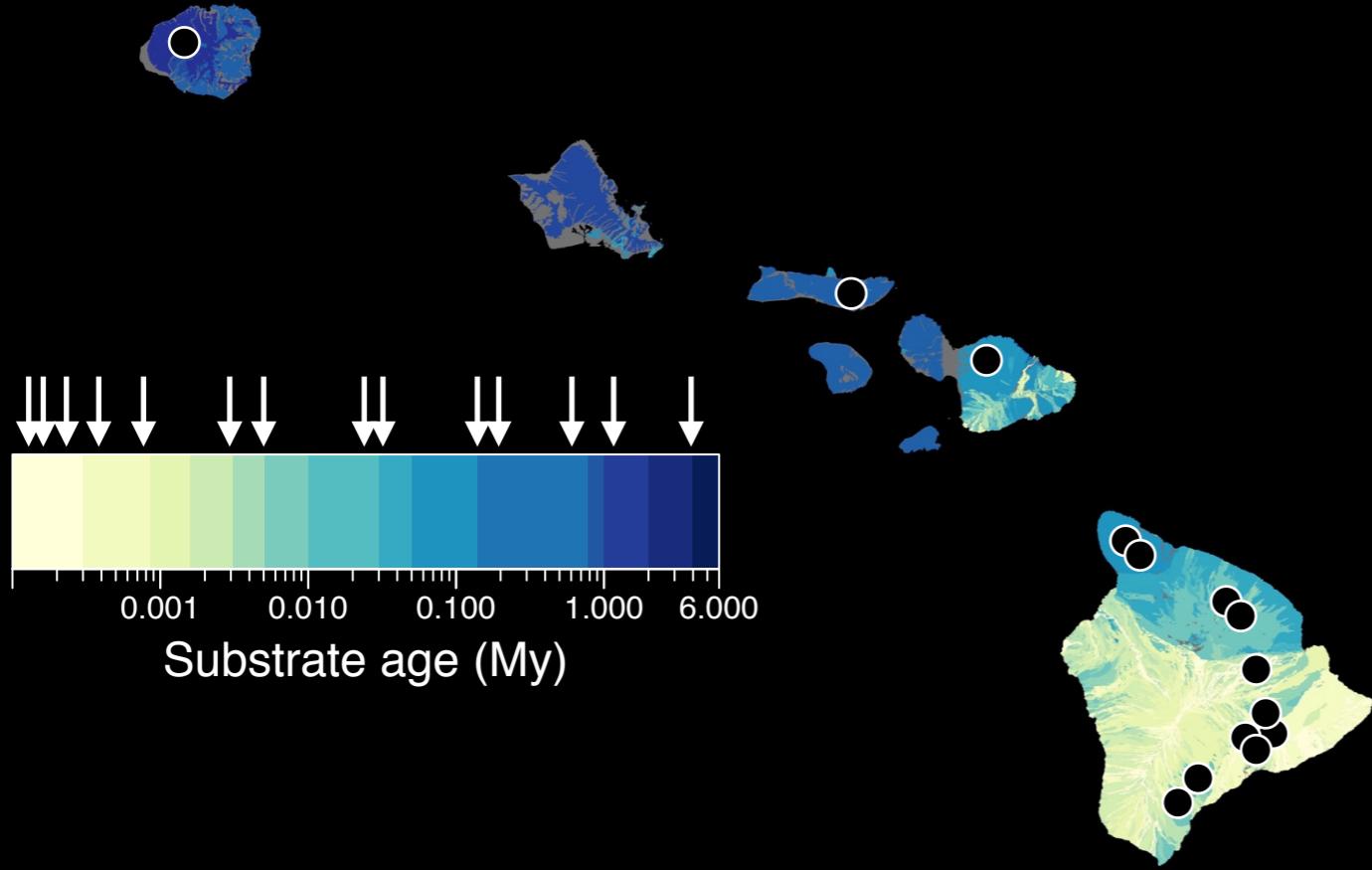
DNA

amplified  
fragment

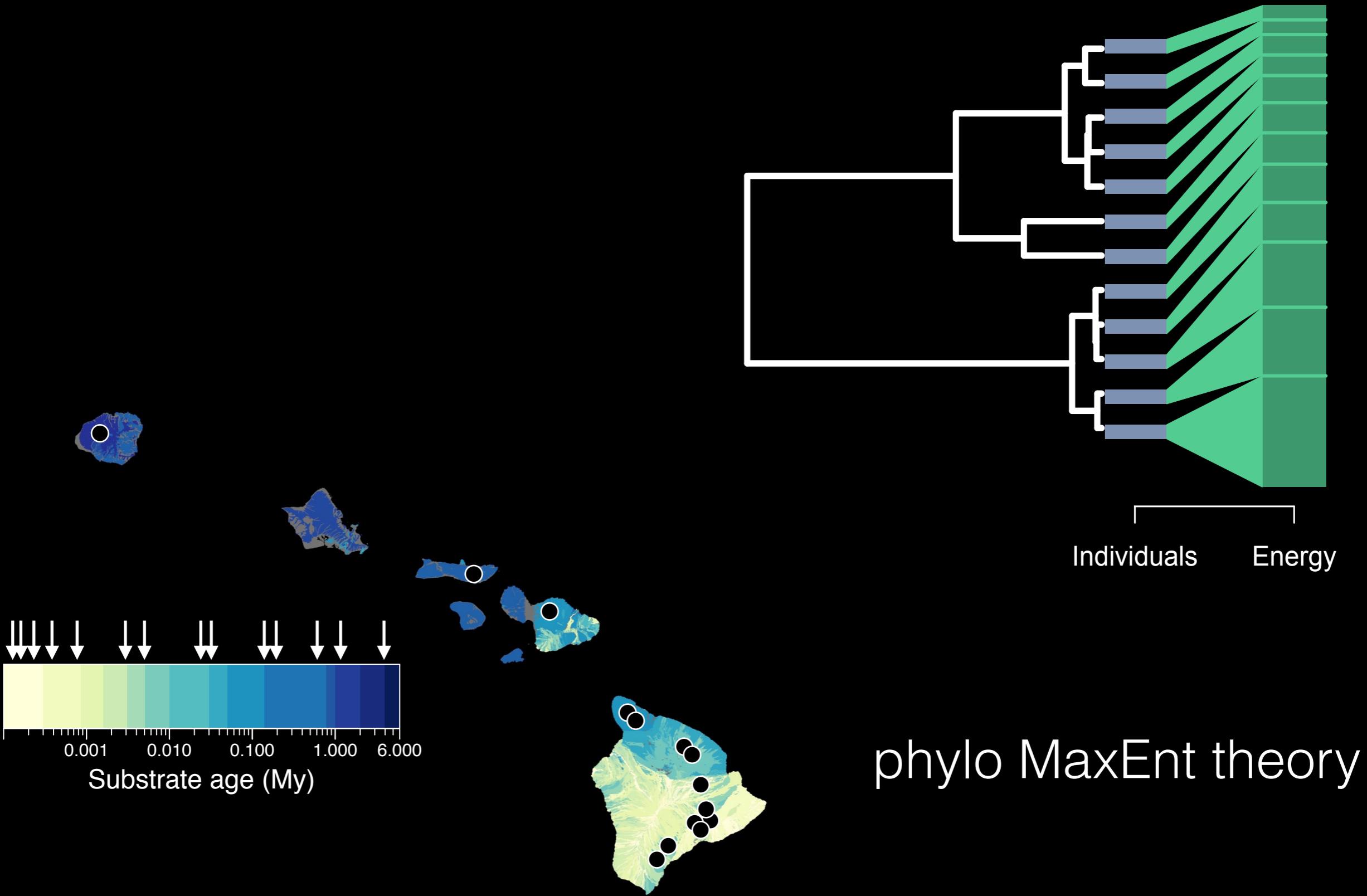
reconstructed  
community



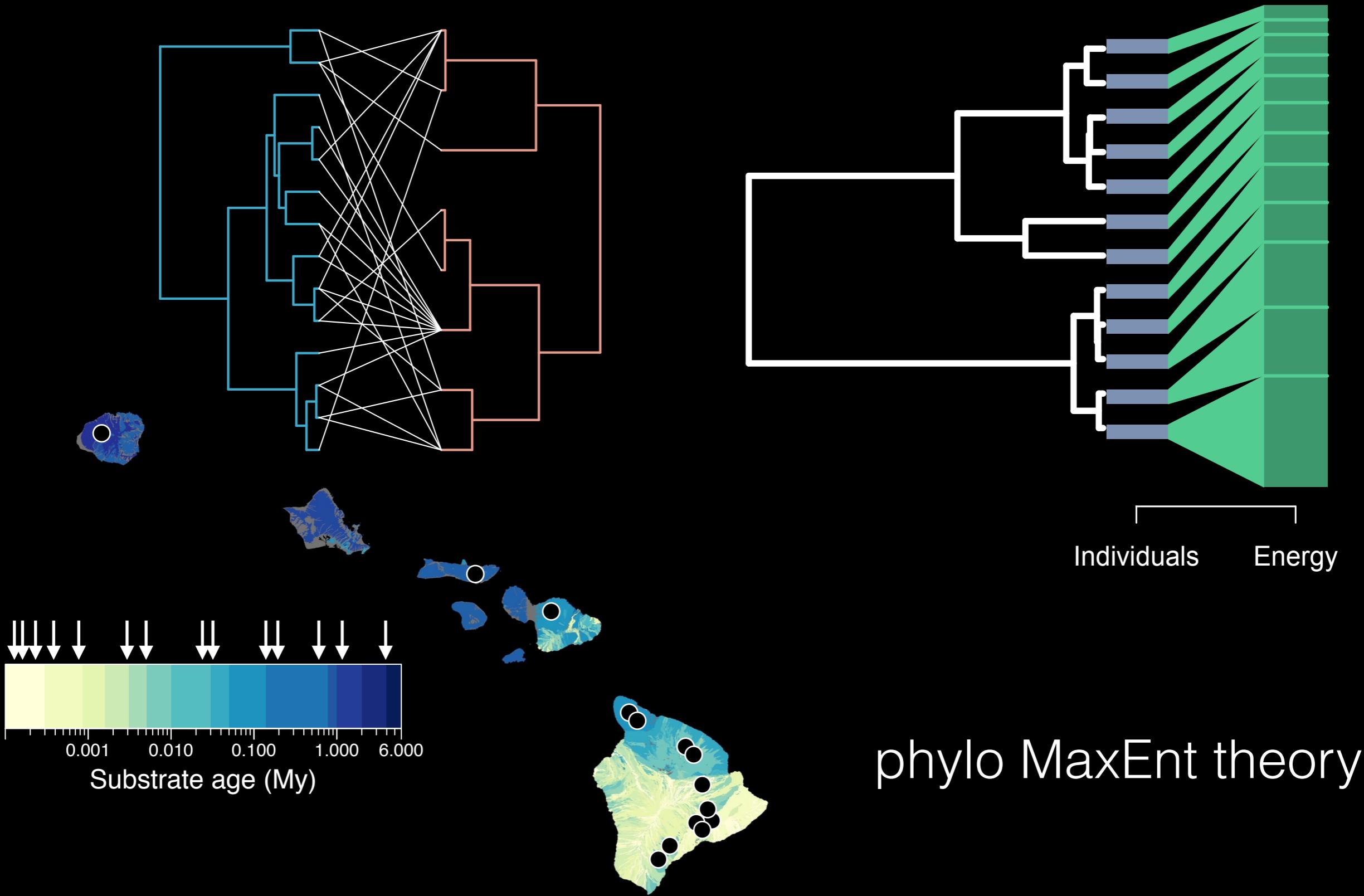
# High throughput ecology



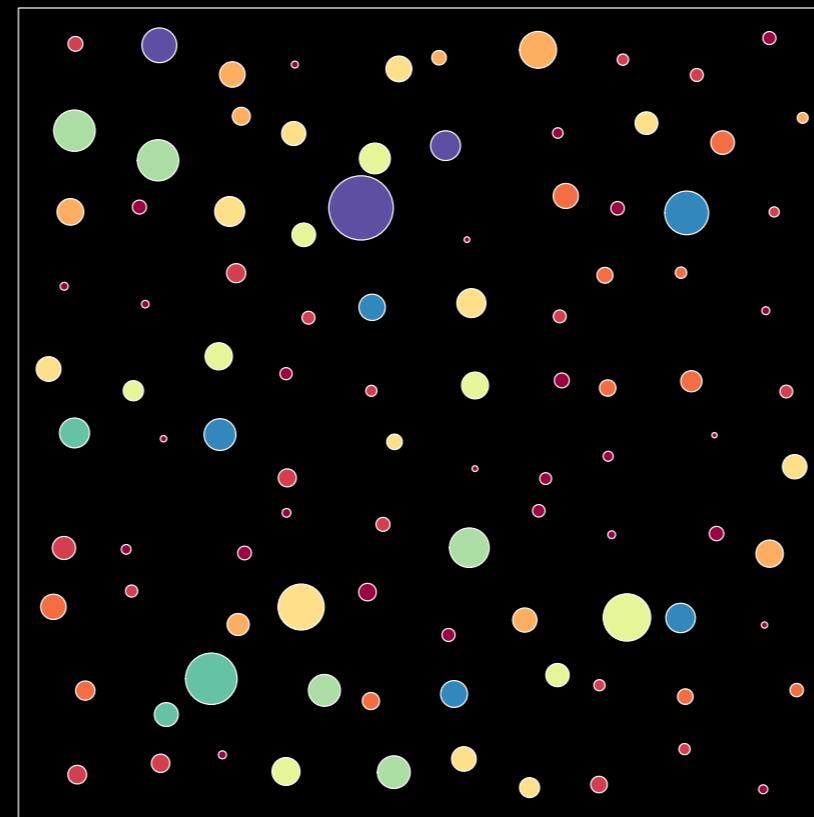
# High throughput ecology



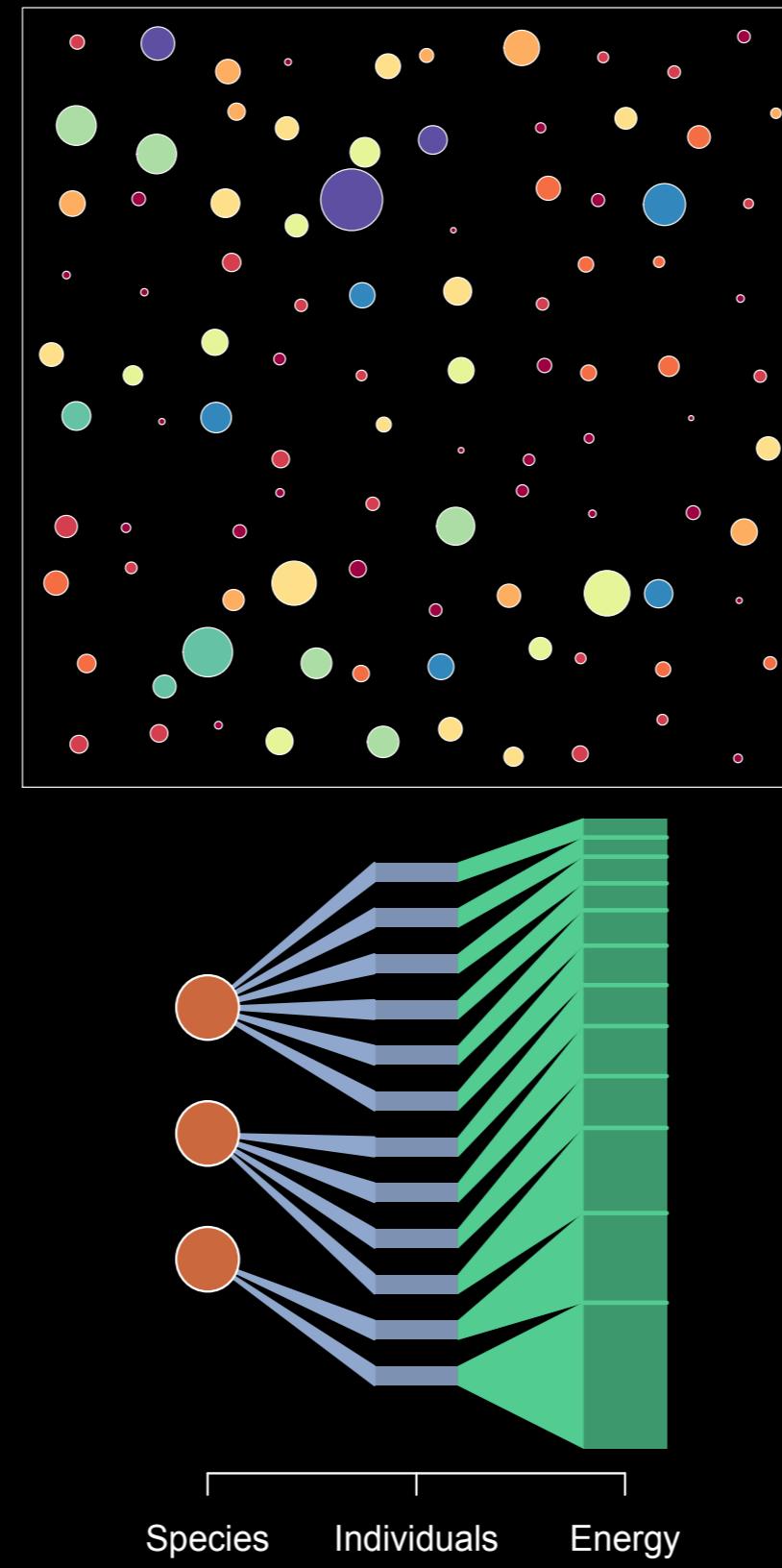
# High throughput ecology



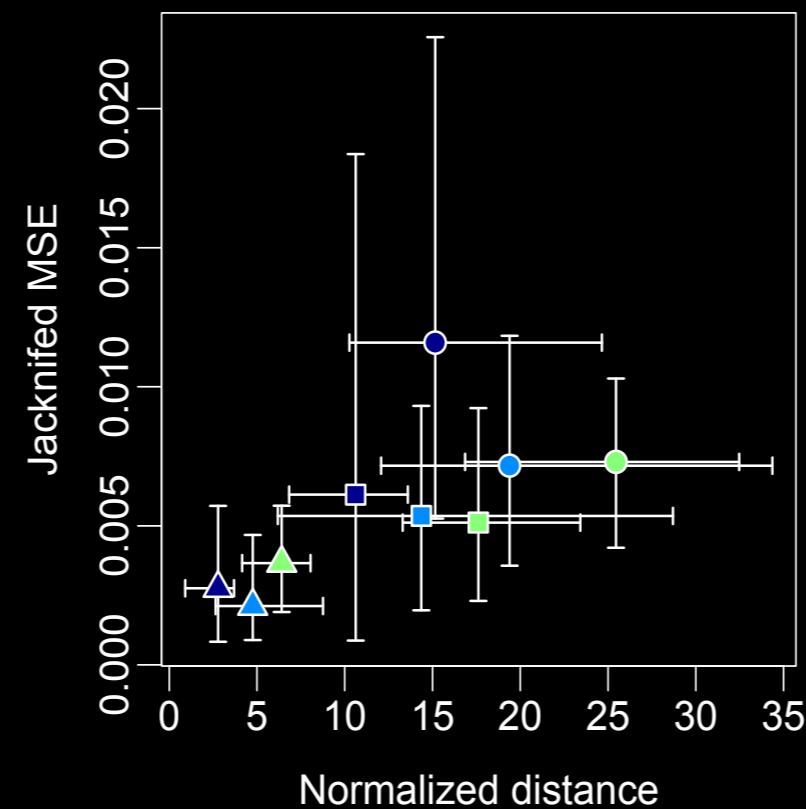
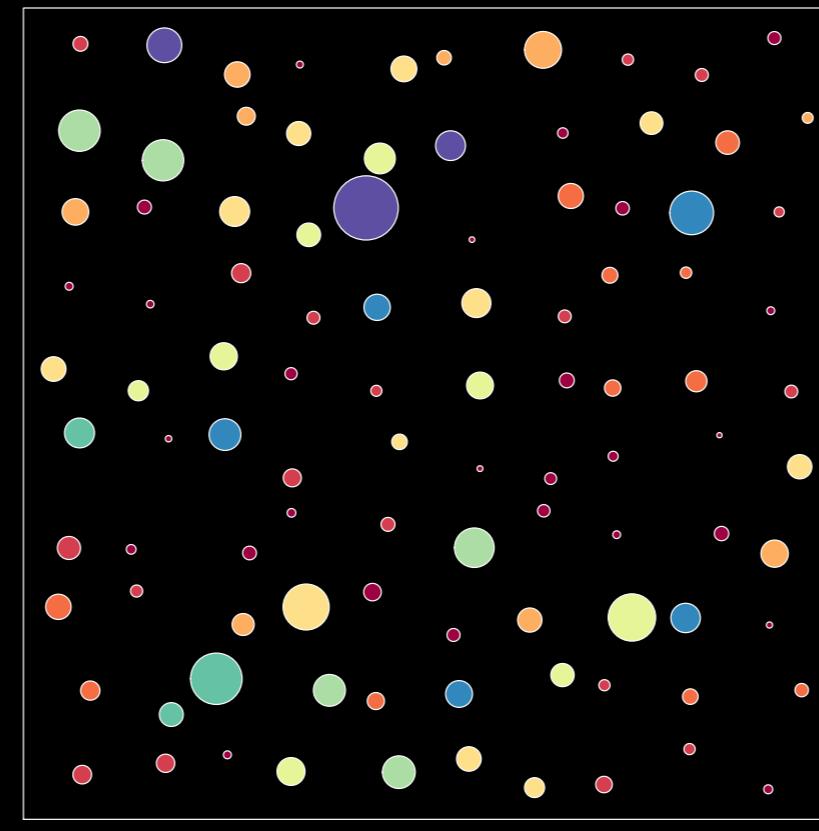
# What constrains biodiversity?



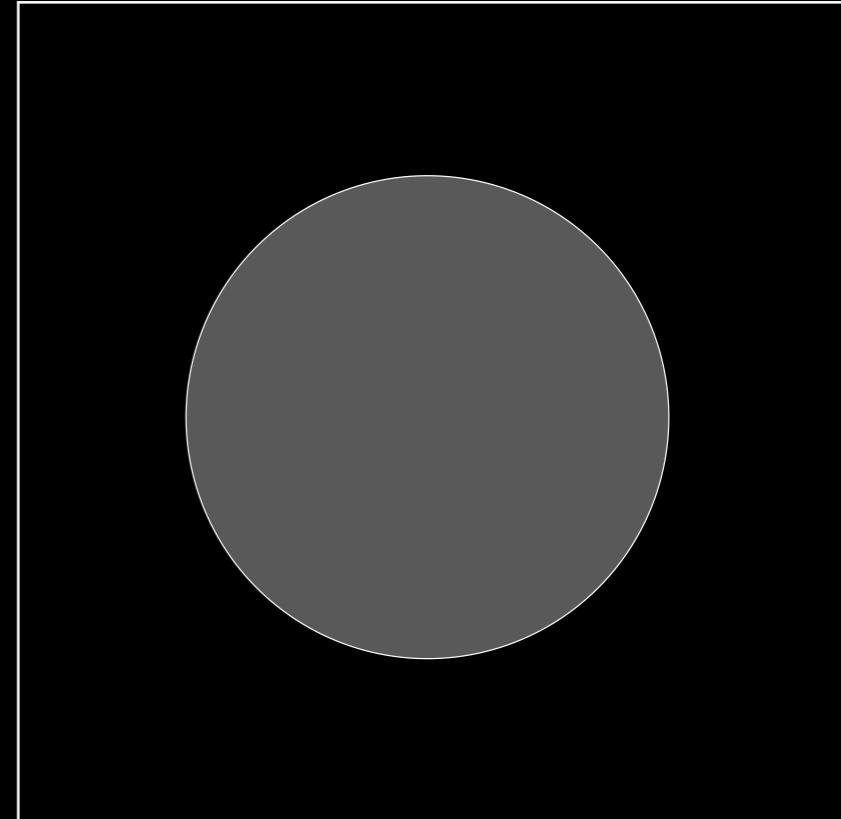
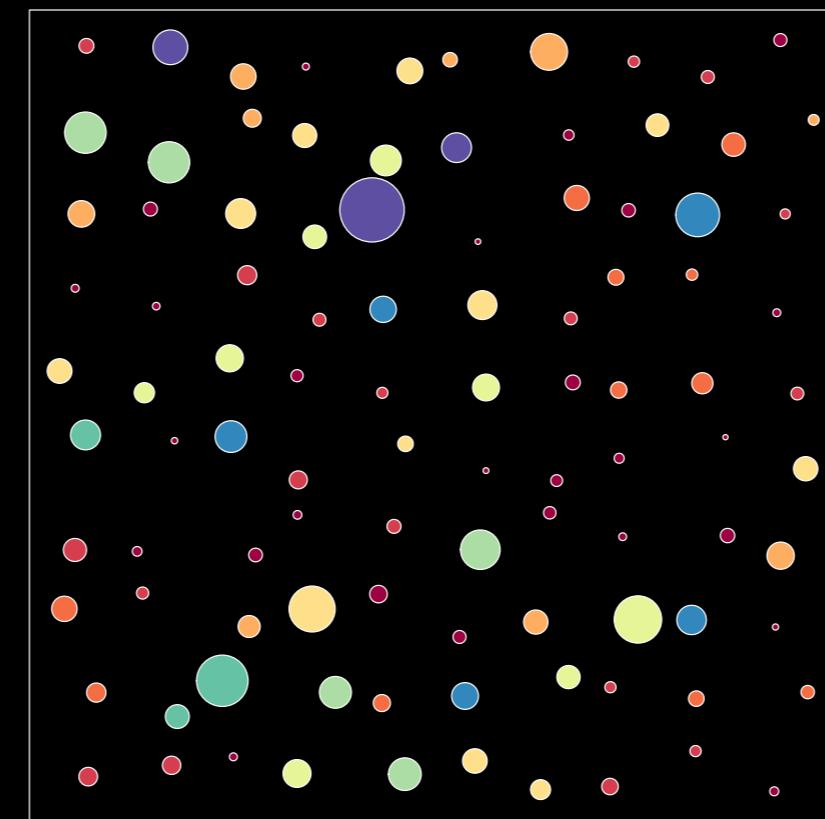
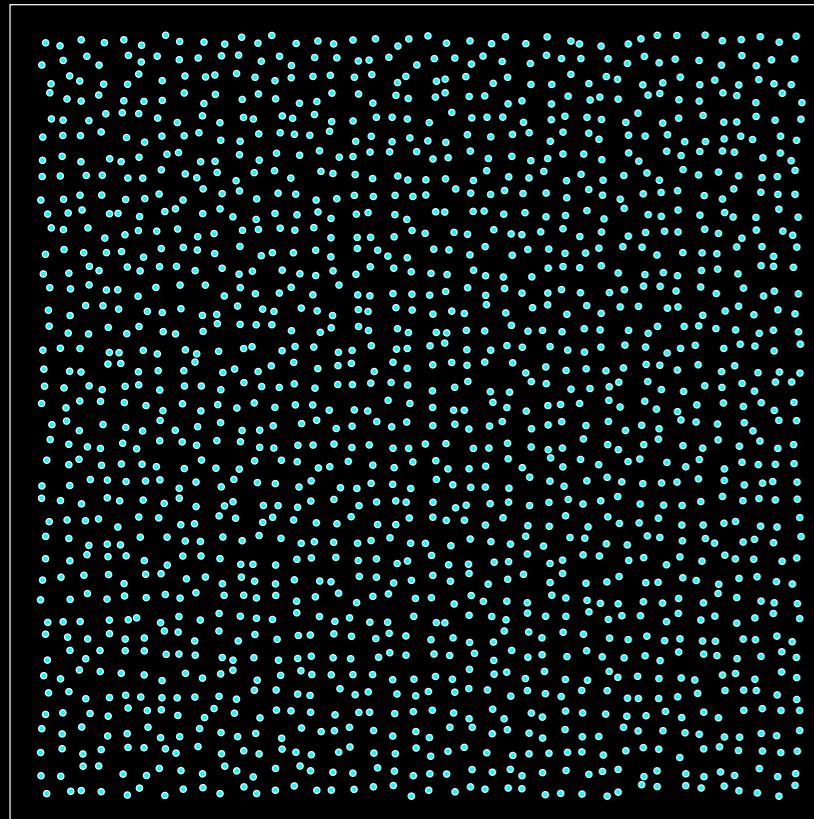
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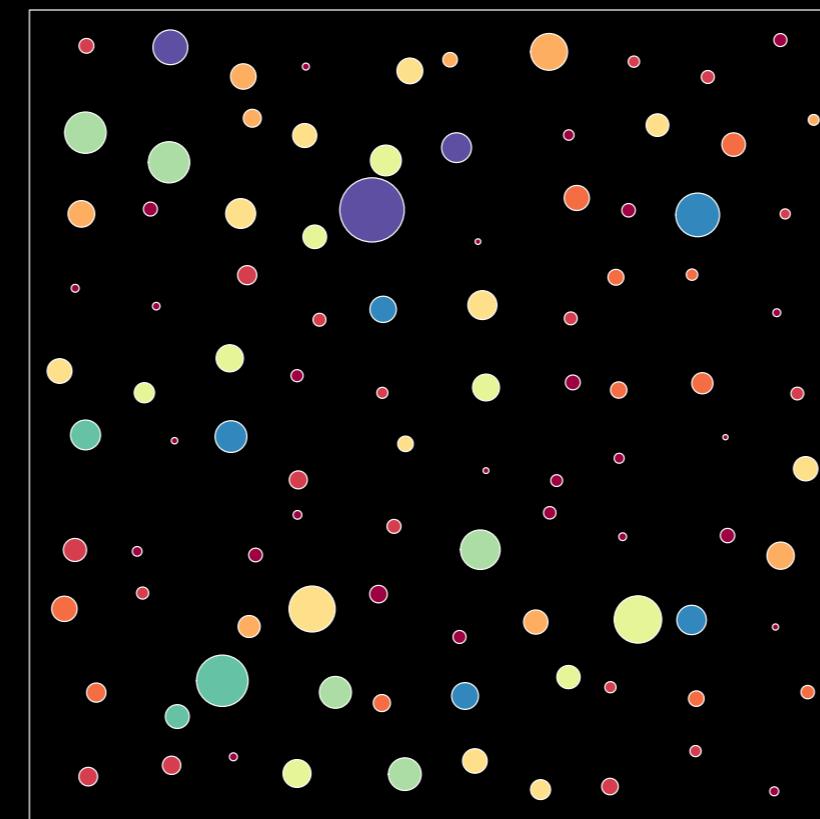
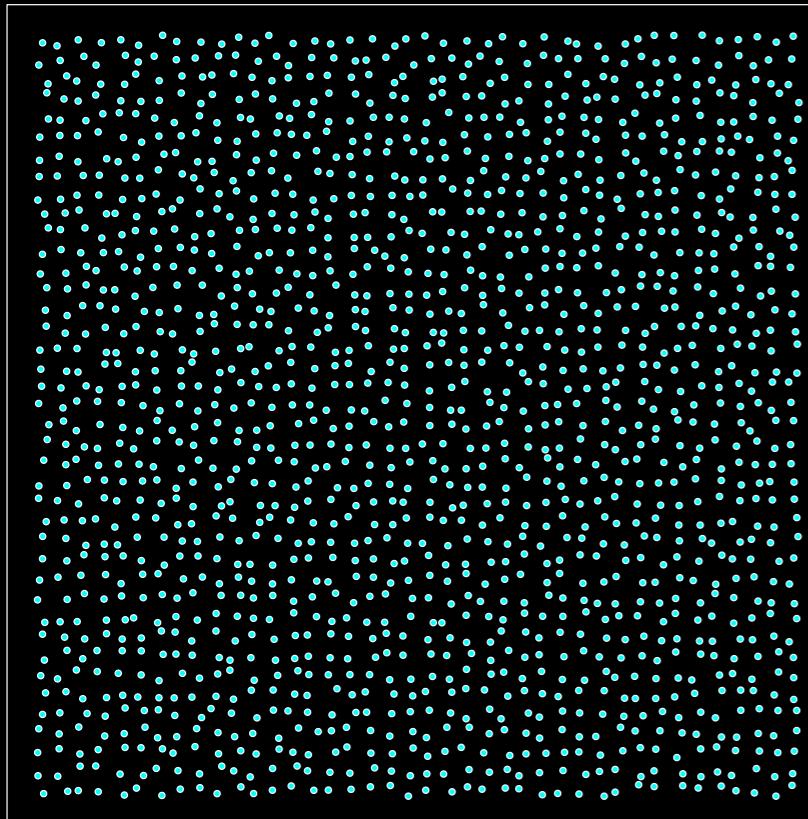
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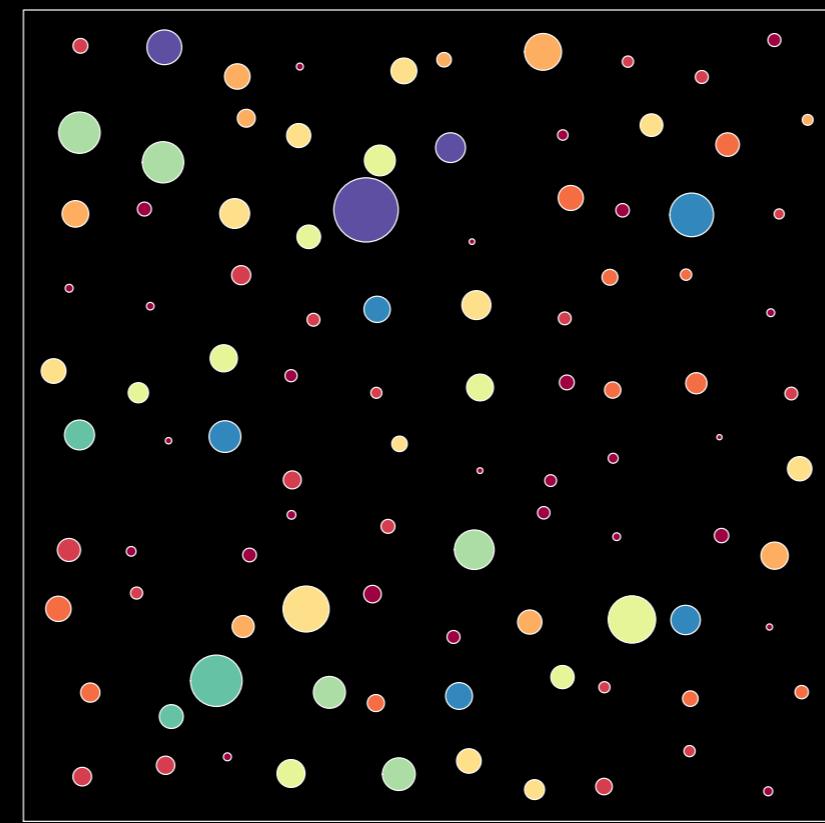
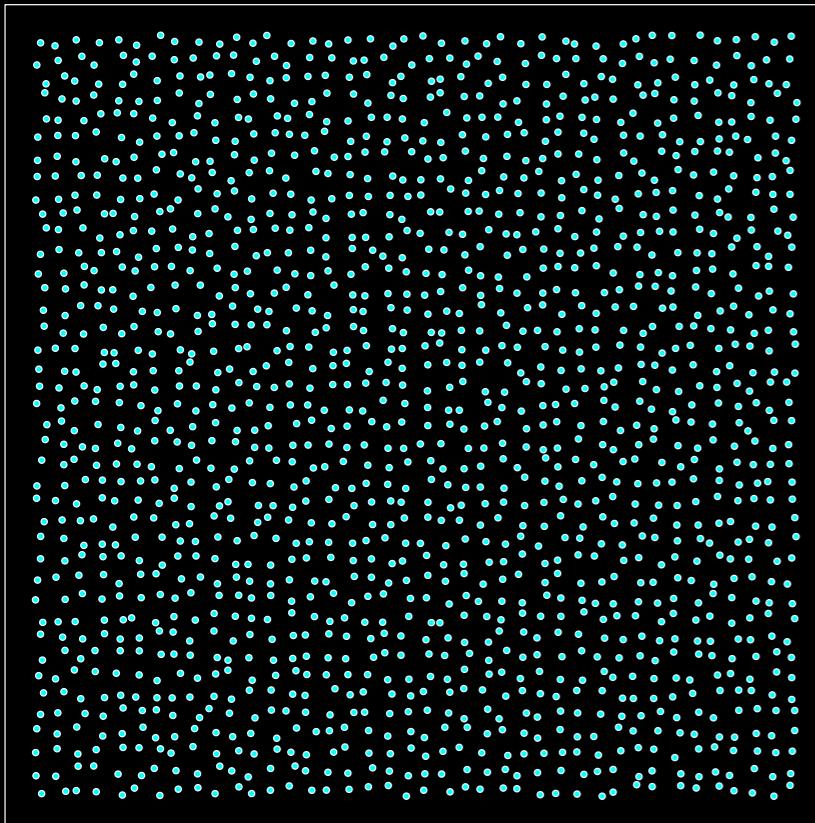
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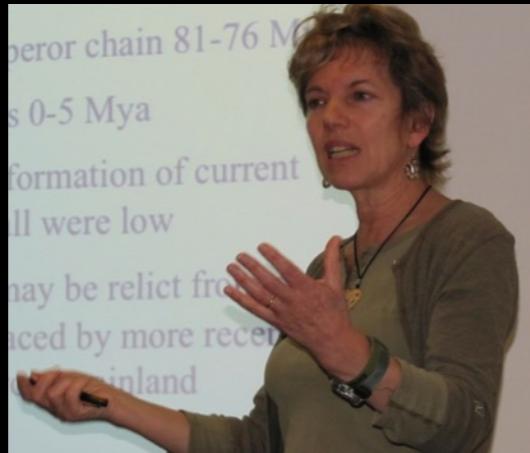
# What constrains biodiversity?



# Thank you!



J. Harte



R. G. Gillespie



J. Y. Lim



K. R. Goodman



D. S. Gruner



GORDON AND BETTY  
**MOORE**  
FOUNDATION



y'all!