

My ventures are not in one bottom trusted,
Nor to one place; nor is my whole estate
Upon the fortune of this present year:
Therefore my merchandise makes me not sad.

Shakespeare, Merchant of Venice, 1598



False prophets?

The challenges of quantifying ecological portfolios

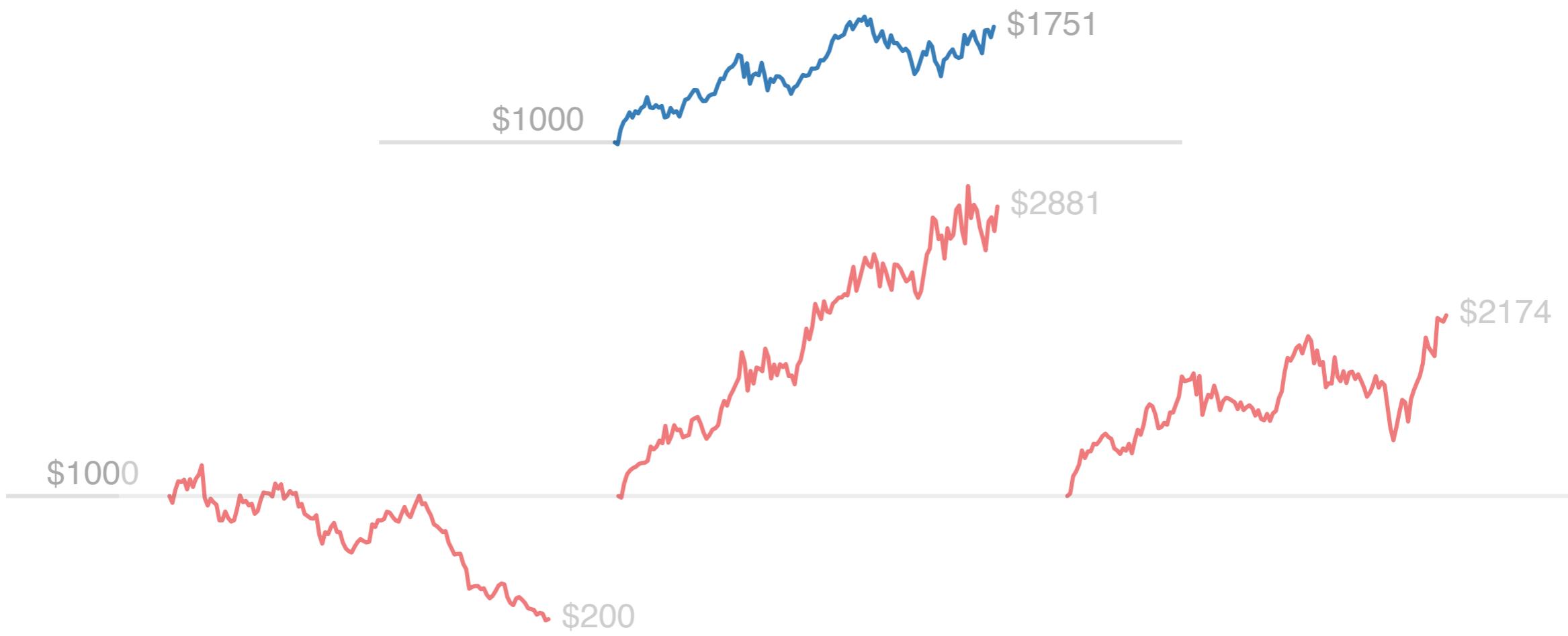
Sean C. Anderson

with: Nick Dulvy and Andy Cooper
(Simon Fraser University)

thanks also to: Trevor Branch, Jon Moore, Branch lab

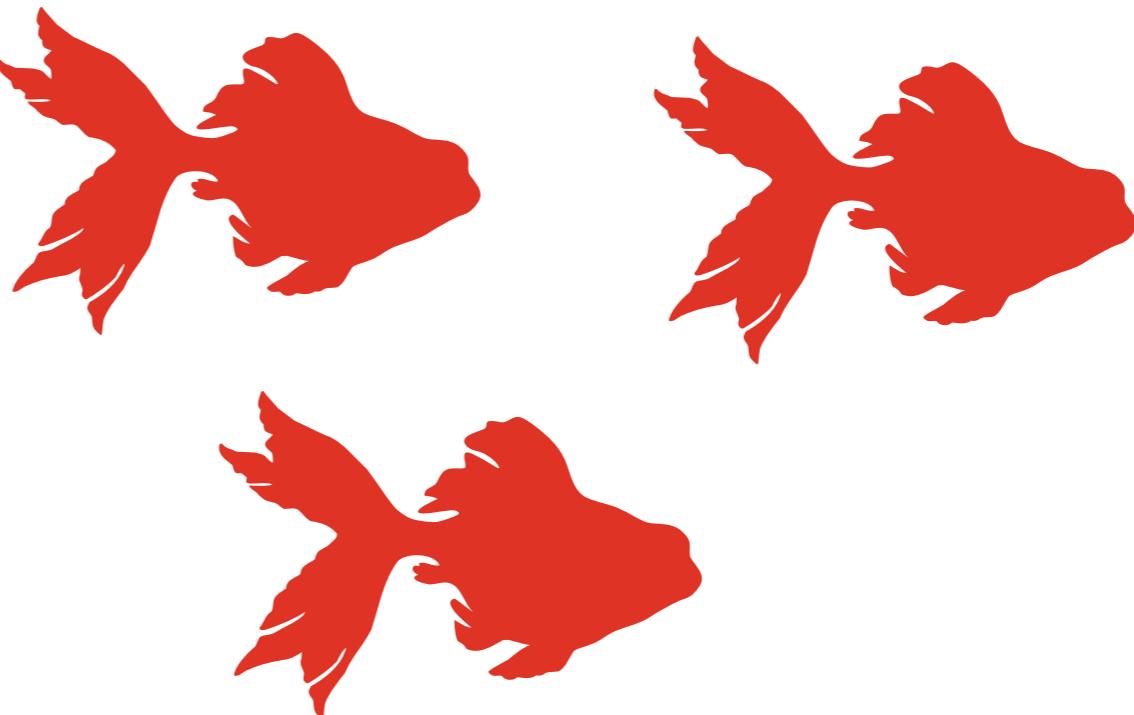




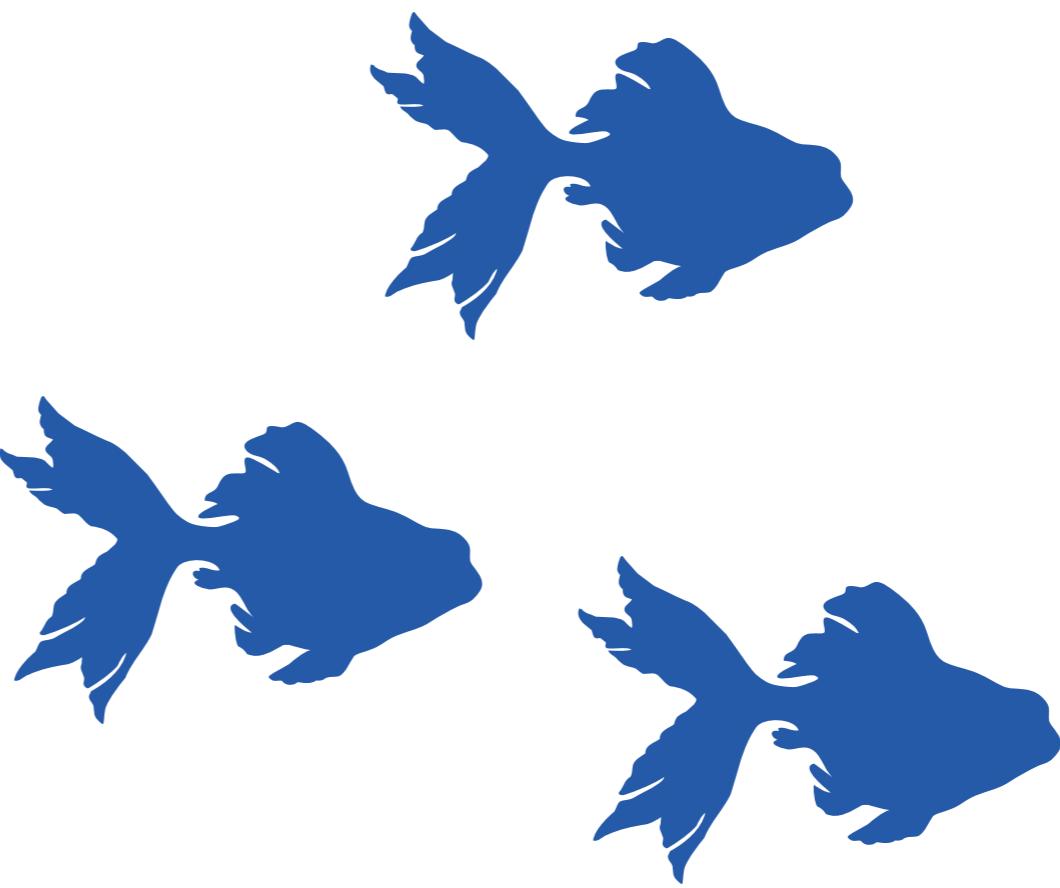




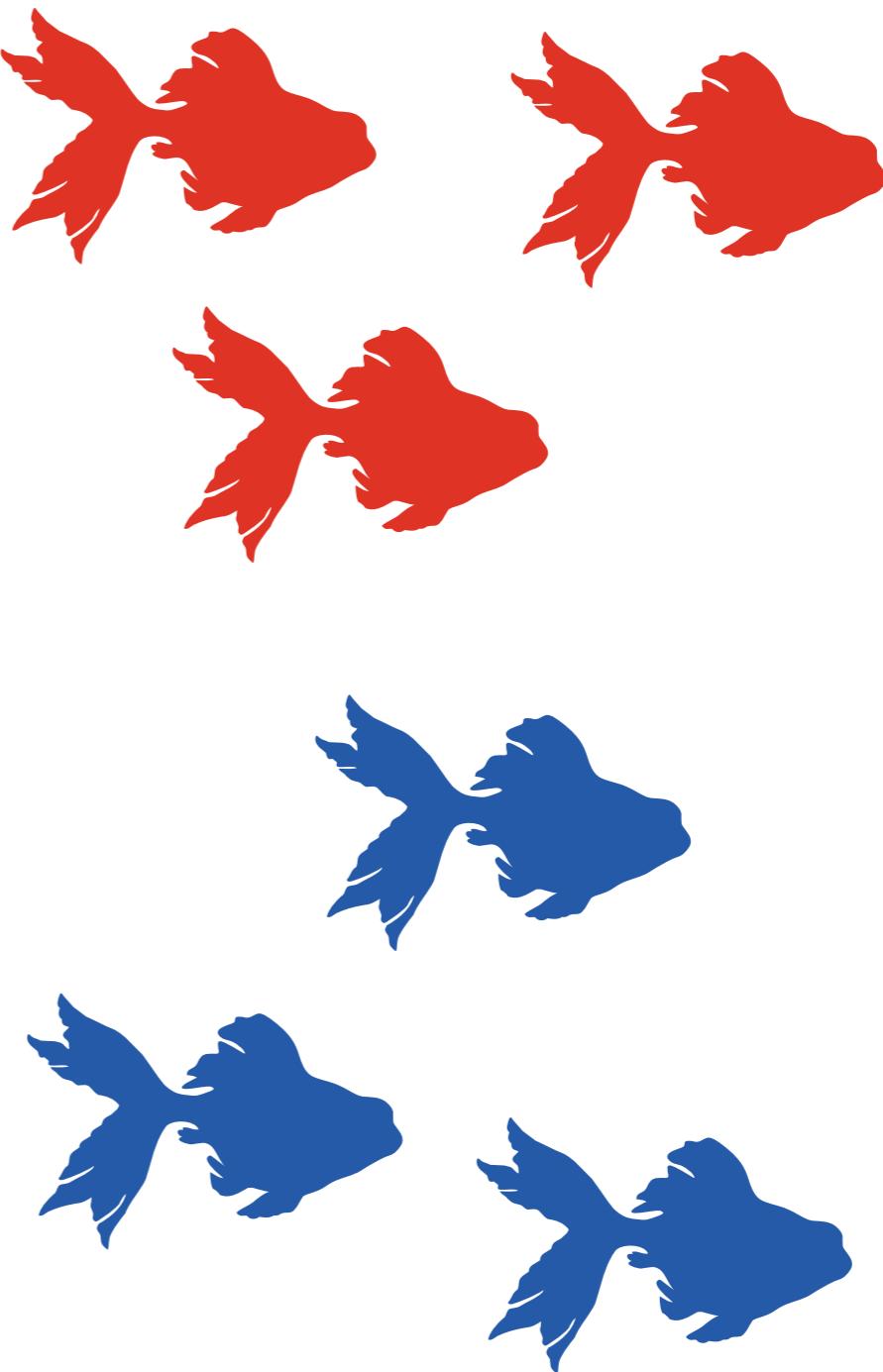
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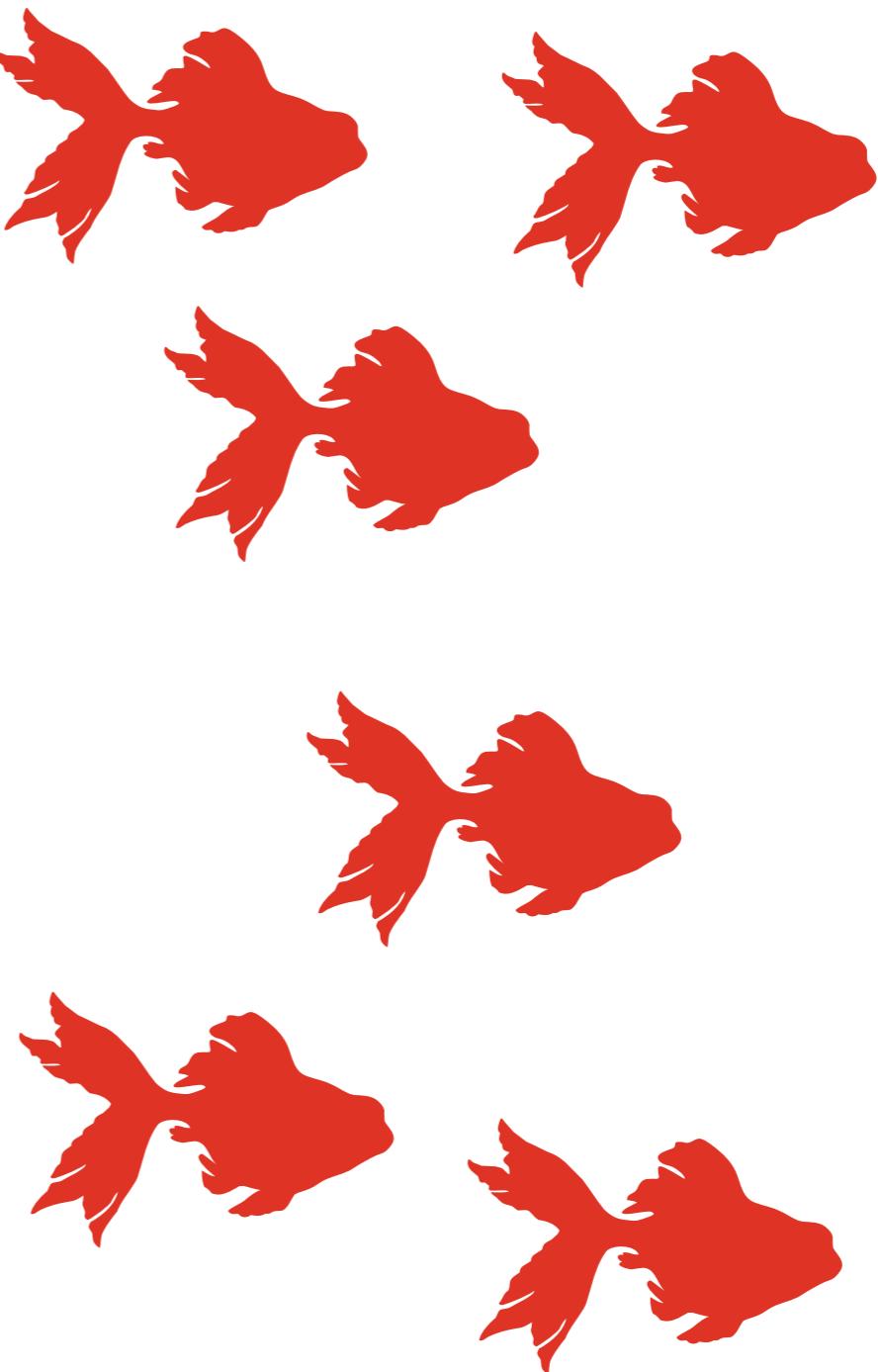
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Diversified portfolio



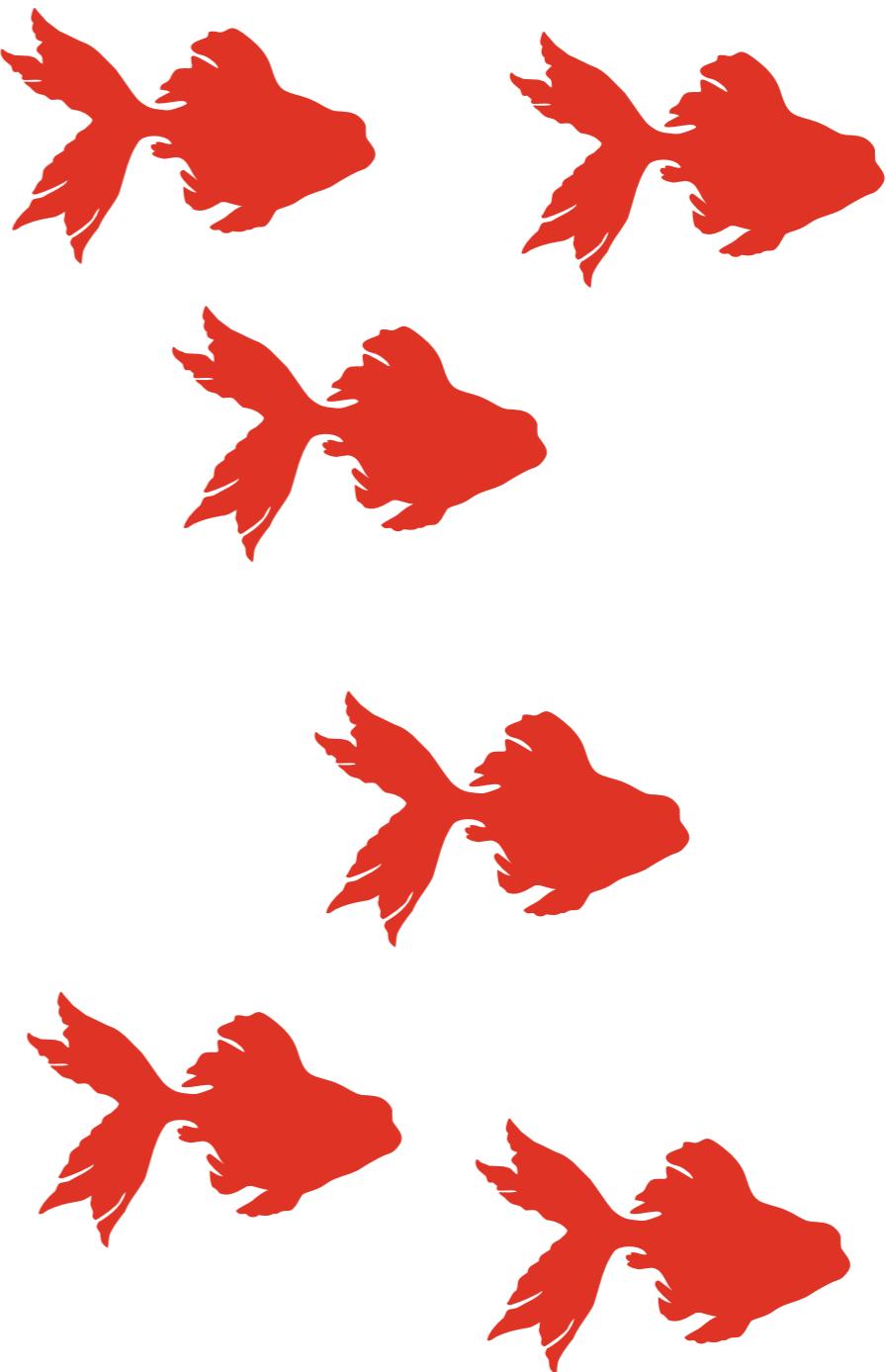
Single asset portfolio



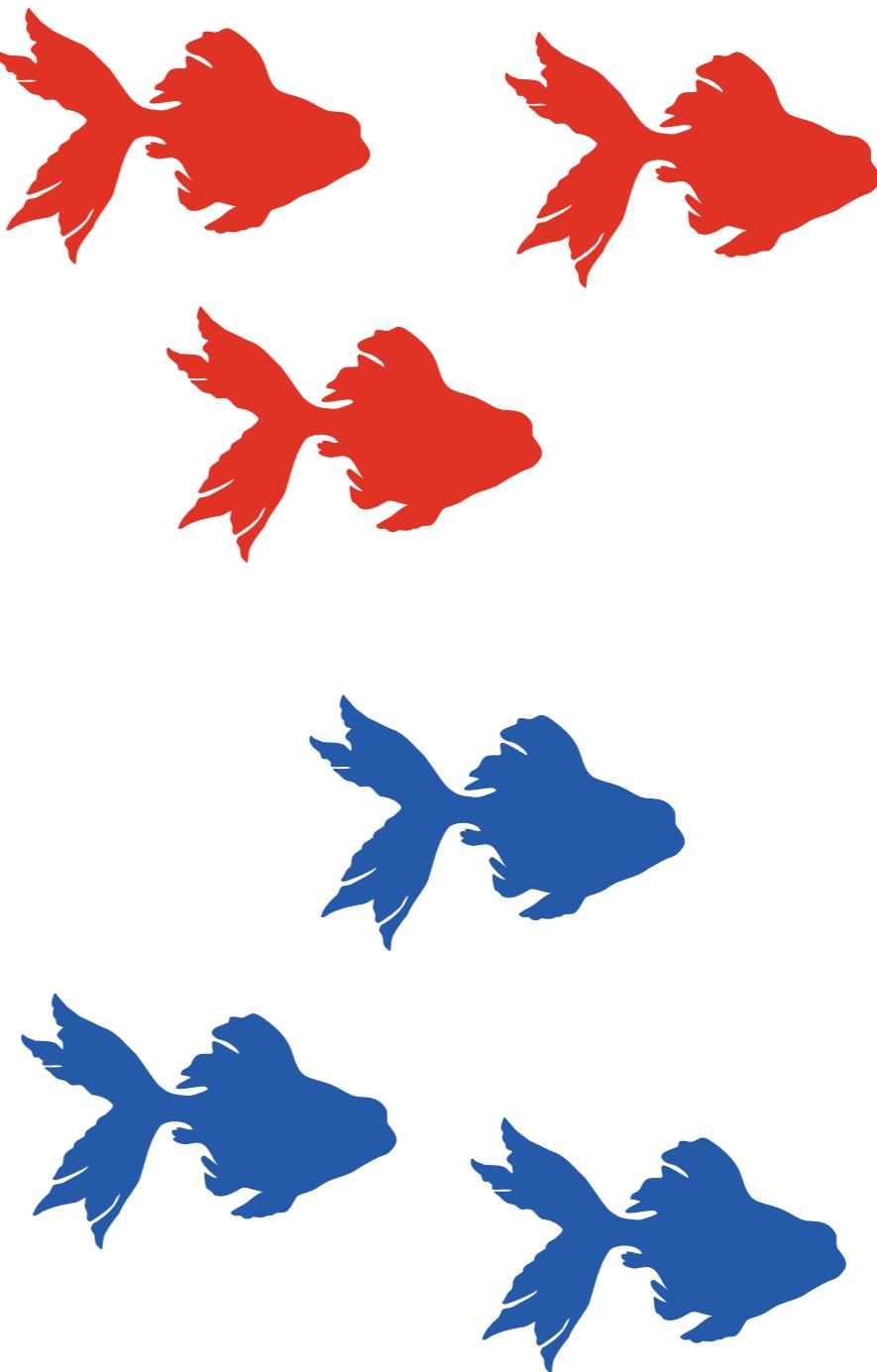
single asset CV

portfolio CV

Single asset



Diversified portfolio







COFFEE BAR			
HOUSE COFFEE	1.10	1.30	1.50
ESPRESSO	.75	1.25	HOT CHOCOLATE
CAPPUCCINO	1.90	2.50	1.60
CAFFE LATTE	1.95	2.60	2.25
CAFFE MOCHA	2.35	2.80	STEAMED MILK
CAFFE AU LAIT	1.80		1.80
CAFFE RICANA	2.45	3.20	TURKISH COFFEE
			1.90
All Drinks Available Grande (16 oz.) Add .50			
Whipped Cream, Syrup or Soya Milk Add .50			
Decaf and Iced Available Add .10			
COLD BEVERAGES			
SODA CAN	.75		BOTTLED WATER
SODA BOTTLED	1.25		MINERAL WATER
ICED TEA	1.35	1.60	.10
			.25

SMOOTHIES			
STRAWBERRY ORANGE	2.85	3.25	
FRESH STRAWBERRIES, Orange Sorbet, Blended with Apple Juice or Milk			
WILD BERRY	2.85	3.25	
FRESH BERRIES, Raspberry Sorbet, Blended with Apple Juice or Milk			
CHOCOLATE BANANA	2.85	3.25	
Chocolate Sorbet, Banana, Blended with Milk			
PEACH MELBA	2.85	3.25	
Peaches, Raspberry Sorbet, Blended with Apple Juice or Milk			
MIDNIGHT PEACH	2.85	3.25	
Peaches, Blackberry Sorbet, Blended with Apple Juice or Milk			
RED, WHITE & BLUE	2.85	3.25	
Strawberries, Bananas, Blueberries and Non-Fat Vanilla Yogurt, Blended with Apple Juice or Milk			
FRESH ORANGE			
FRESH APPLE			
FRESH CARROT			
APPLE CARROT			
ORANGE APPLE			
CANTALOUPE			
& WATERMELON			

ICE CREAM from DOUBLE RAINBOW			
SMALL	2.25	HAND PICKED PINT	4.65
REGULAR	2.75	HAND PICKED Q	5.95
LARGE	3.25		
SPECIALTY Sundaes			
10 FT FUDGE SUNDAE			
2 Pint Chocolate Sorbet, Non-Fat Whipped Cream, Chocolate Syrup and a Large Spoonful of Hot Fudge Sundae Topped with Shakes of Bacon			
BANANA HOT FUDGE SUNDAE			
Banana Fudge Sundae Topped with Shakes of Bacon			
BANANA SPLIT			
A Traditional Favorite, Best Described as Amazing			
FROM THE FOUNTAIN			
MILKSHAKE or MILK 3.85		ESPRESSO SHAKE	3.85
2 Milk or Dairy Beverage		Fresh Milk or Ice Cream Topped with Shakes of Bacon	
NUT		Topped with Whipped Cream, Vanilla and Bacon	
WATER		Vanilla and Bacon	
SCUBBY FREEZE	3.75		
Smoothie with Shakes of Bacon Frozen with Shakes of Bacon			
TORANI ITALIAN SOFA			
A Sophisticated Soda Available in a Wide Variety of Flavors			

BAGEL SANDWICHES

POPULAR CHEESE SPREADS	
VEGETABLE	1.95
SUN-DRIED TOMATO	1.95
HERB GARLIC	1.95
PLAIN	1.95
*	
BUILD YOUR OWN CREAM-CHEESE CREATION	
You Choose of Cream Cheese	

COFFEE BAR

Now Serving:

FRENCH RIVIERA
FRENCH DARK ITALIAN
VIENNESE

NUT
WATER





Frank Angelo, 1922
70-3849

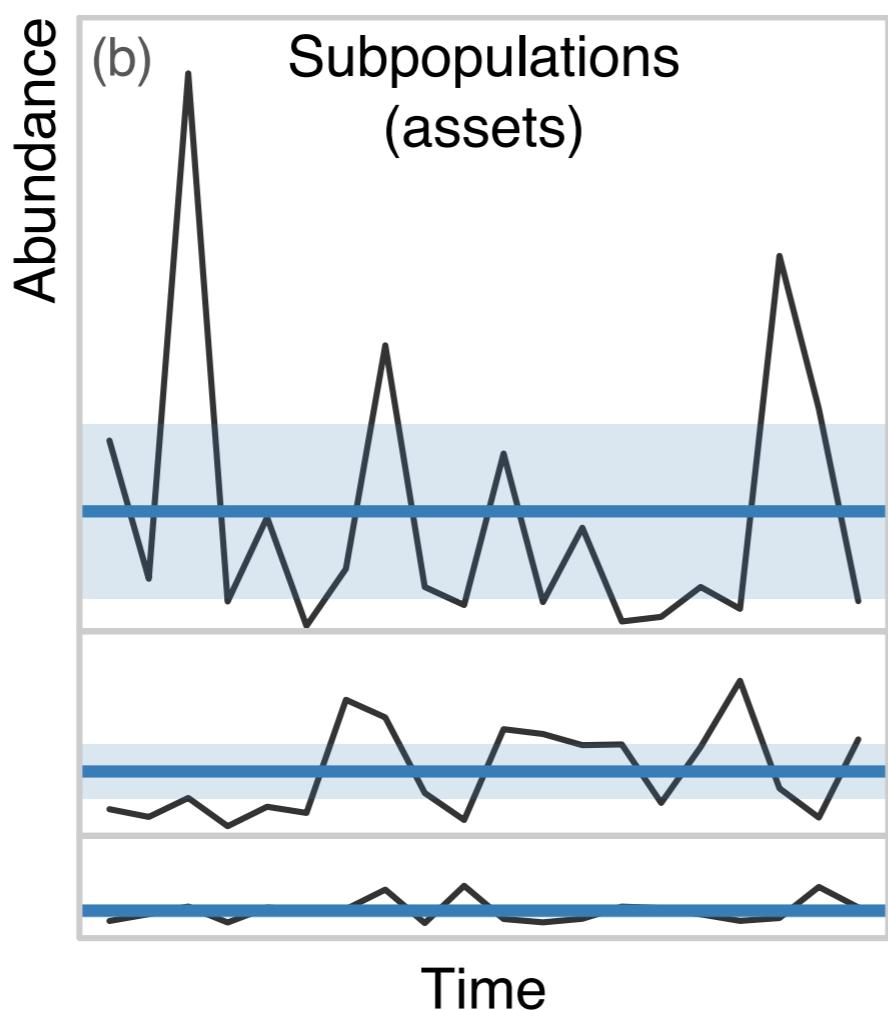


Taylor 2007, J. Anim. Ecol.

Roy (L. R.) Taylor (1924–2007)

Taylor's power law

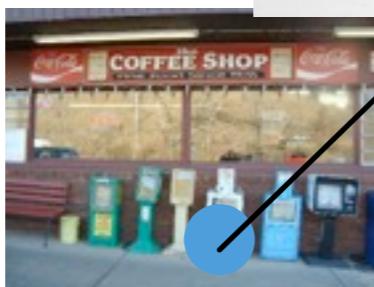
variance = c · mean^z



$\log(\text{variance})$

$\log(\text{mean})$

?

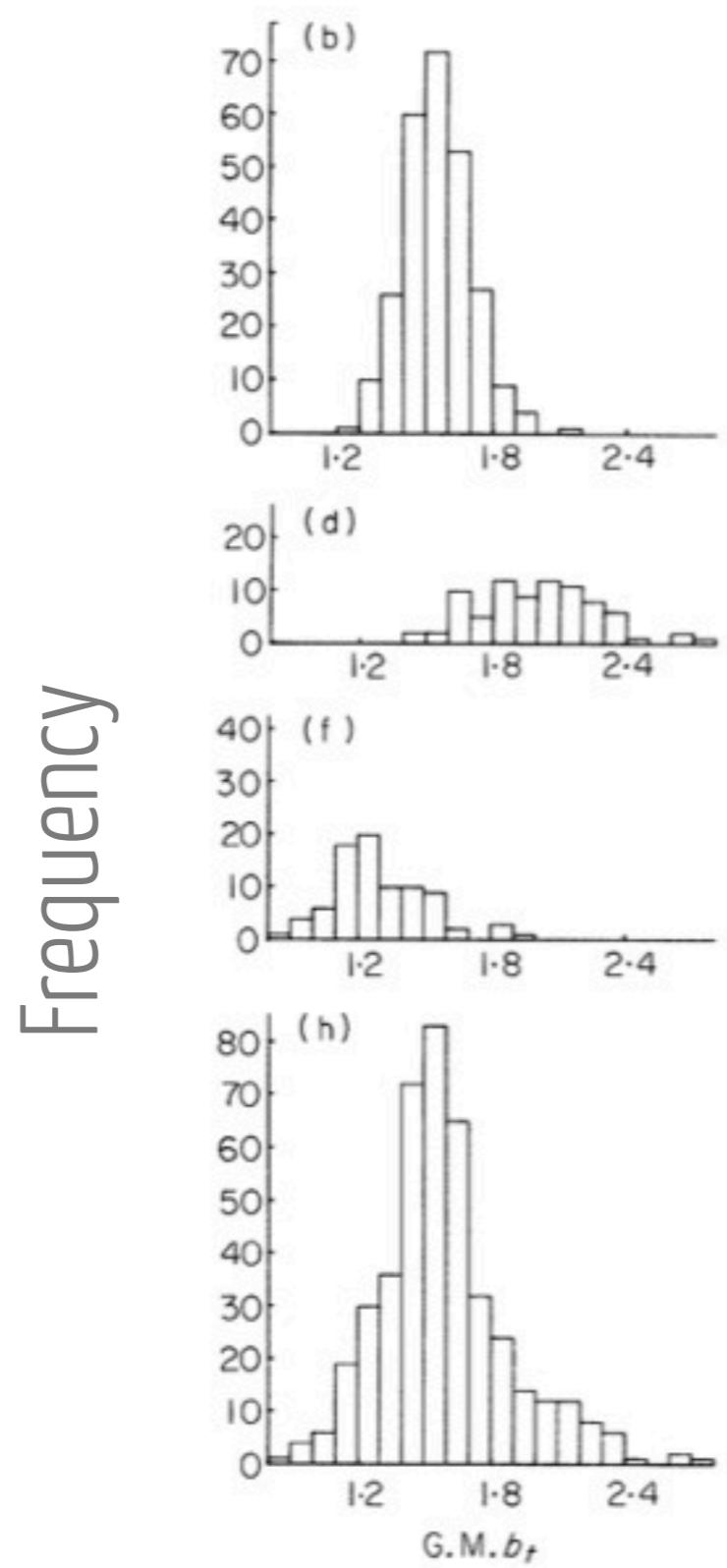


Taylor's power law

variance = c · mean^z

Taylor's power law

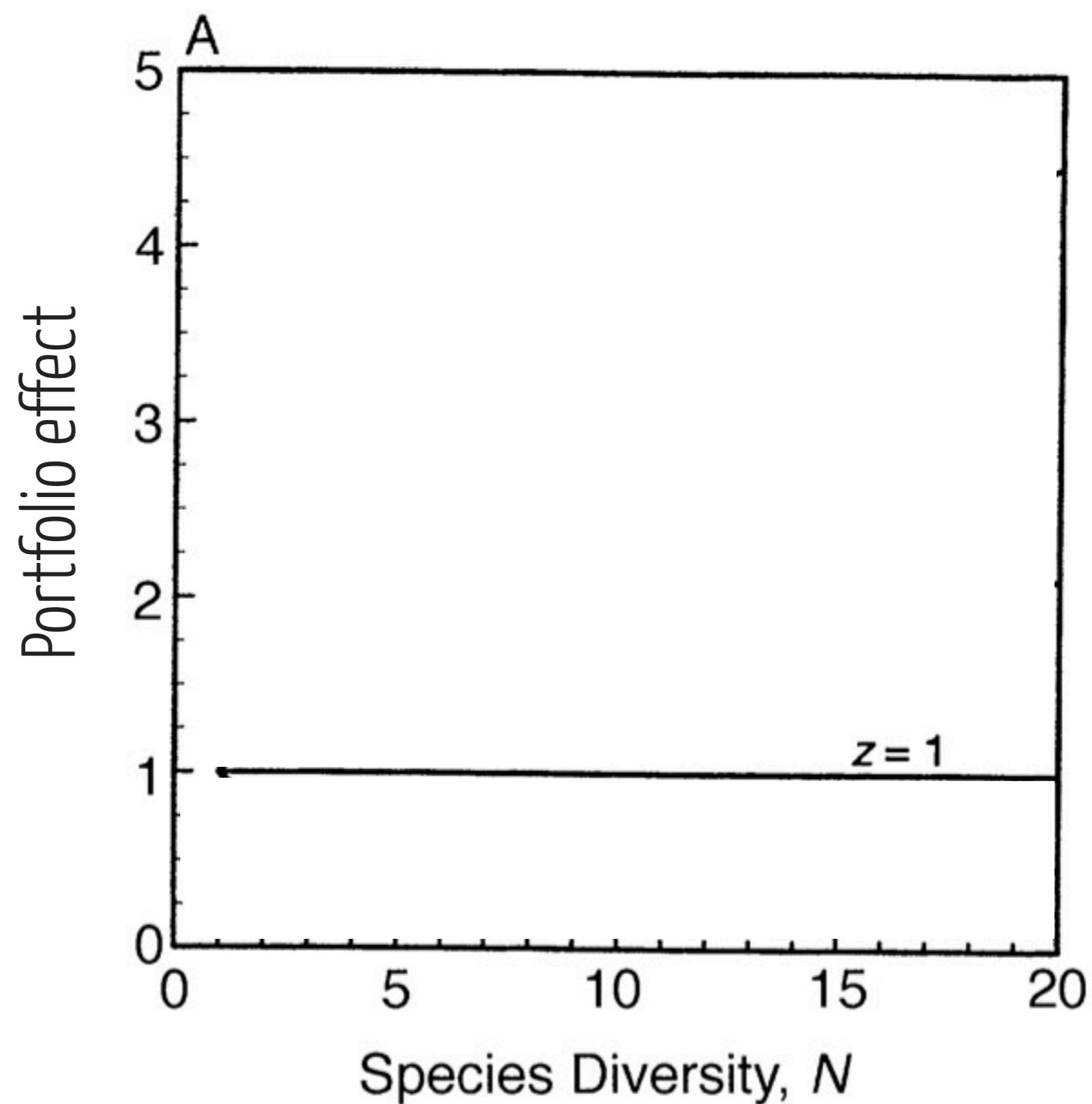
$$sd^2 = c \cdot \text{mean}^z$$



z value



Taylor et al. 1982, J. Anim. Ecol.



Tilman 1999, Ecology

But what if you assume $z = 2$?

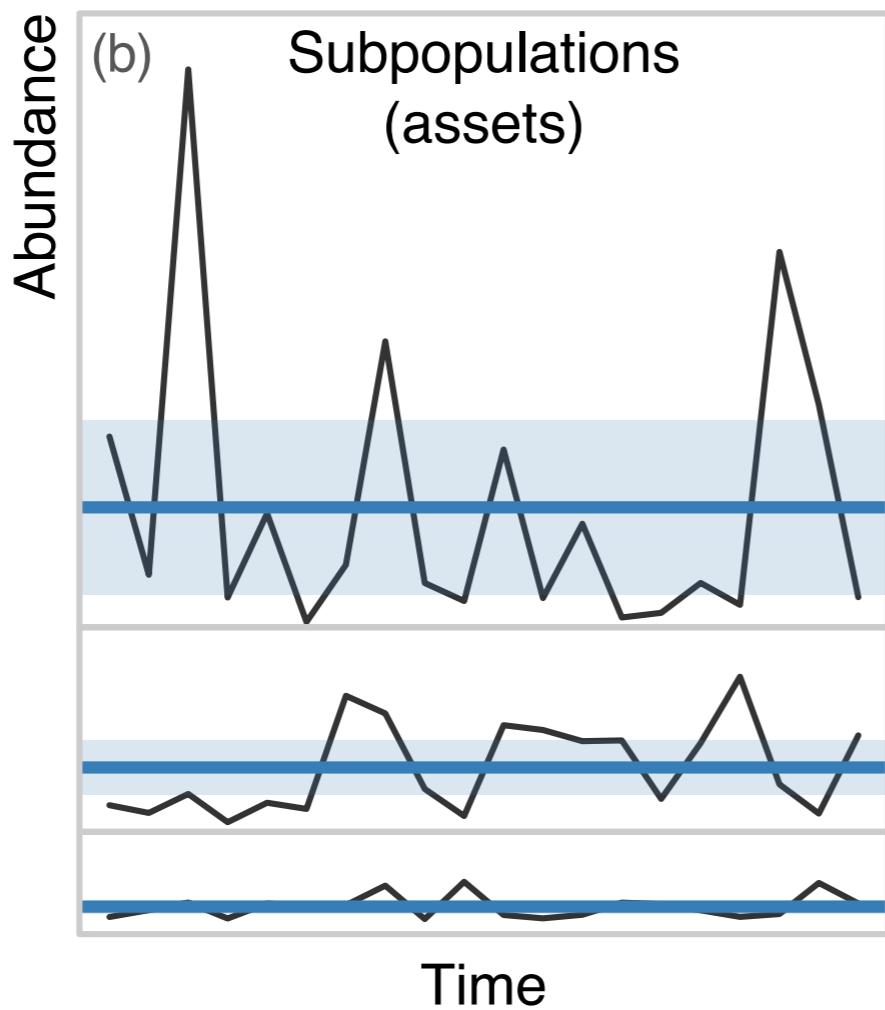
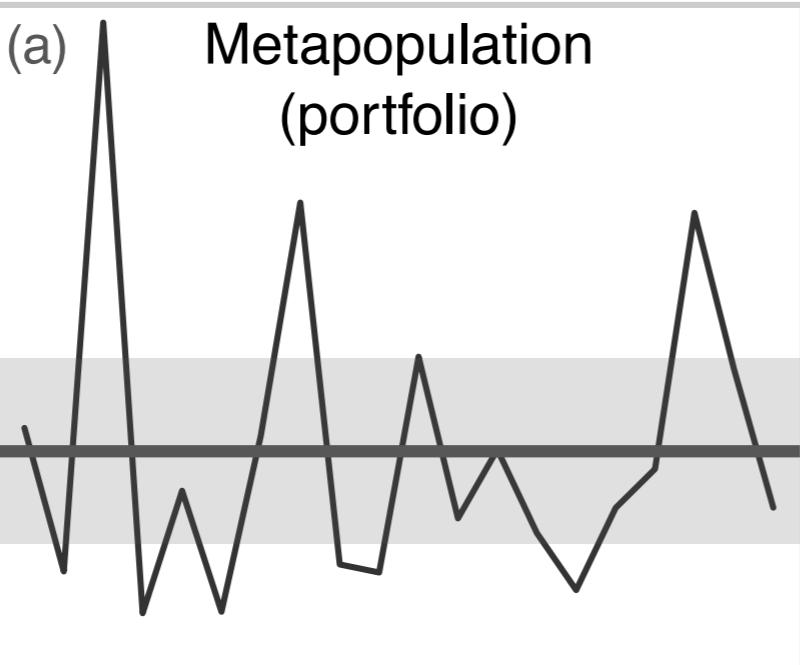
VOL. 151, NO. 3 THE AMERICAN NATURALIST MARCH 1998

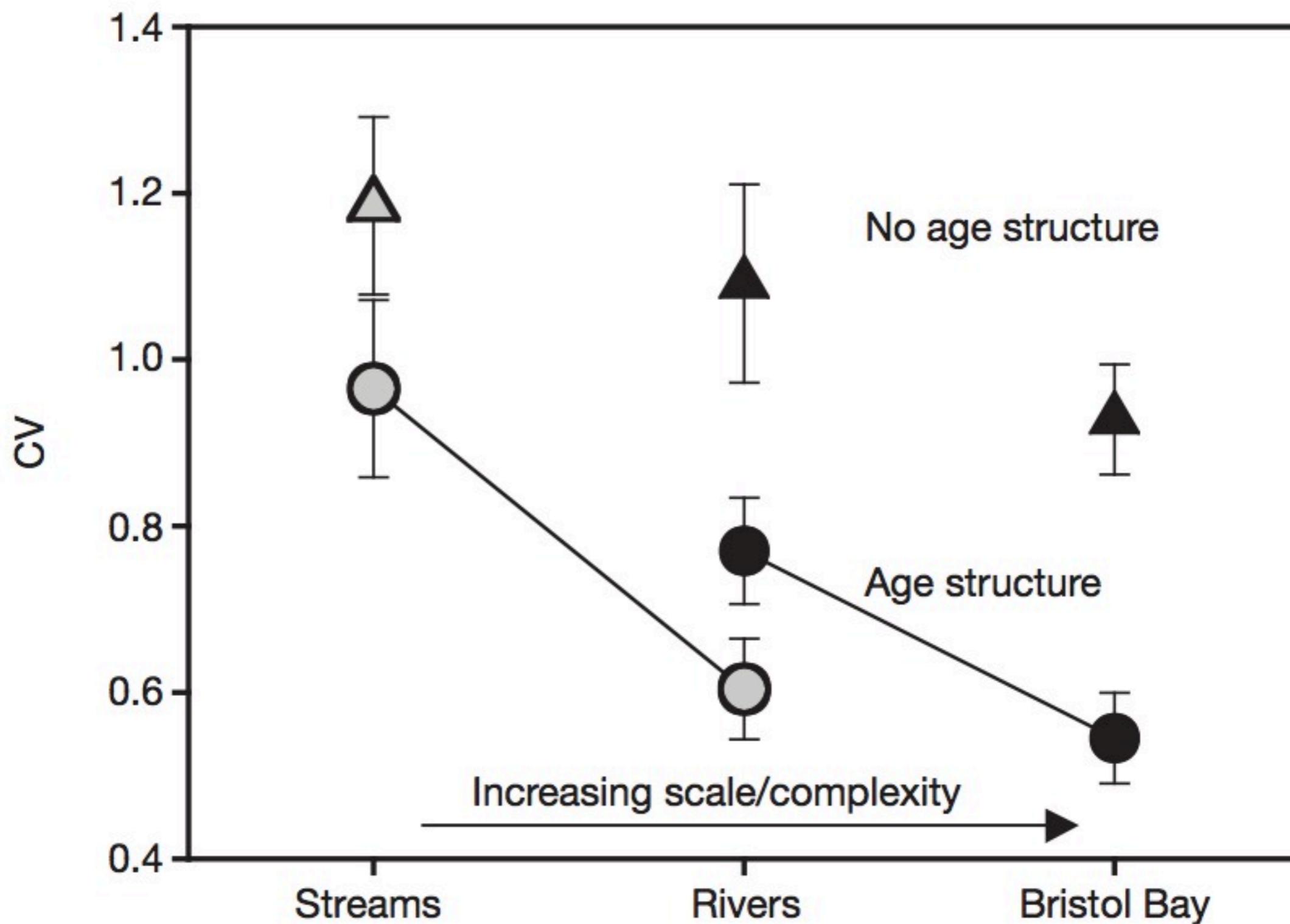
The Statistical Inevitability of Stability-Diversity Relationships in Community Ecology

D. F. Doak,* D. Bigger, E. K. Harding, M. A. Marvier, R. E. O'Malley, and D. Thomson†

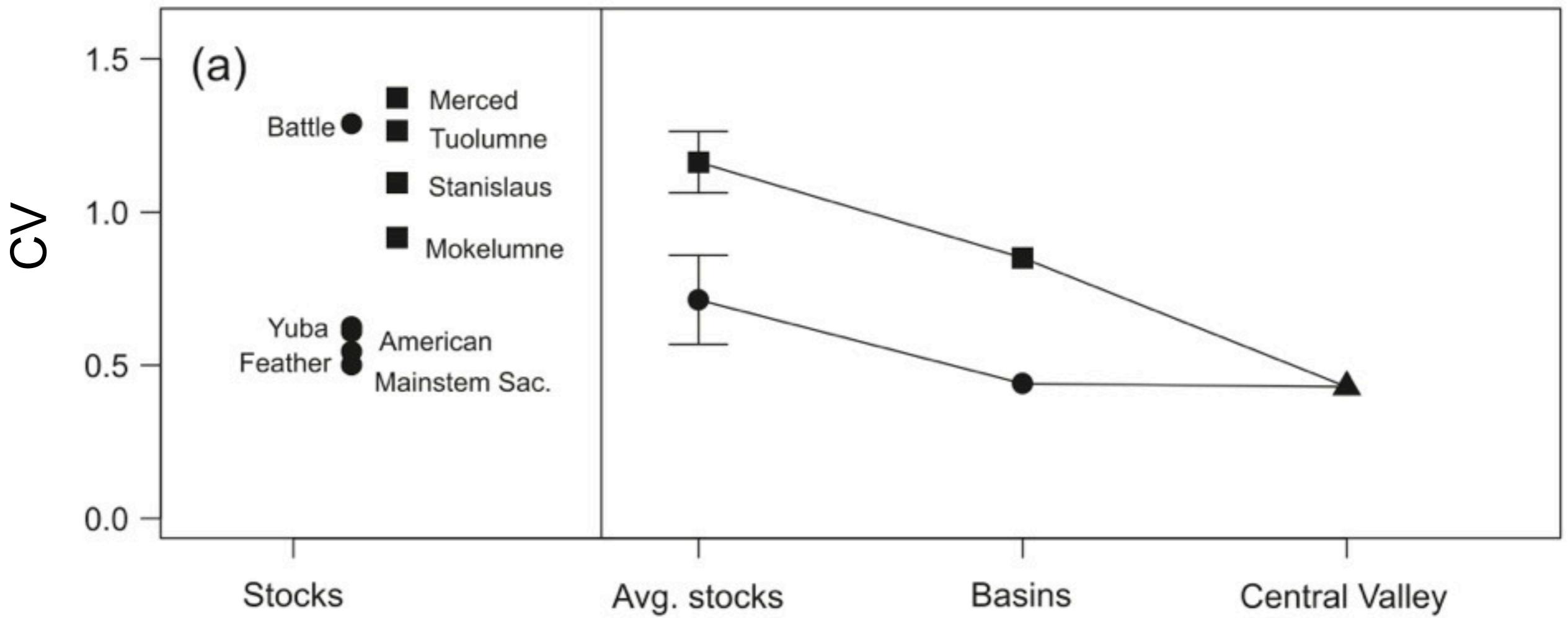


PE data





Schindler et al. 2010, Nature



Mean-variance portfolio effect



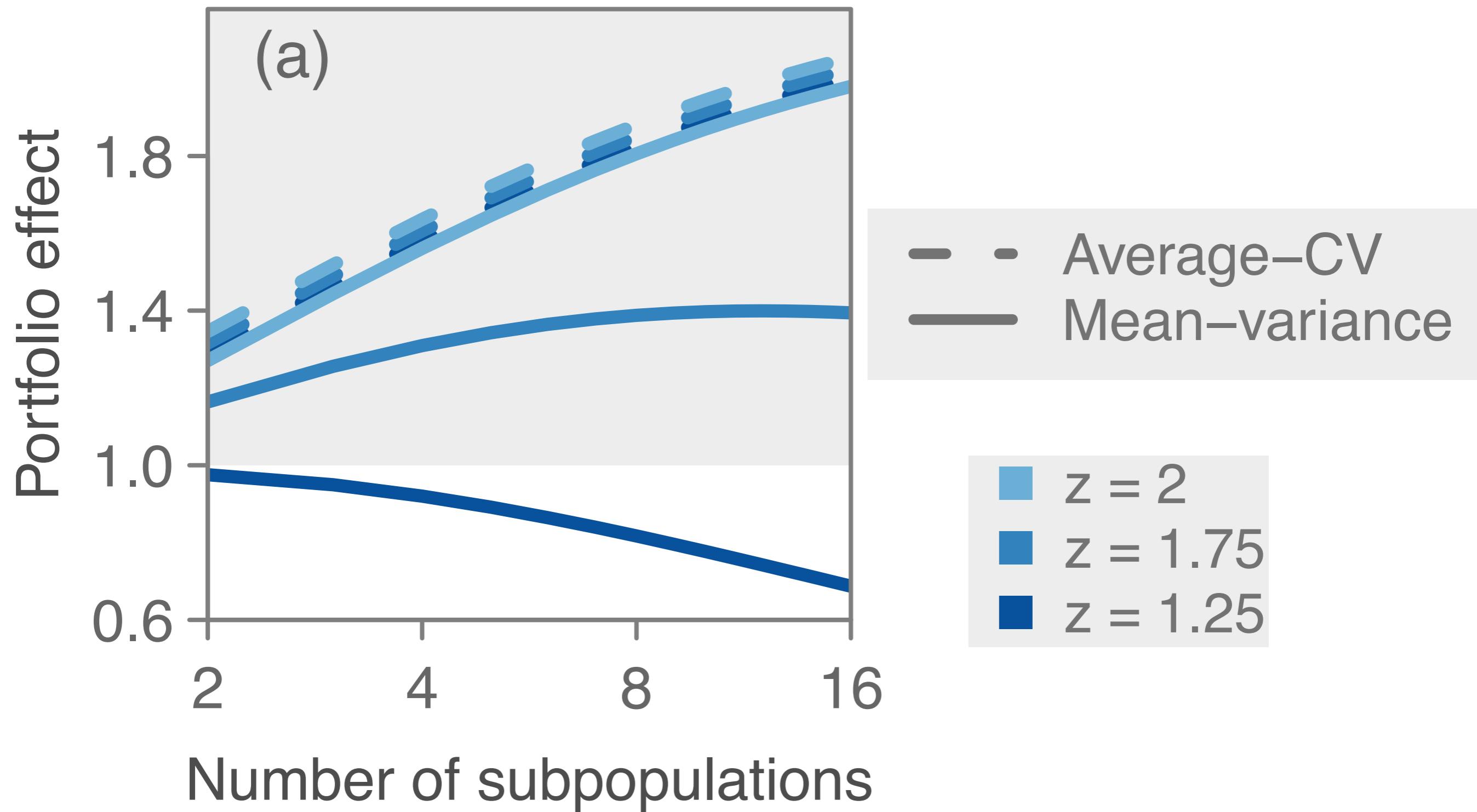
Average-CV portfolio effect



1. How does the average-CV and mean-variance portfolio effect differ when applied to **theoretical systems** with varying z values?

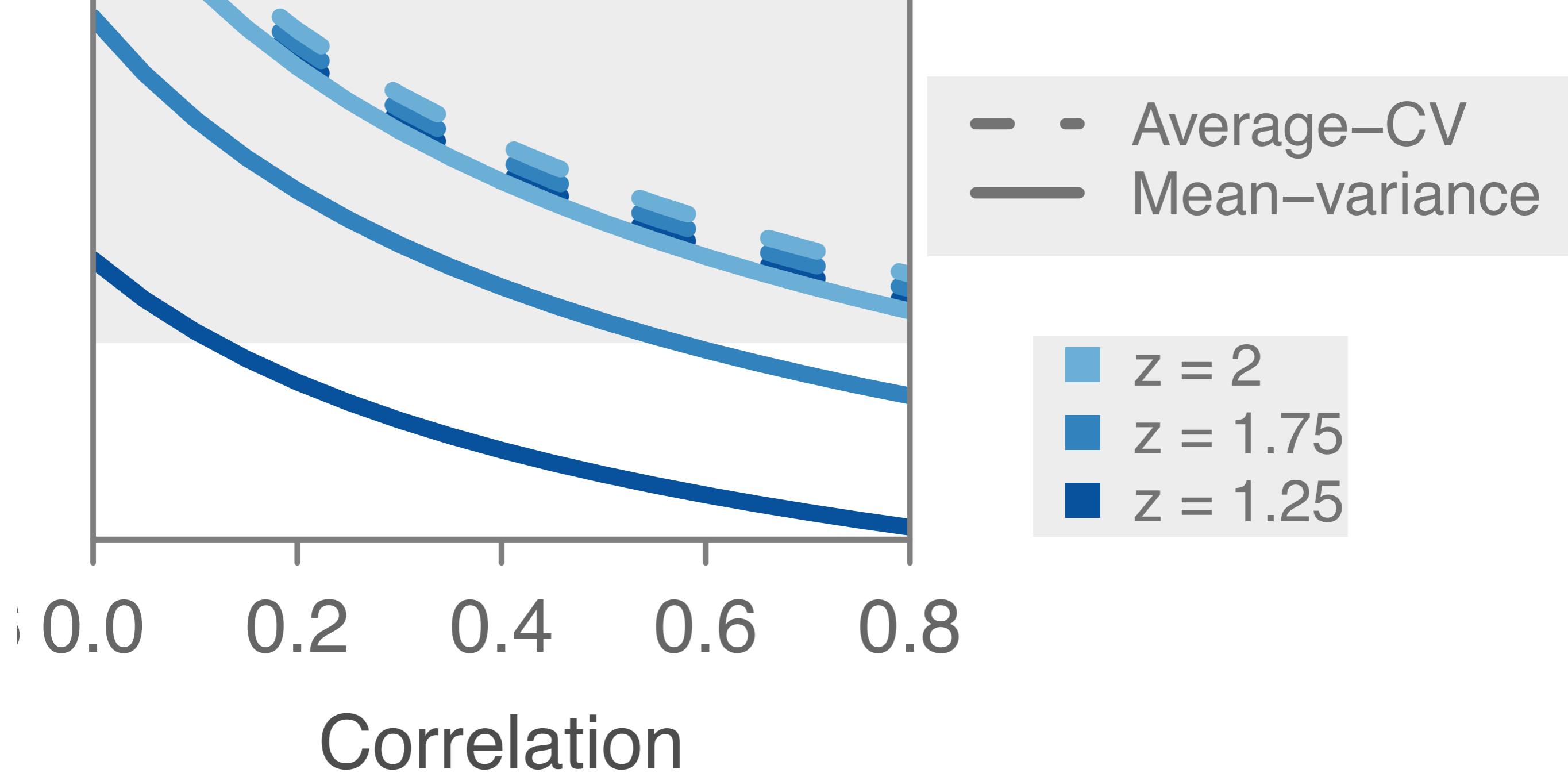
2. How prevalent and strong is this difference **across 51 metapopulations** and 1070 subpopulations of salmon, moths, and reef fishes?

3. Despite its stronger theoretical foundations, is the mean-variance portfolio effect a reliable empirical metric of how population diversity benefits stability?



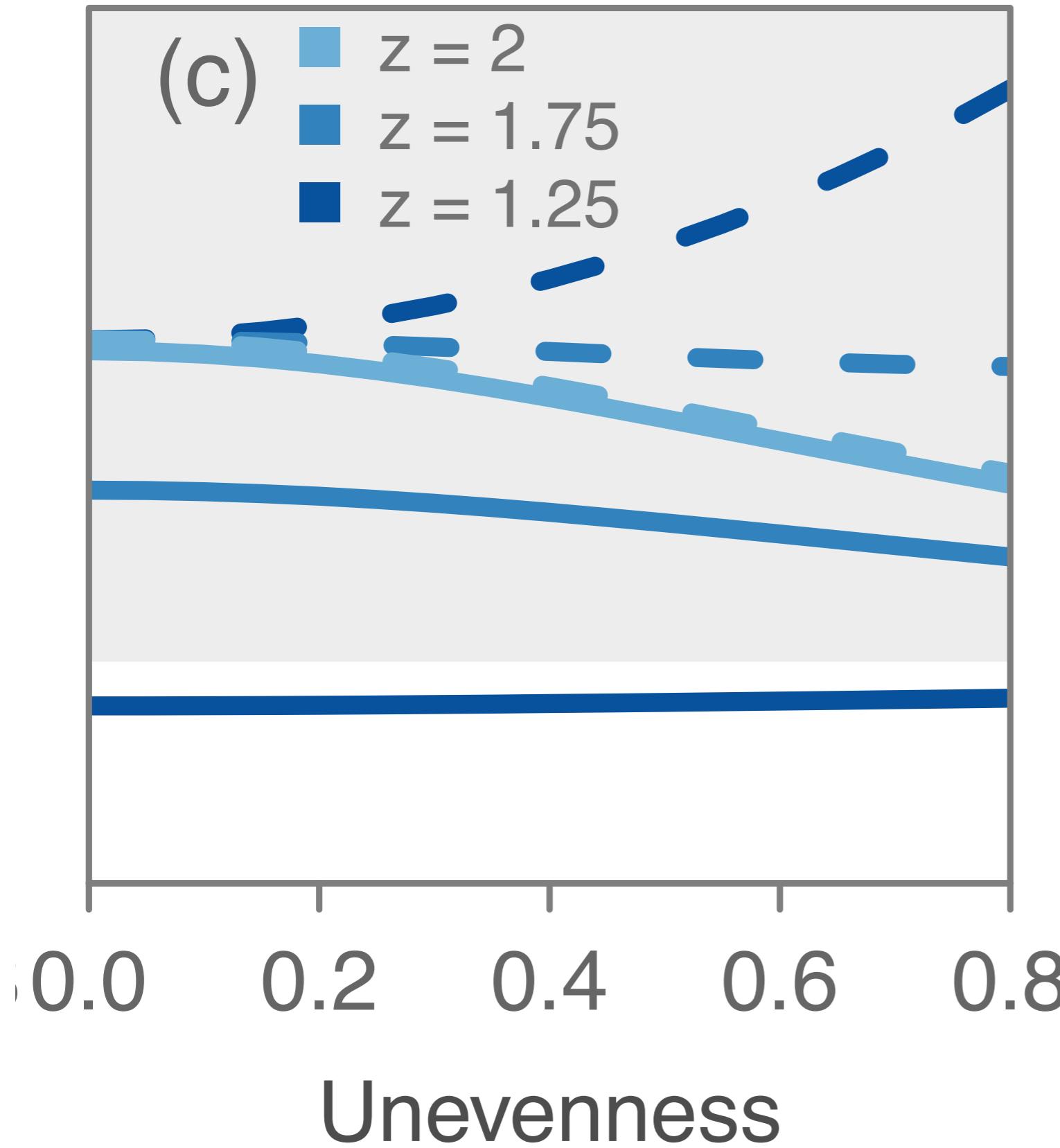
(b)

Average-CV
Mean-variance



(c)

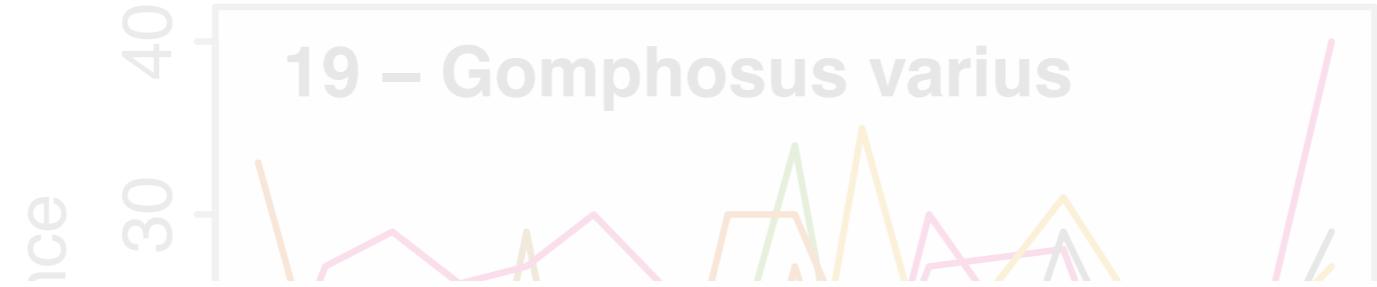
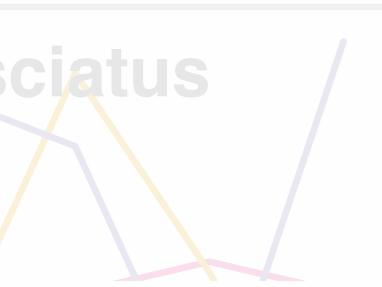
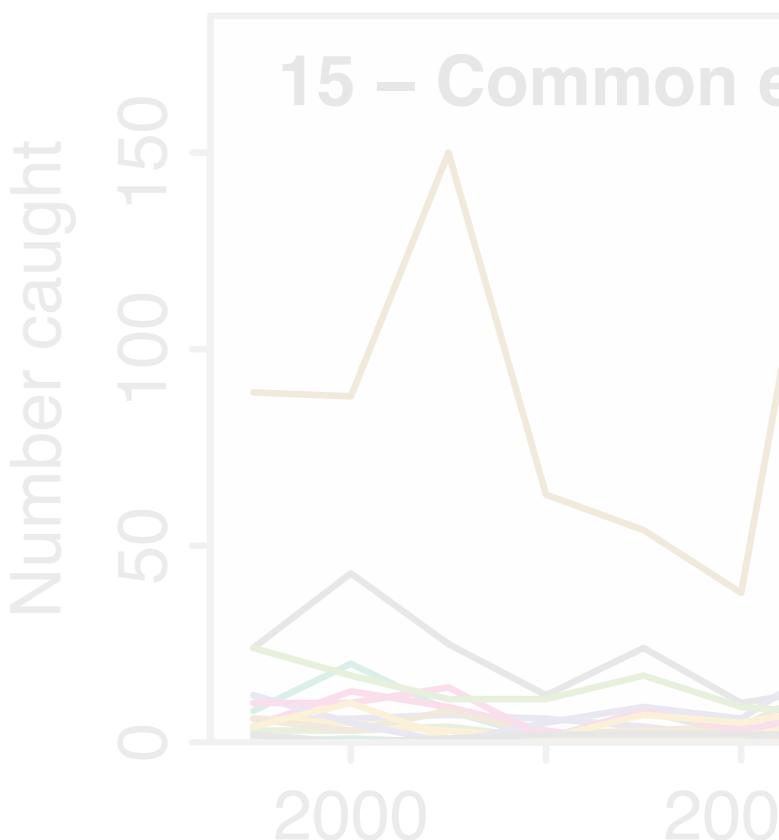
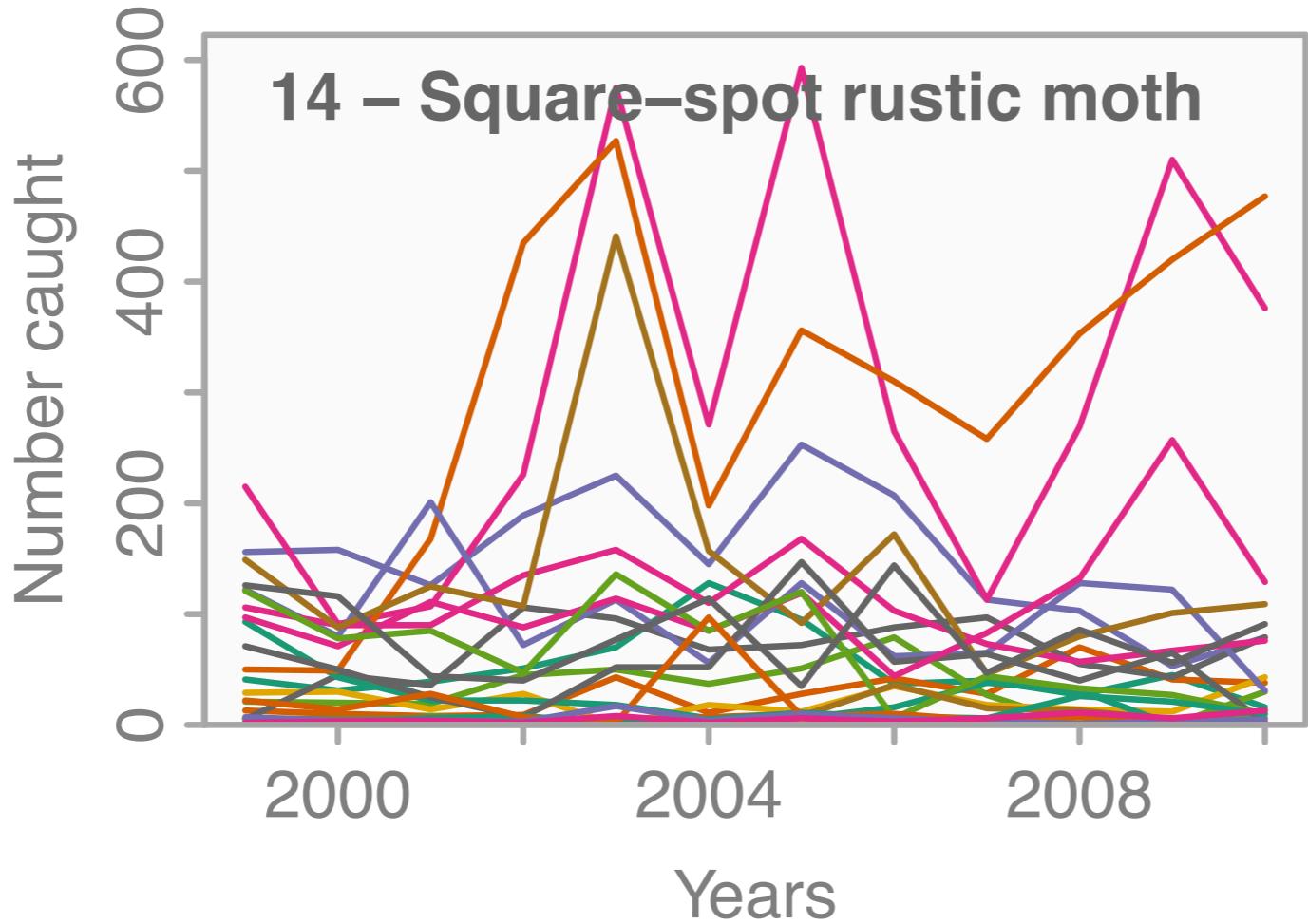
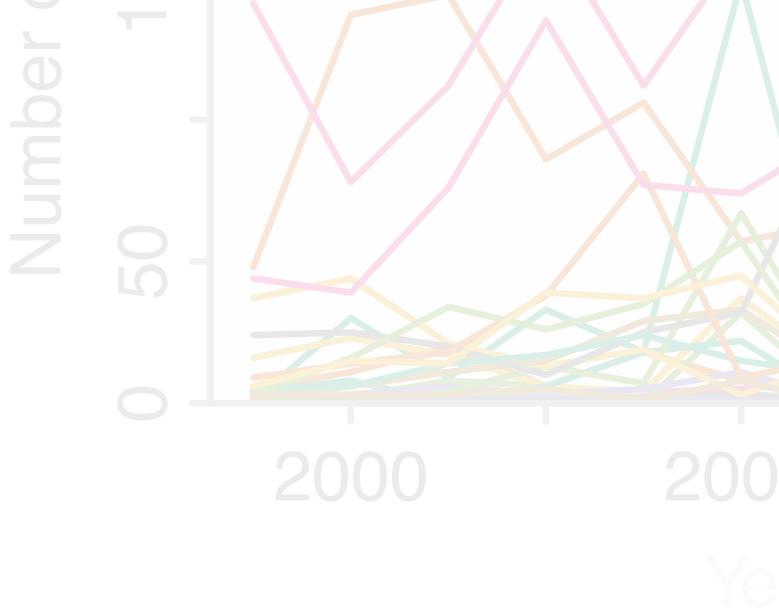
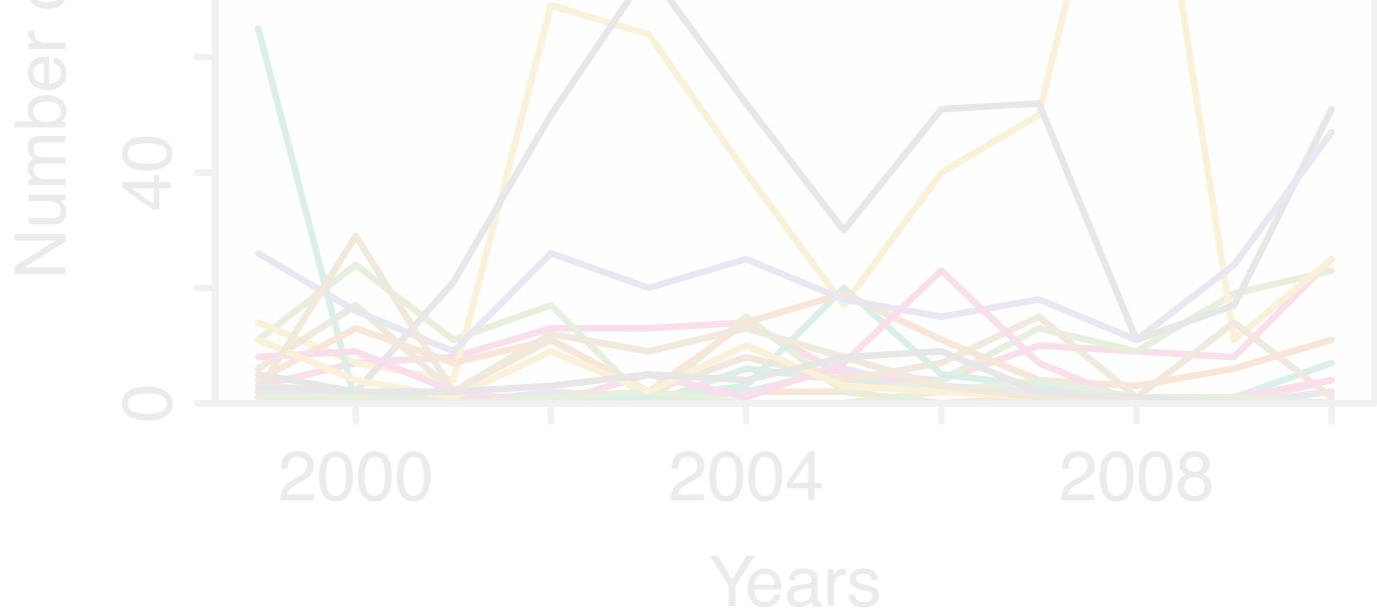
- \square $z = 2$
- \square $z = 1.75$
- \blacksquare $z = 1.25$

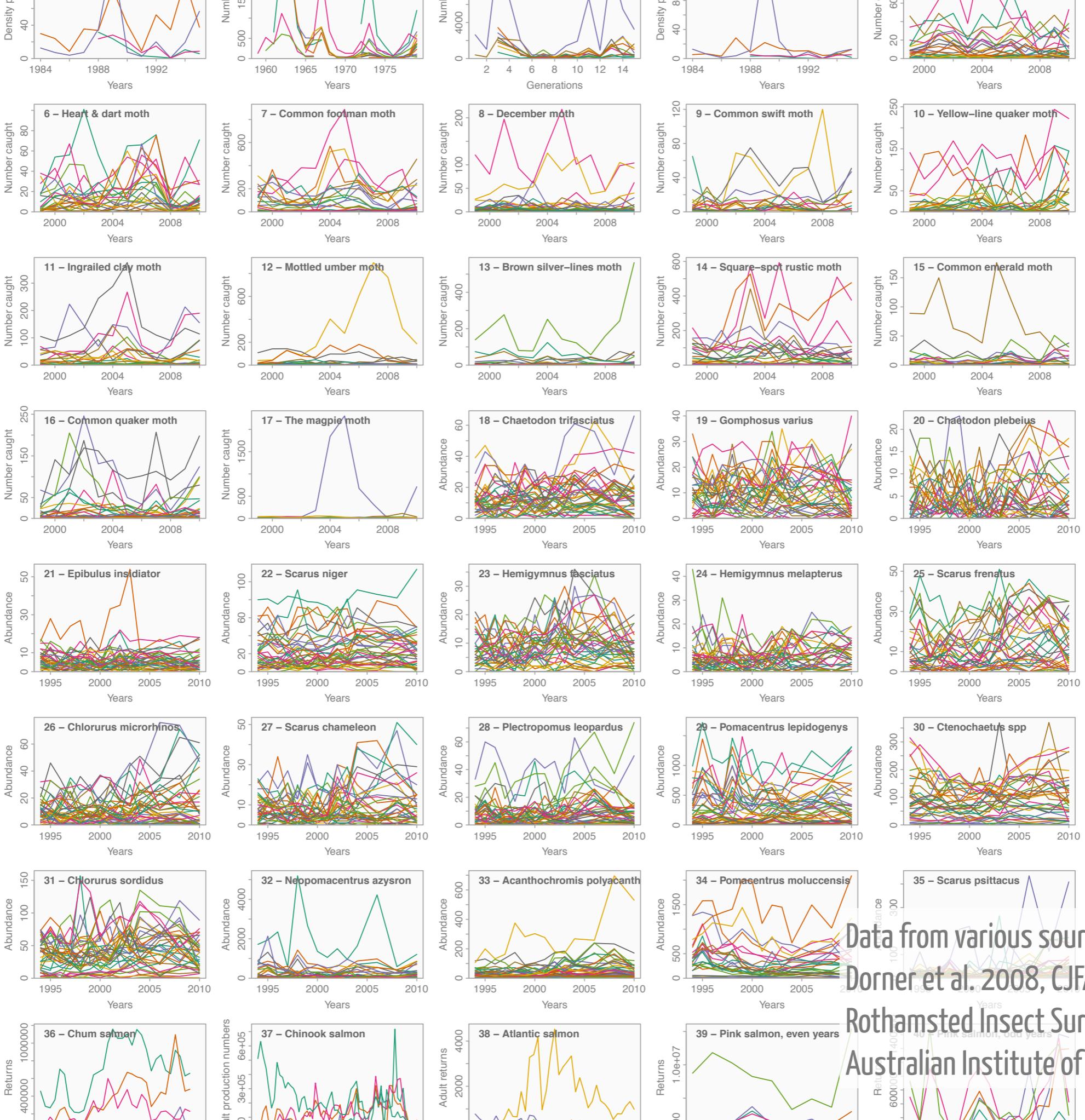


- - Average-CV
— Mean-variance

- \square $z = 2$
- \square $z = 1.75$
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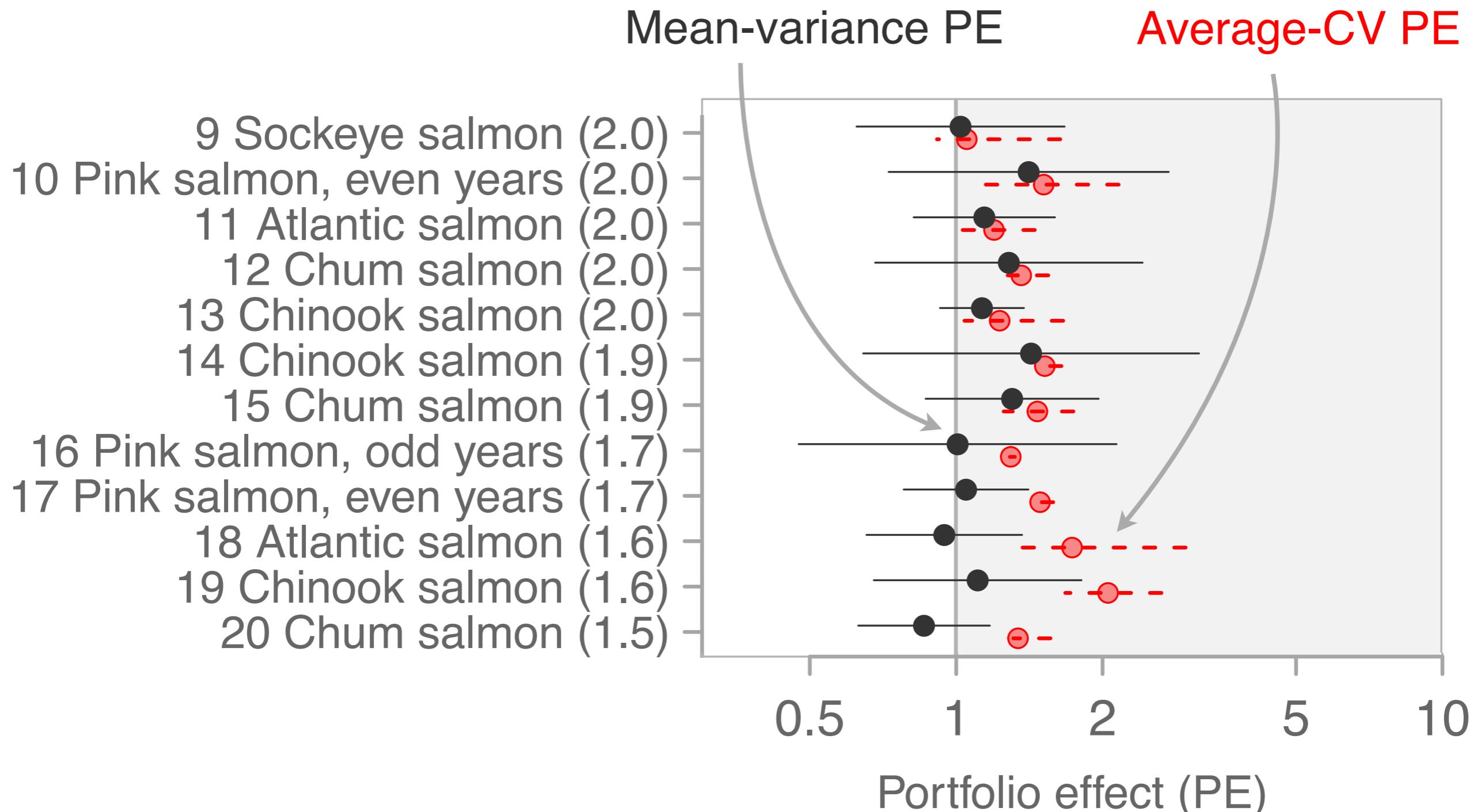


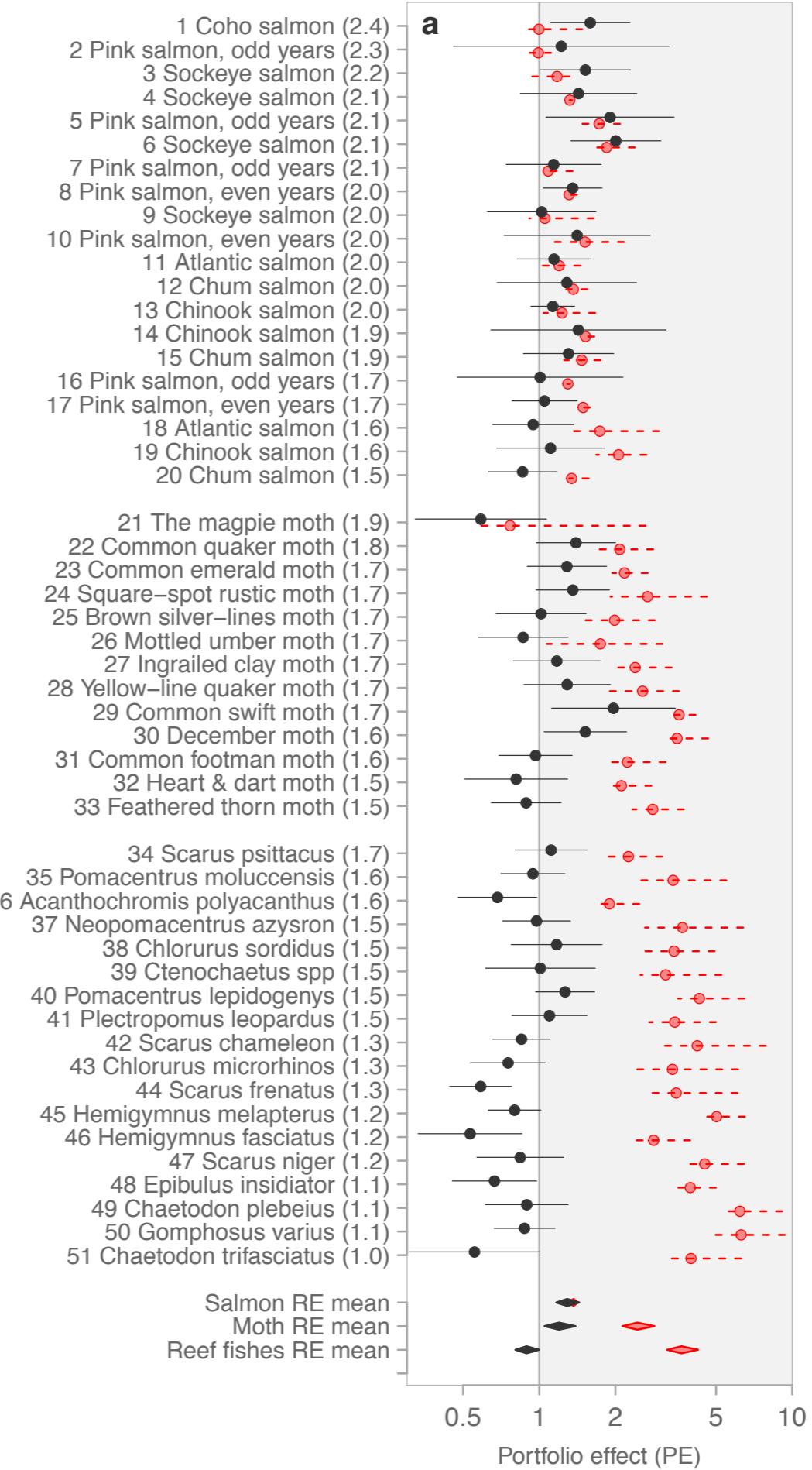
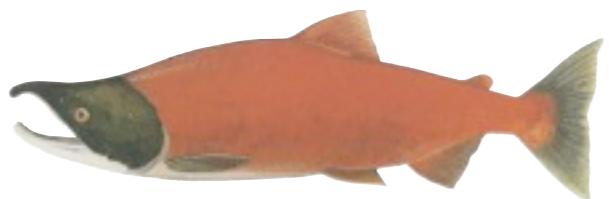


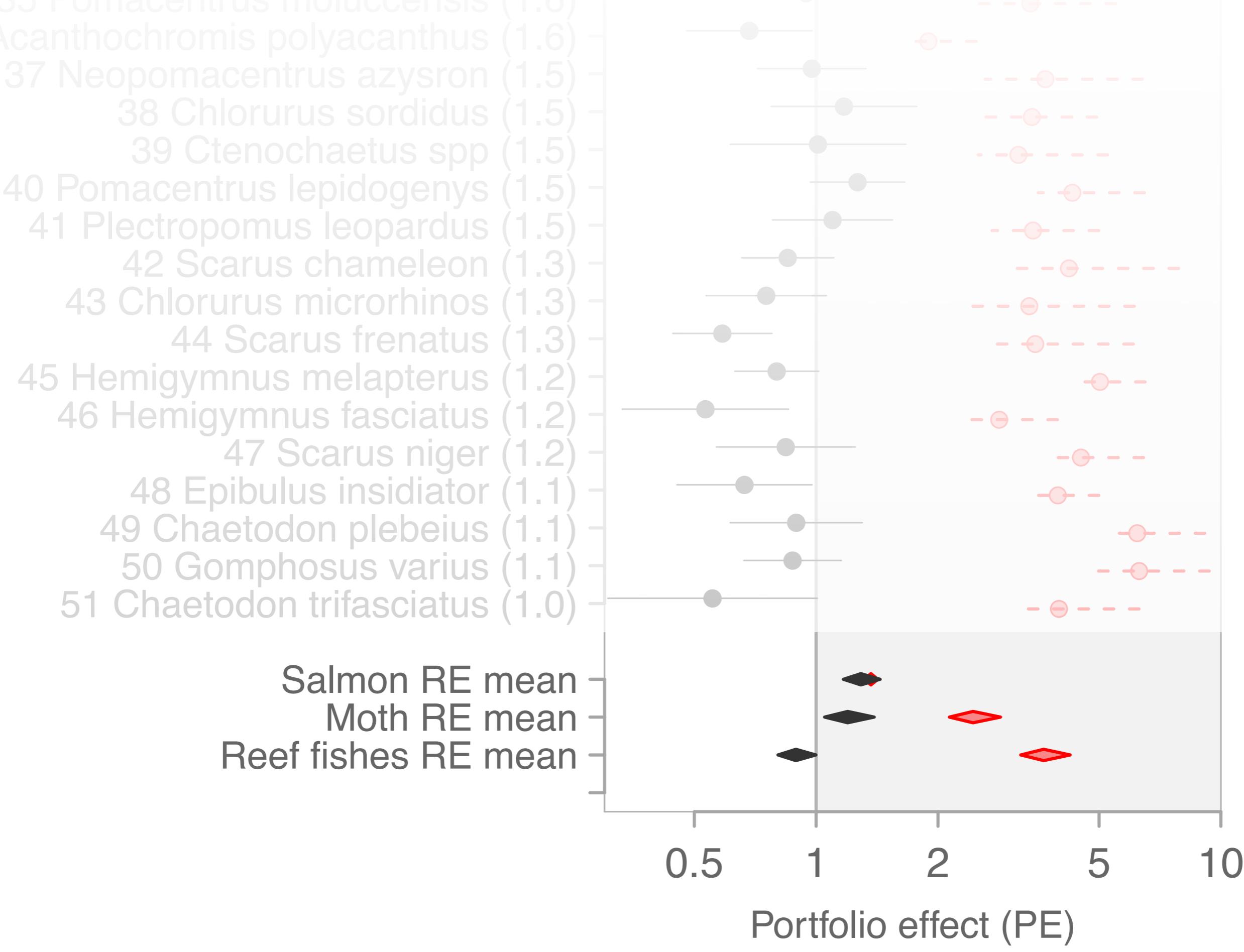


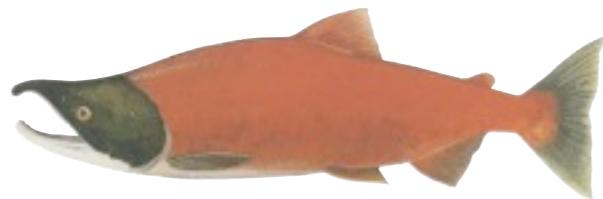
Data from various sources including:
Dorner et al. 2008, CJFAS

Rothamsted Insect Survey
Australian Institute of Marine Science

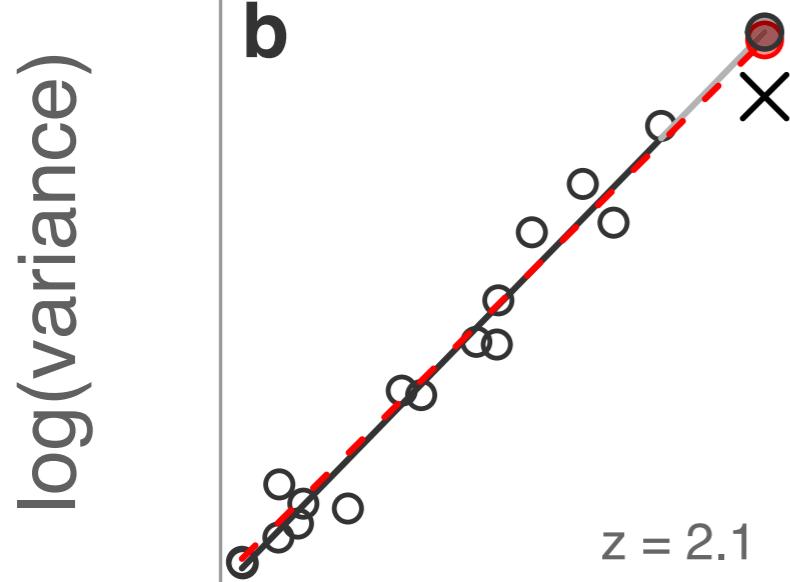




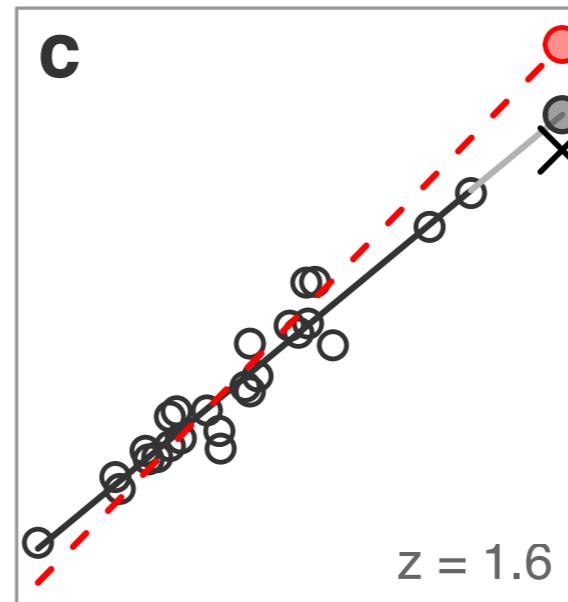




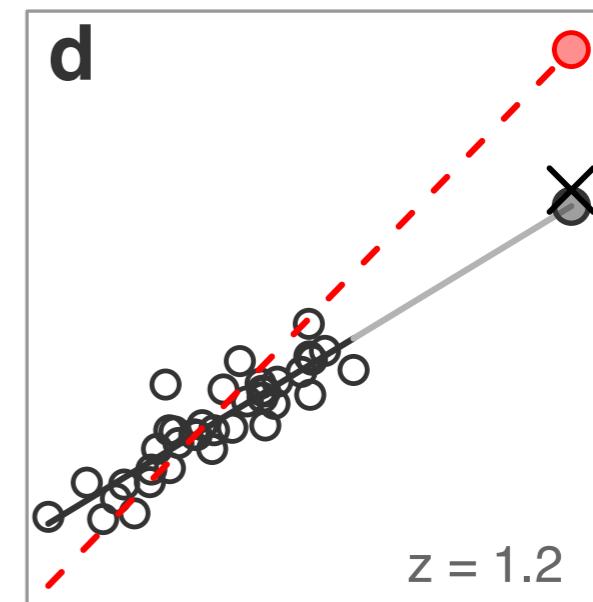
Salmon



Moths



Reef fishes

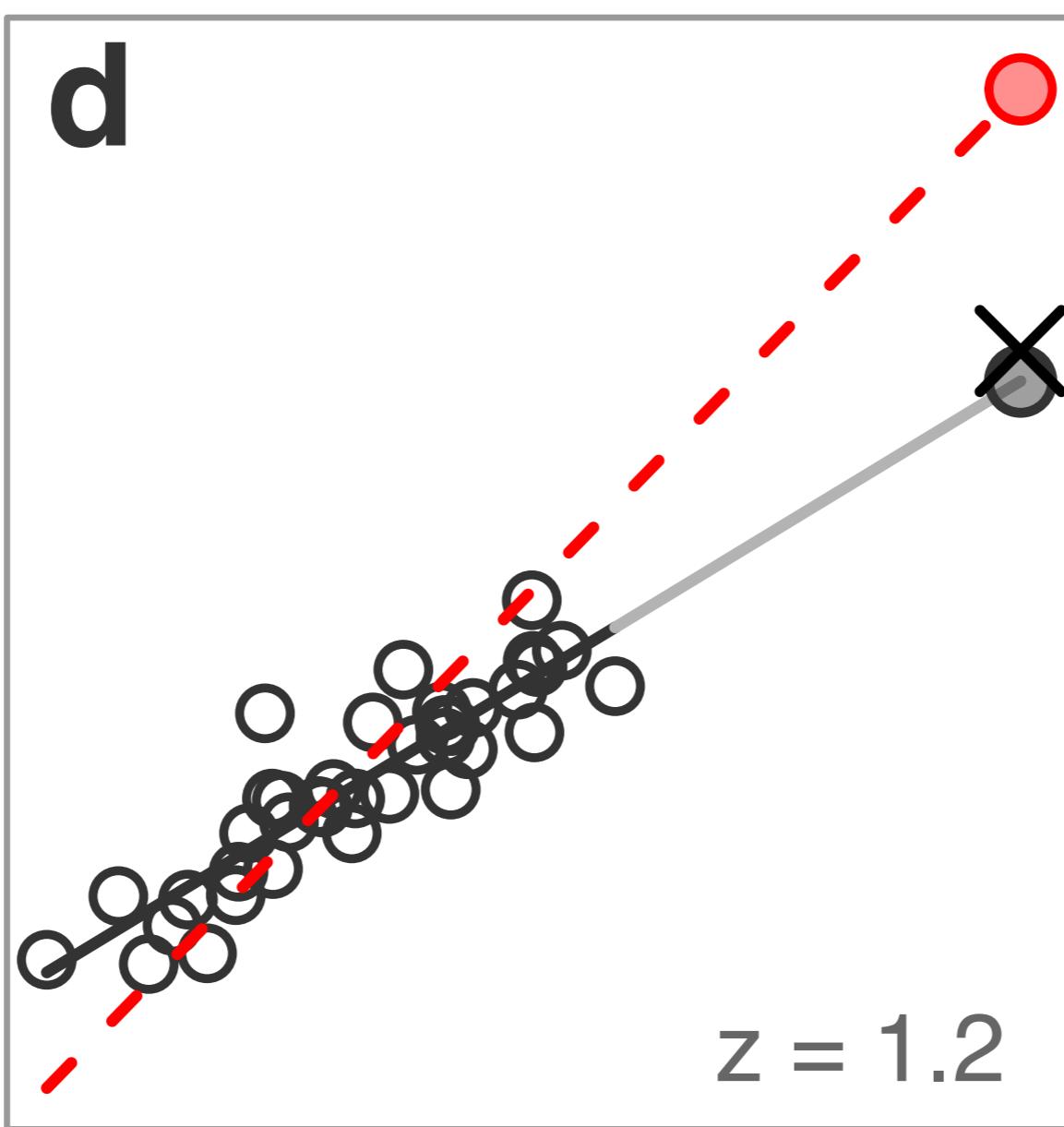
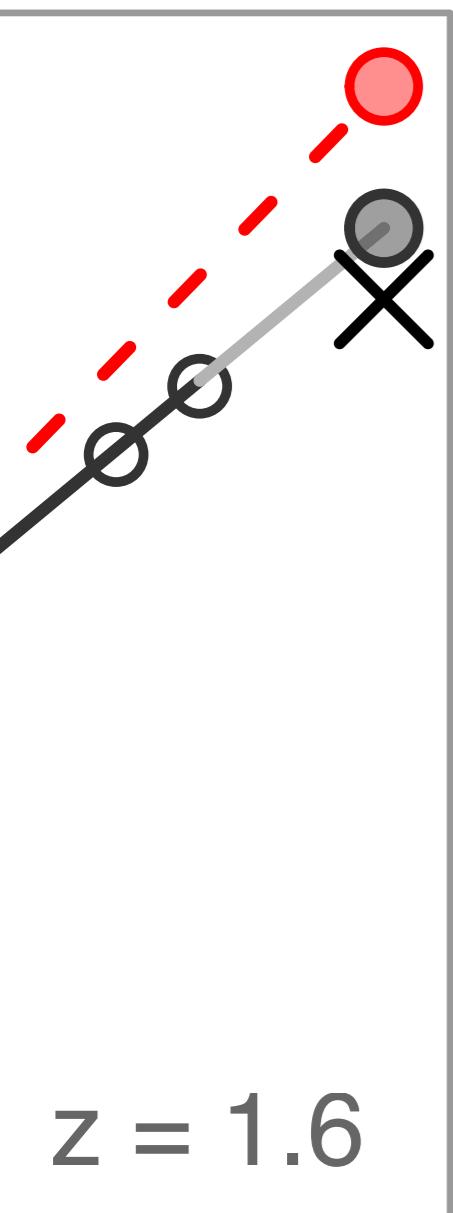


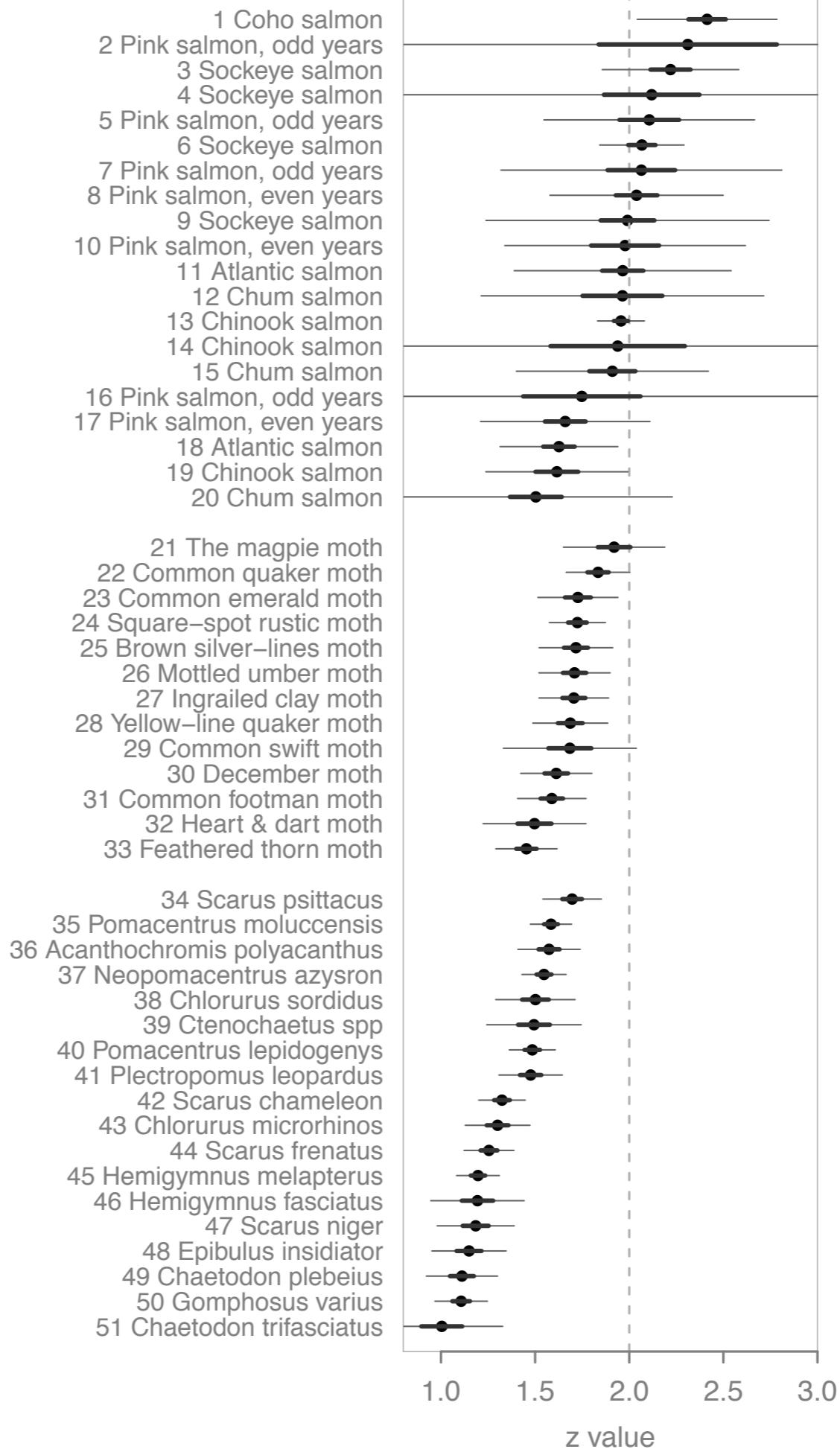
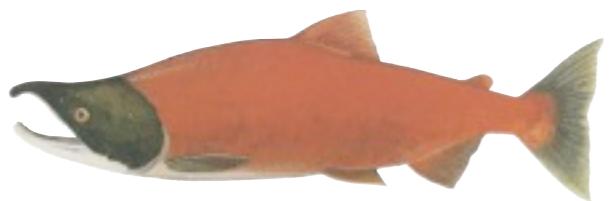
$\log(\text{mean})$

—●— Mean–variance PE
- - o - Average–CV PE

X \otimes Metapopulation
Subpopulations

Reef fishes





1. Mean-variance relationship

2. Number

3. Correlation

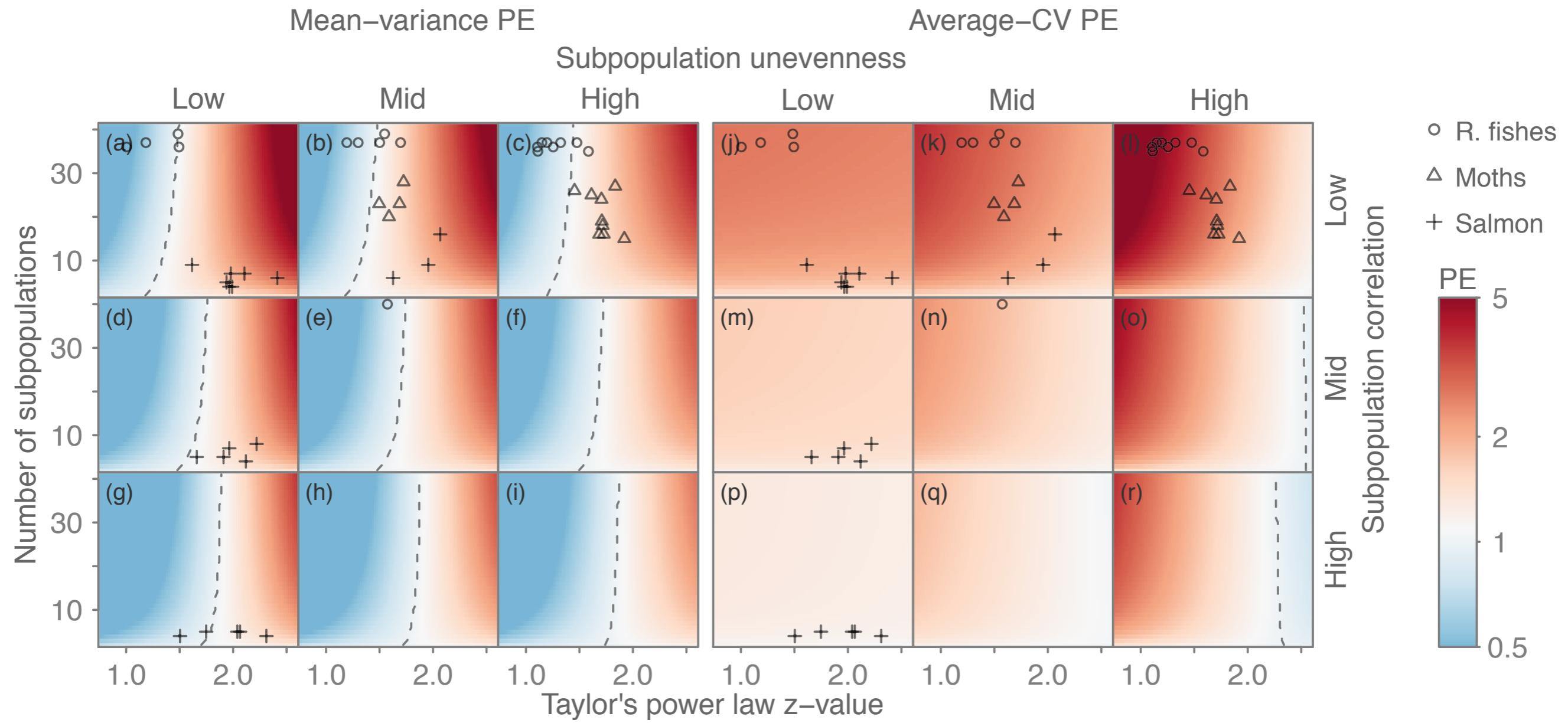
4. Evenness

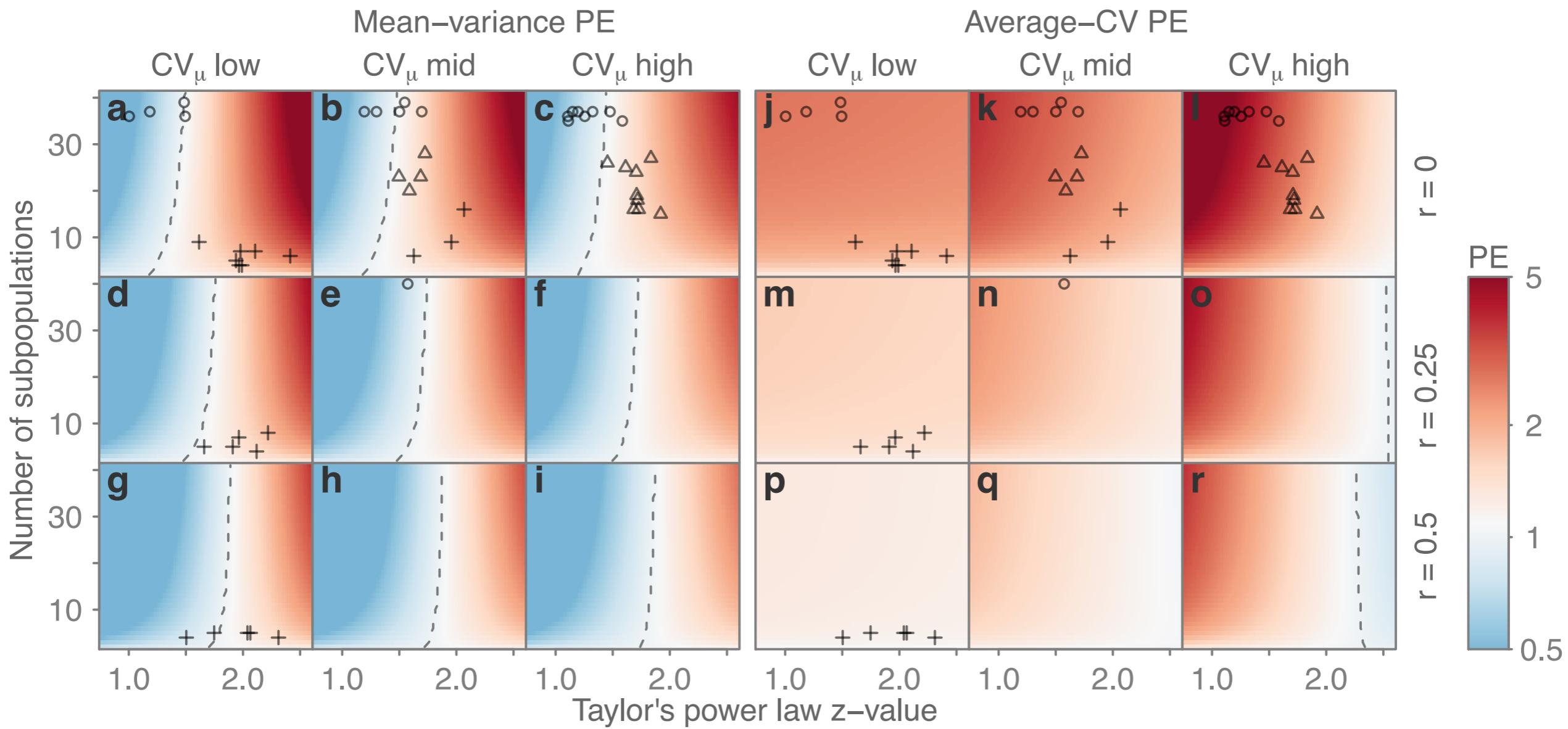


Mean-variance PE

Average-CV PE

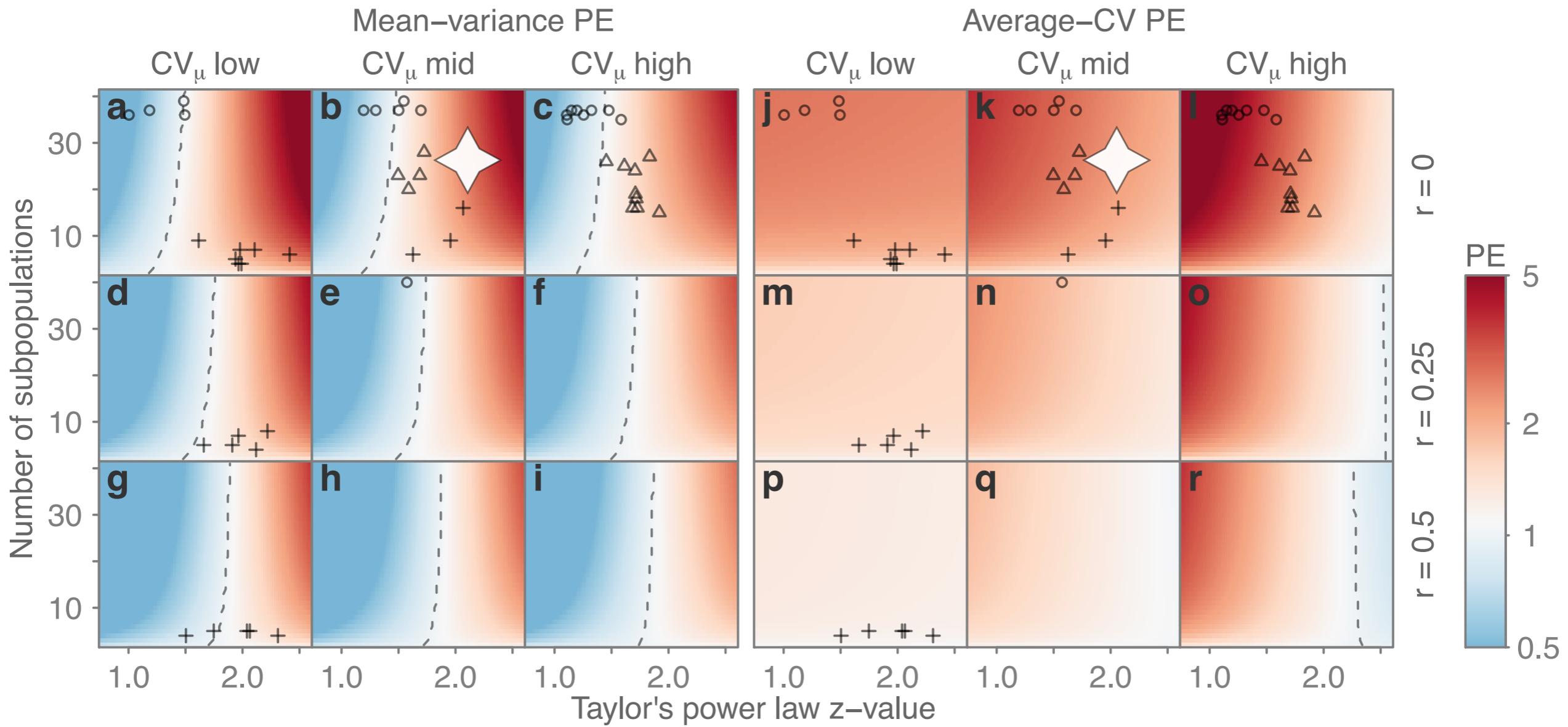
Subpopulation unevenness







Subpopulation extinction

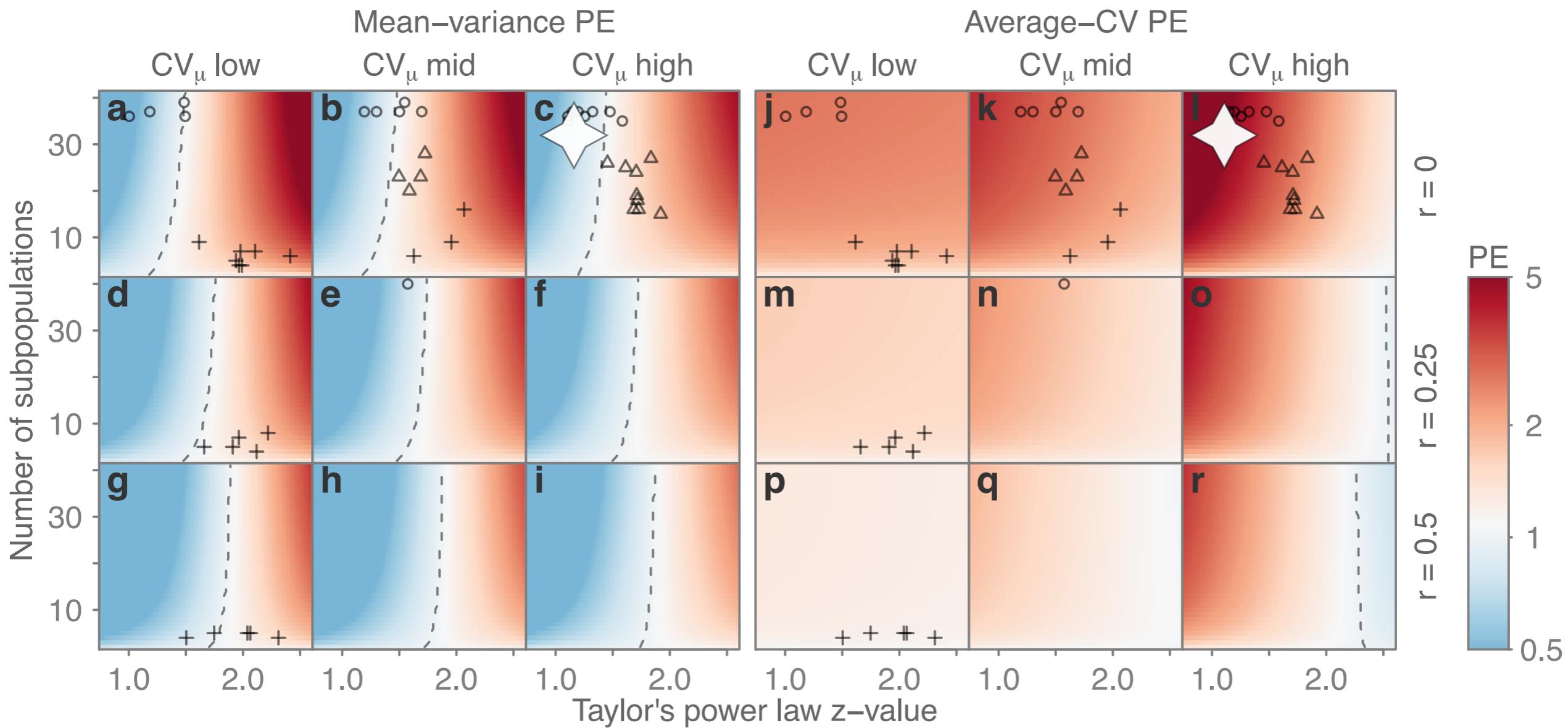


Indicator:





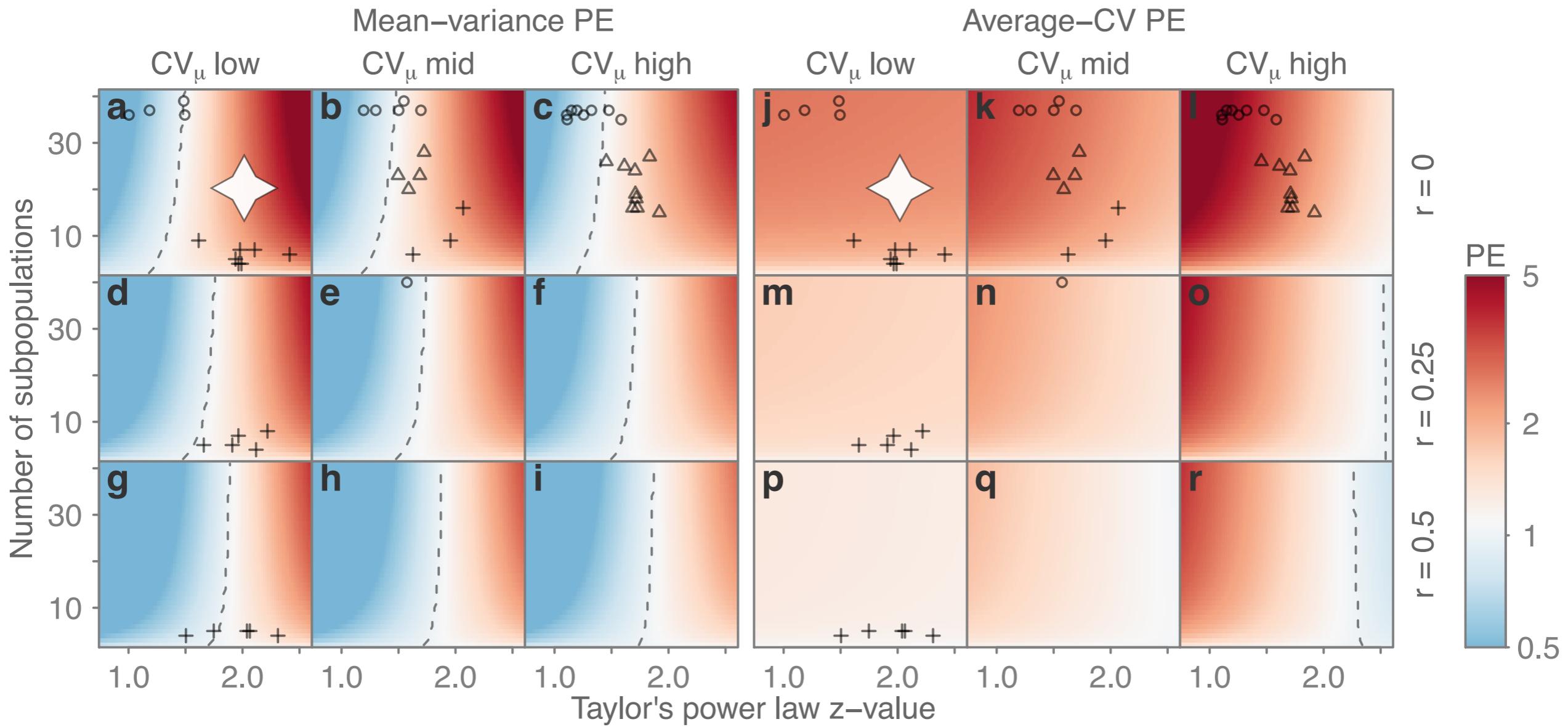
Subpopulation extinction



Indicator: ↑ ↓



Increased synchrony

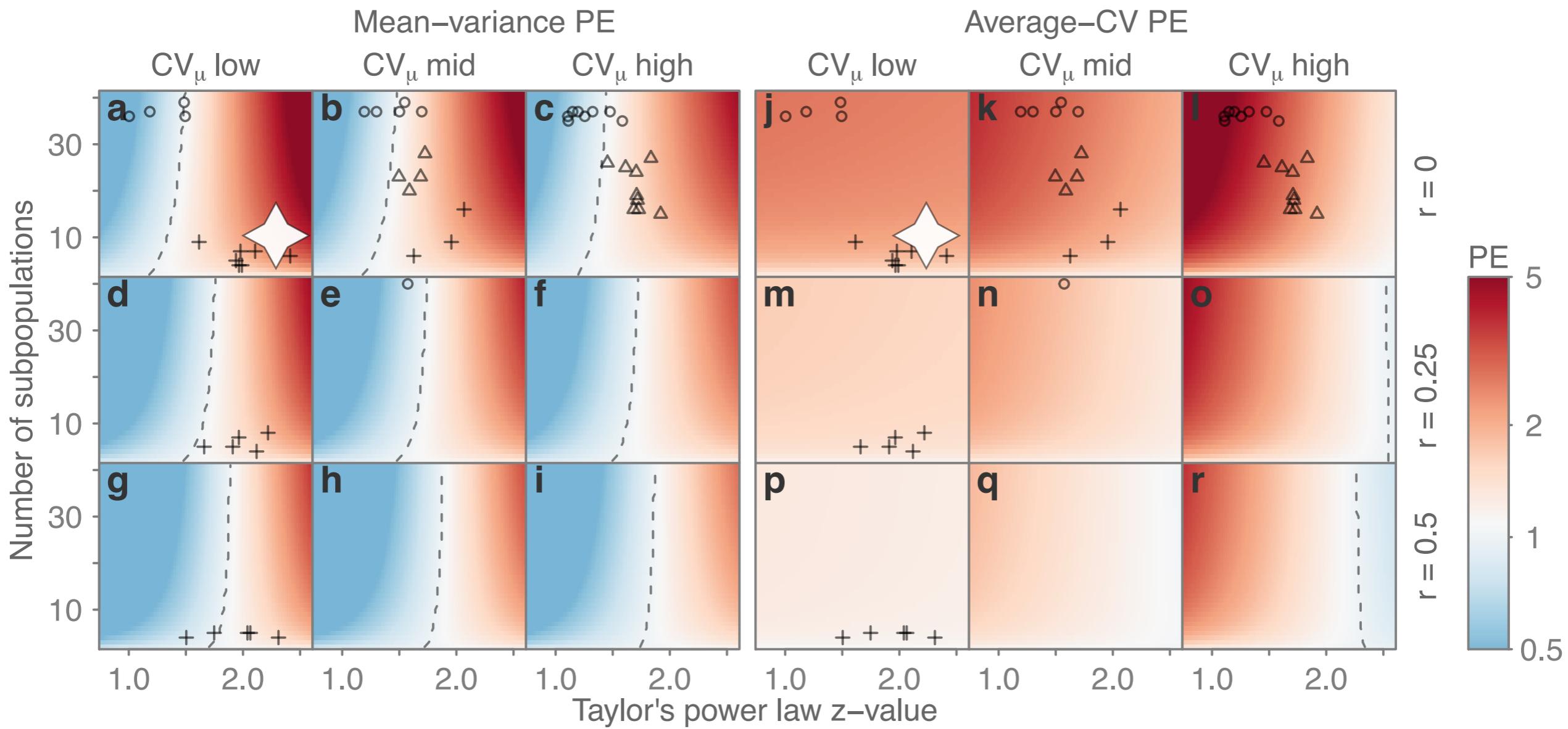


Indicator:





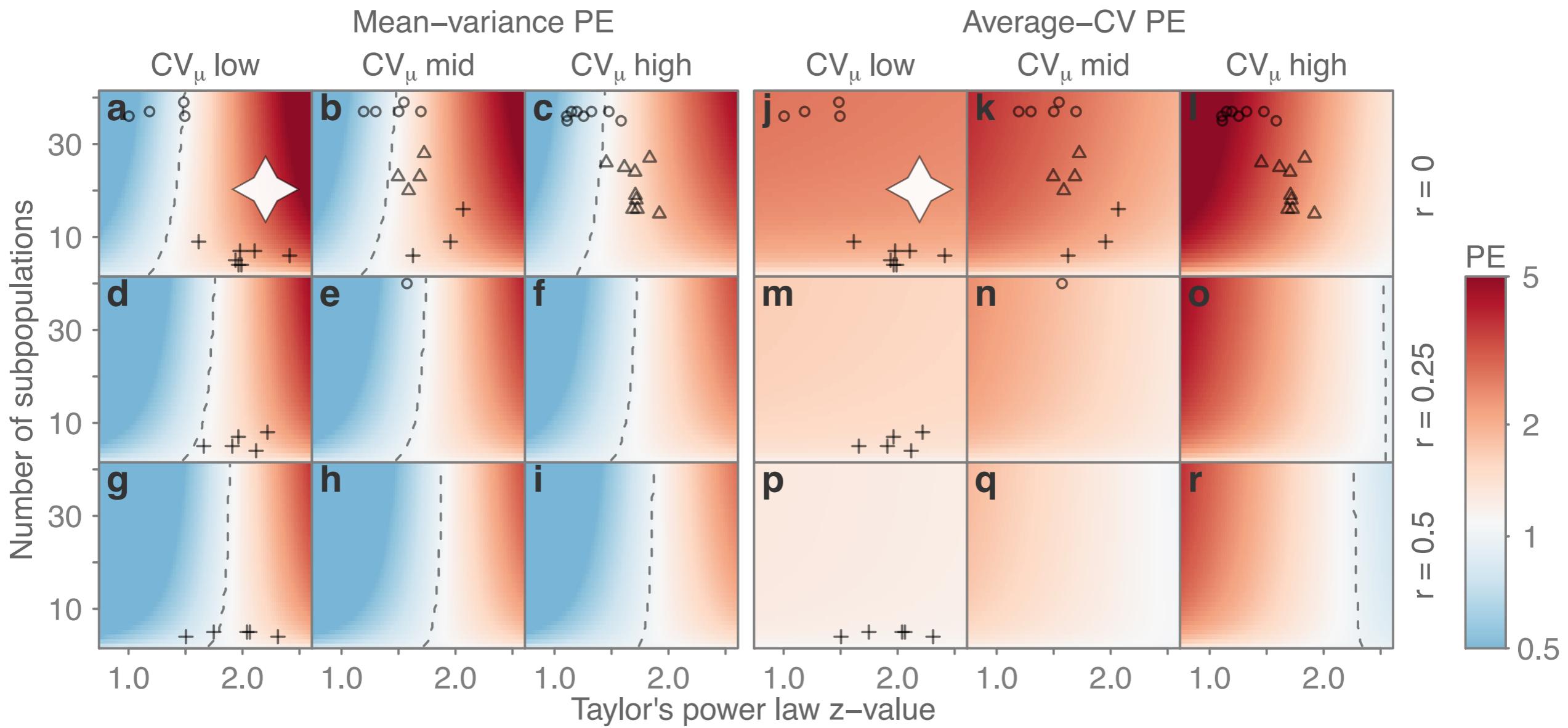
Small populations get smaller and large populations get larger



Indicator: ↓

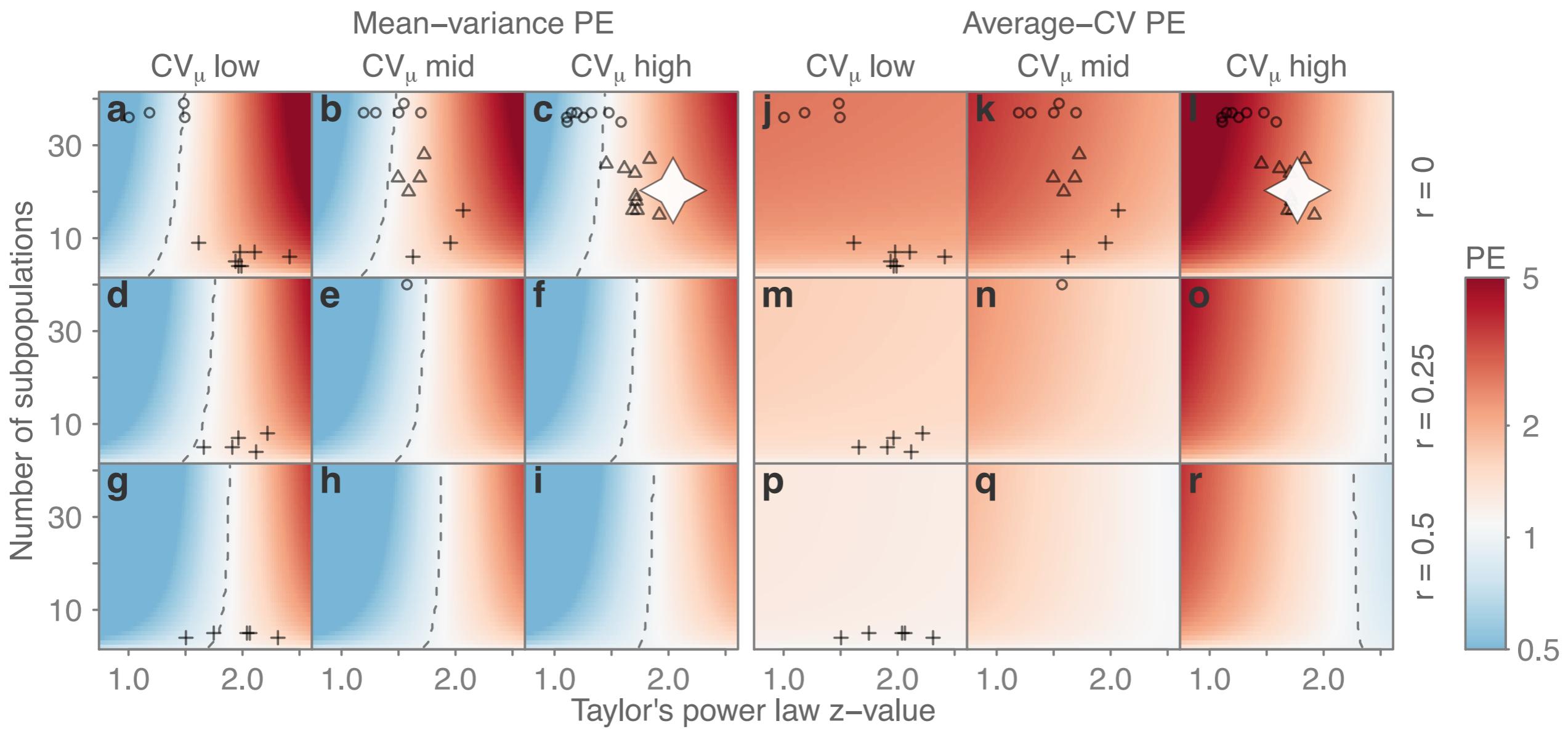


z decreases

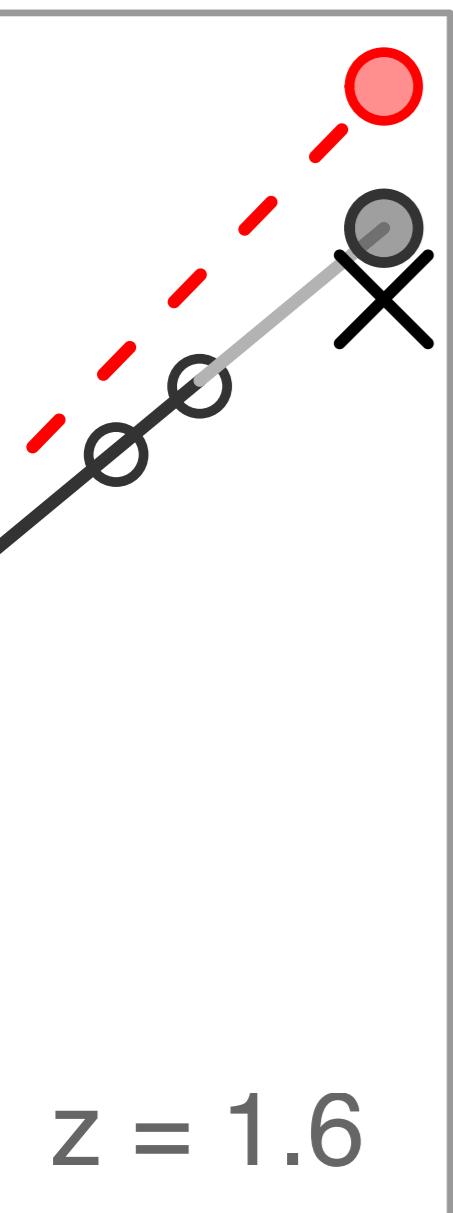




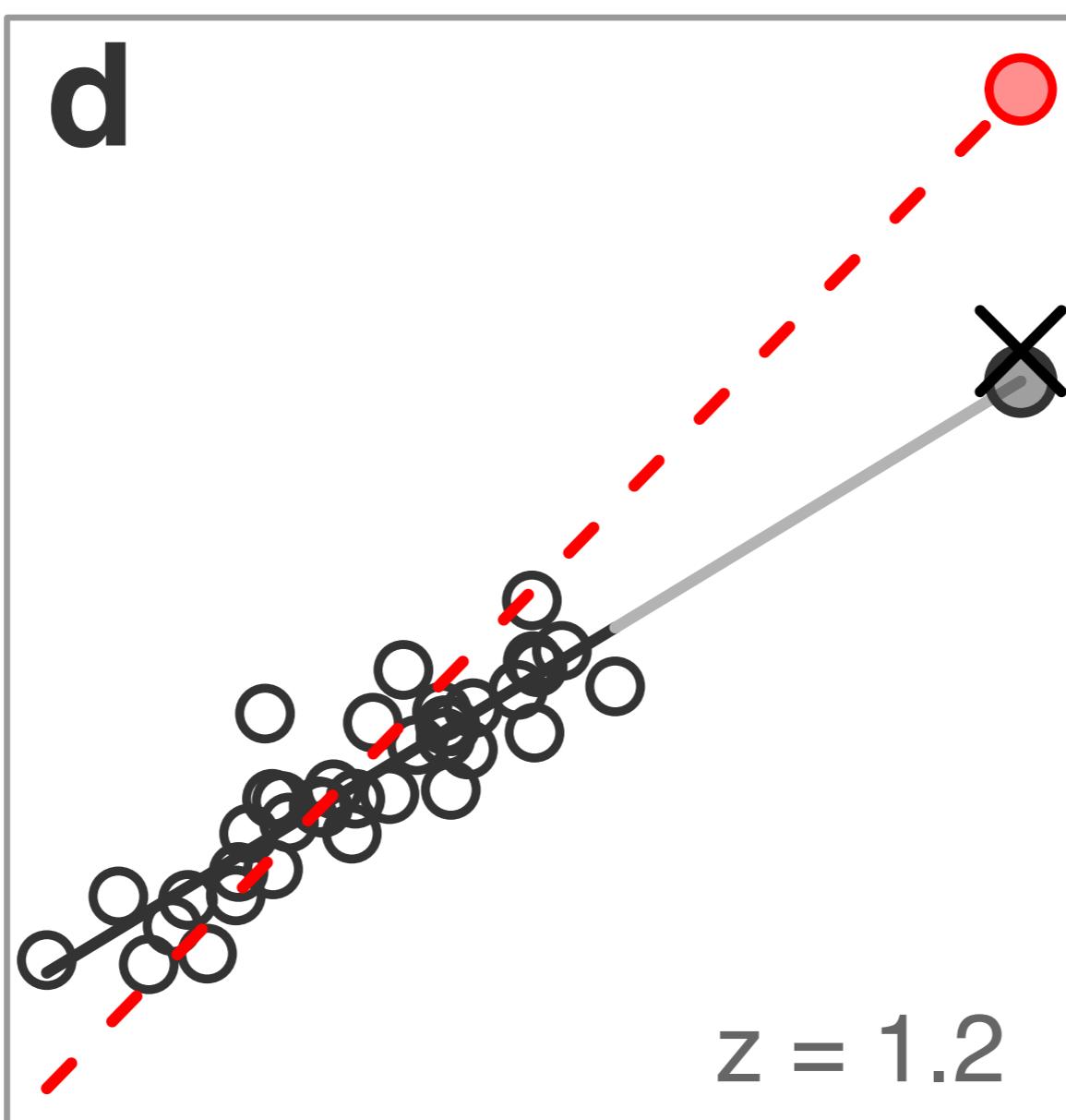
z increases



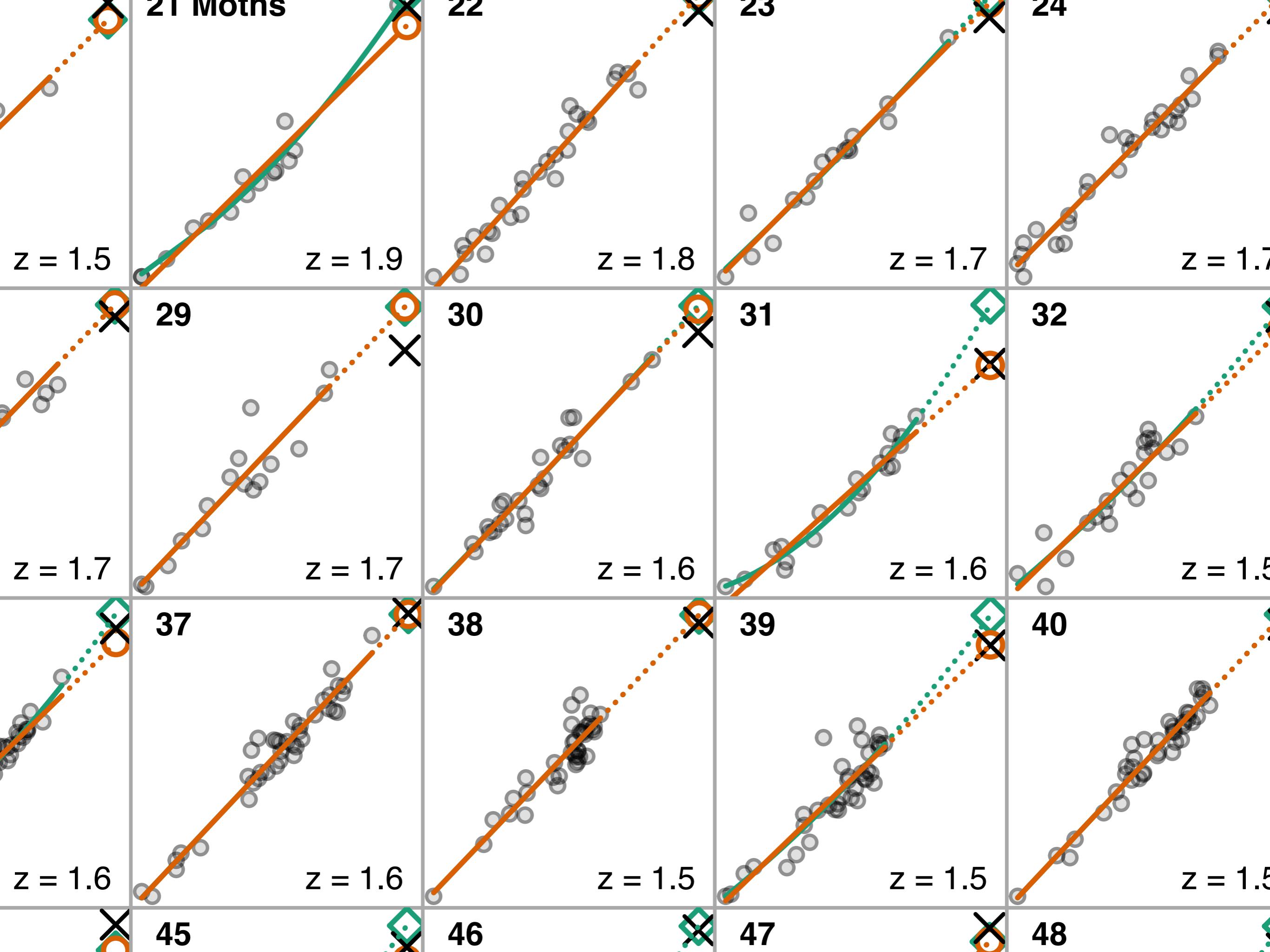
Reef fishes



$z = 1.6$



$z = 1.2$



Alternative mean-variance fits

Extrapolation is suspect

Mean–variance PE

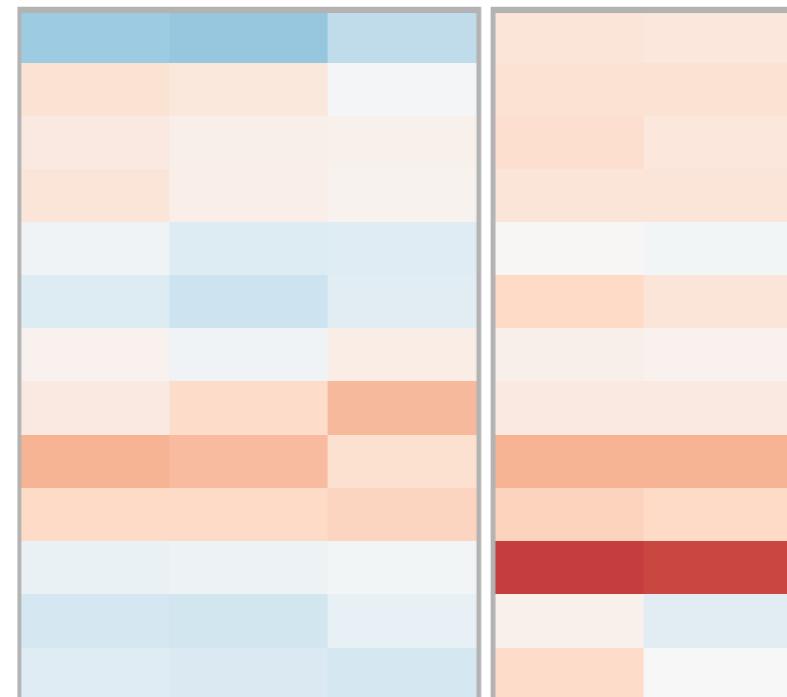
Fig. 3a

Linear detrended

Loess detrended

Quadratic

Quad.-linear avg.



Moths

7

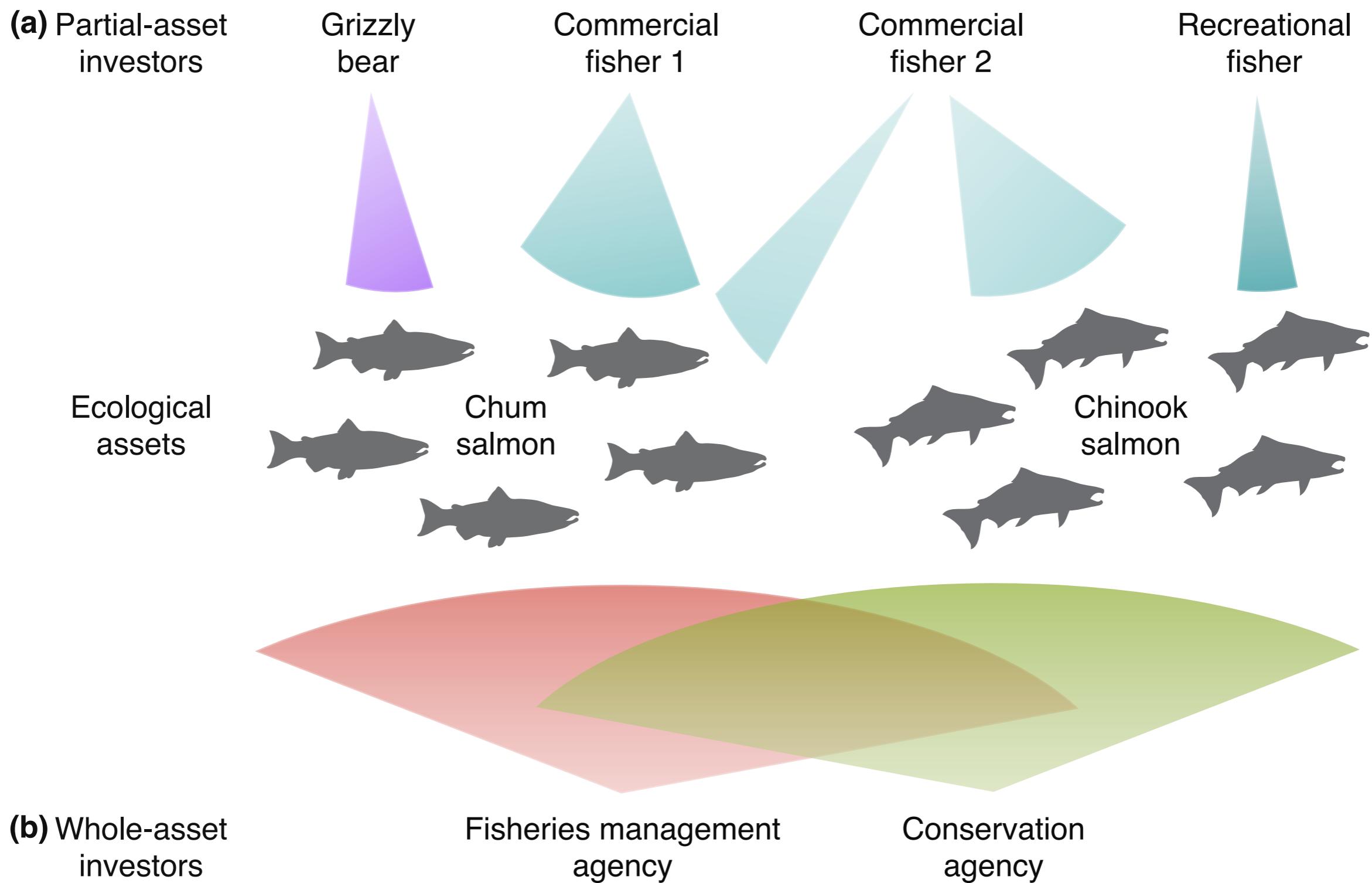
7

Competition

Measurement error

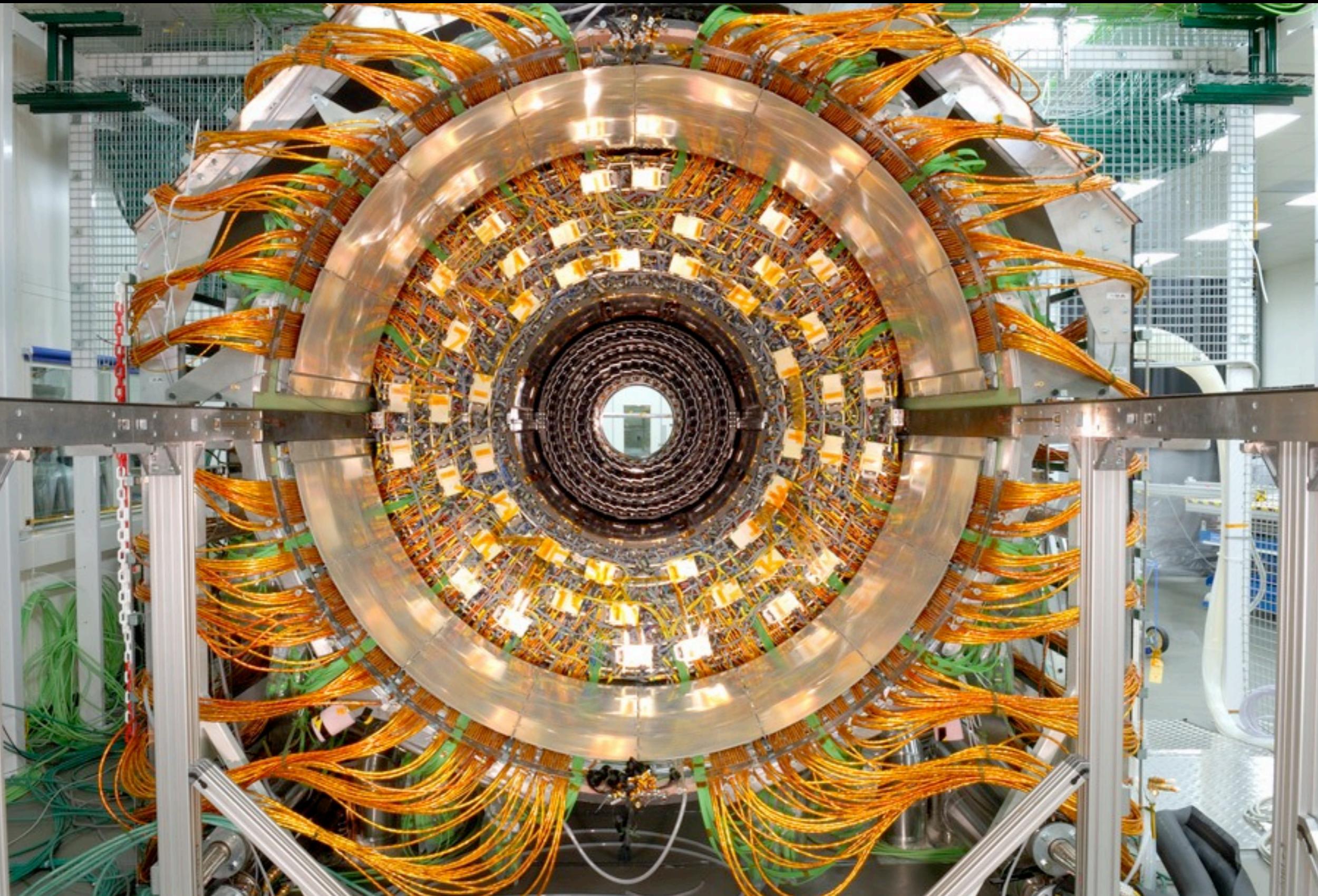
Demographic stochasticity

Hidden diversity



What to do?

It's complicated.



Maximilien Brice, CERN

Metaphor Metric Management





Joel Sartore, National Geographic