Why rarity is common

The evolution of eco-evolutionary rarity in plants

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University of Tennessee

*All artwork is original

Exploring the evolution of rarity

1

Where?

2

How?

Exploring the evolution of rarity

1

Where?

Where does rarity come from?

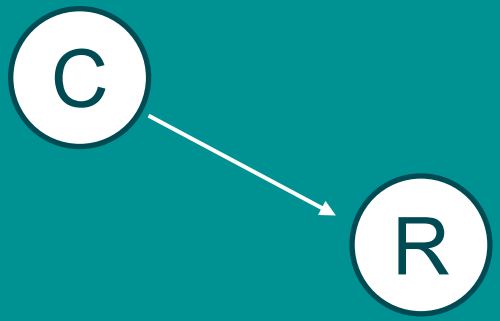
2

How?

Exploring the evolution of rarity

1

Where?



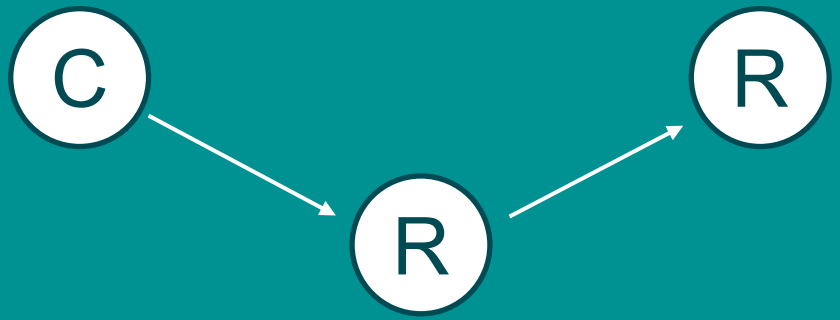
2

How?

Exploring the evolution of rarity

1

Where?



2

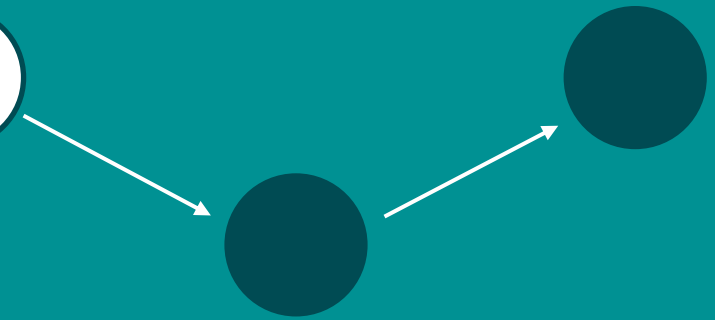
How?

Exploring the evolution of rarity

1

Where?

C



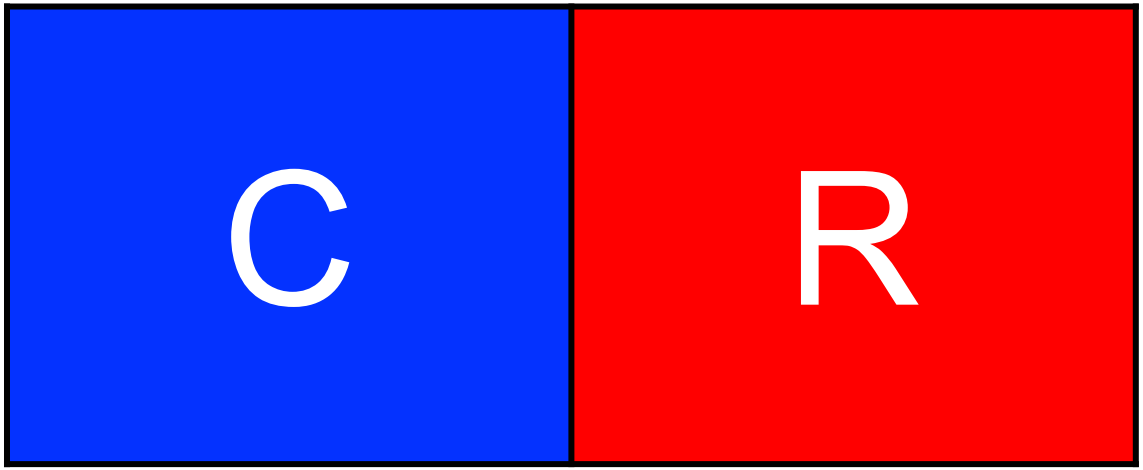
2

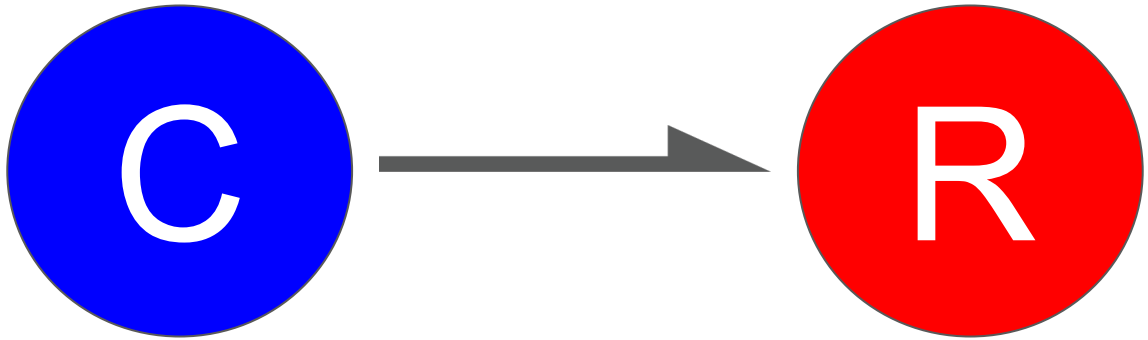
How?

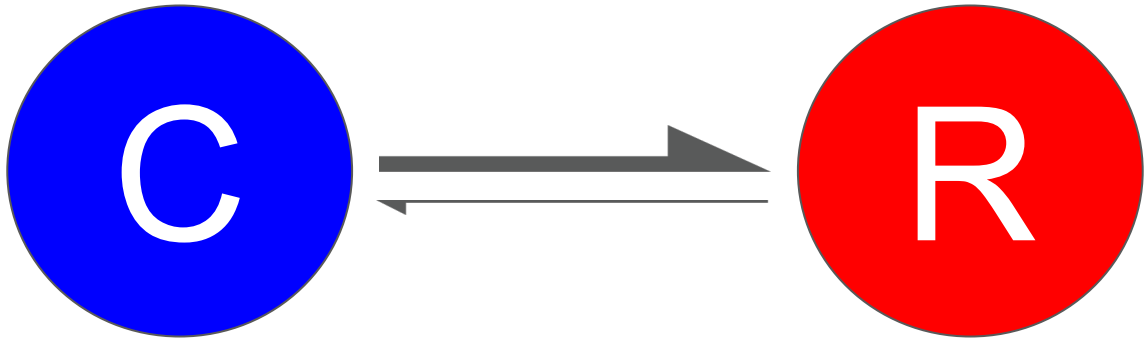
Abundance

High

Low




C
R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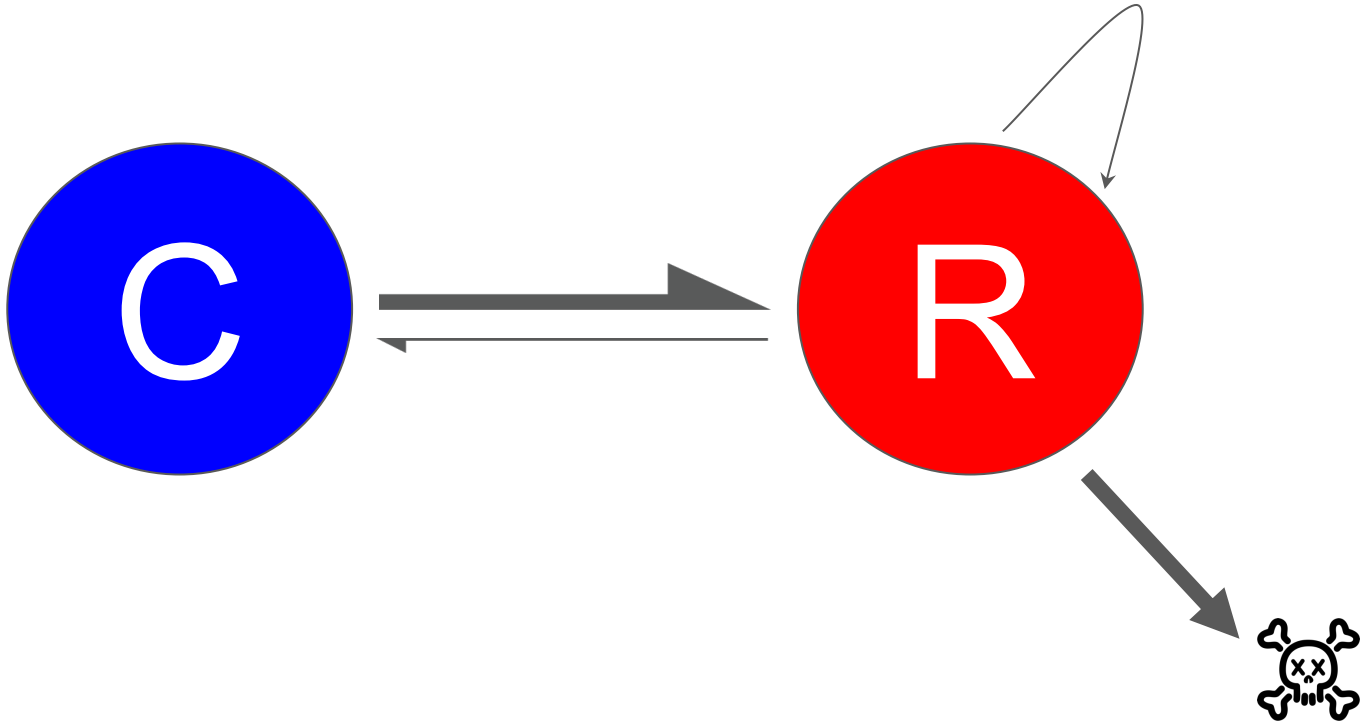
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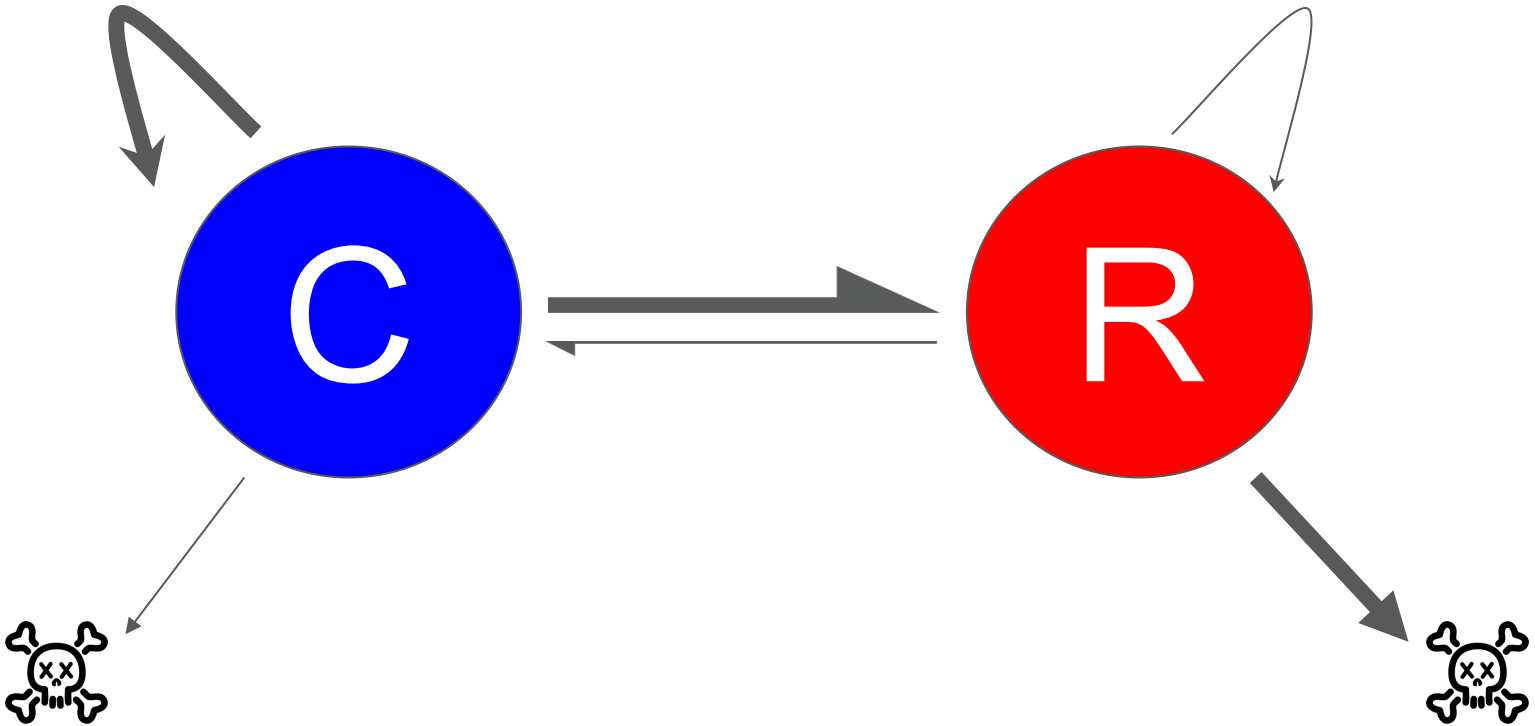
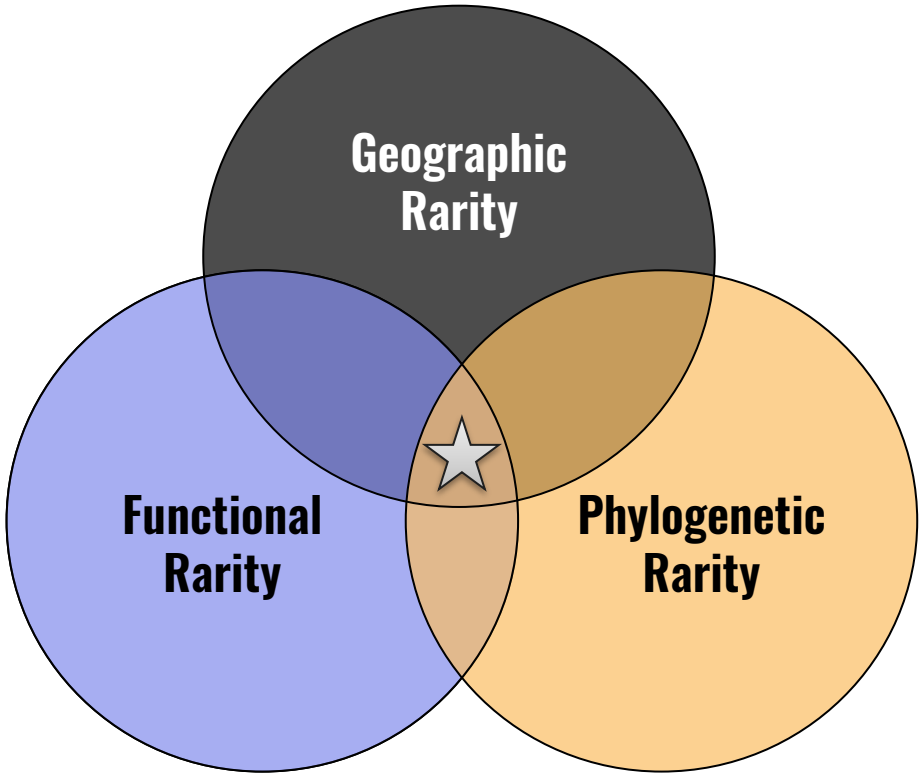
R


C
R


Geographic
Rarity
Functional
Rarity
Phylogenetic
Rarity

		Large		Small	
Geographic Range					
Habitat Specificity		Wide	Narrow	Wide	Narrow
Local Population Size	Large				
	Small				

Rabinowitz 1981. *The Biological Aspects of Rare Plant Conservation*

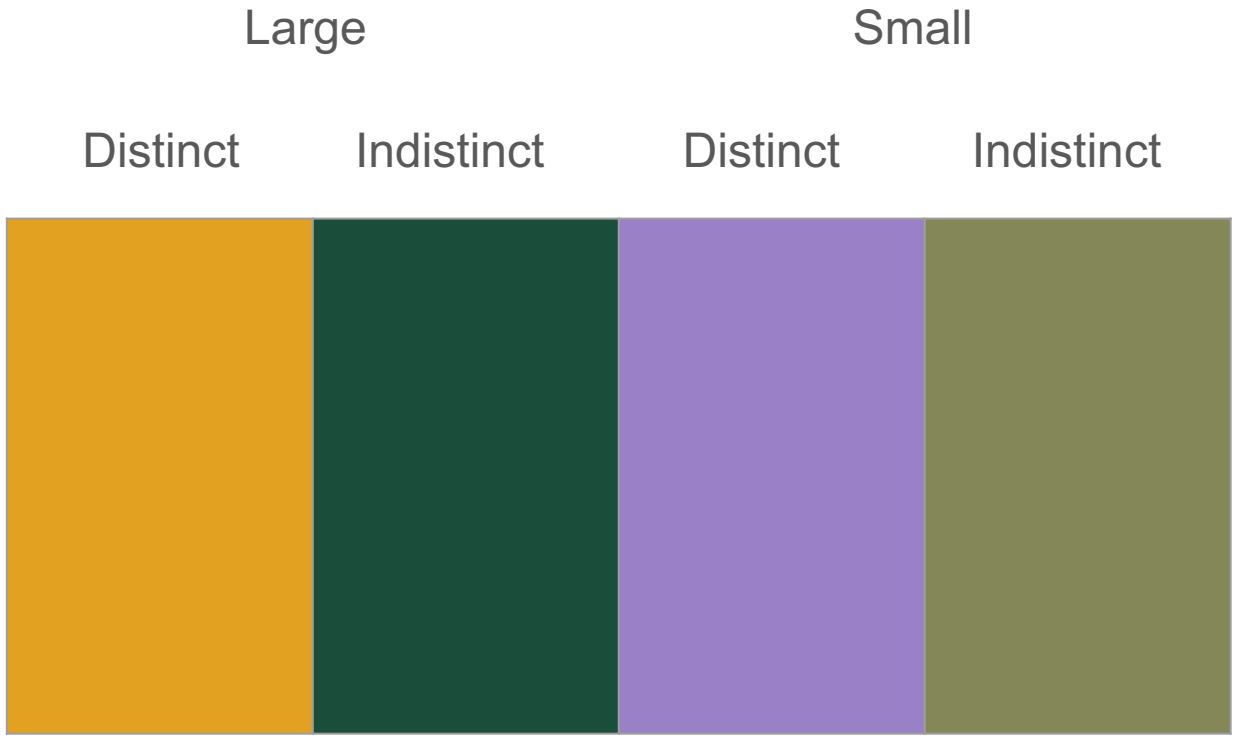
Range Size

Large

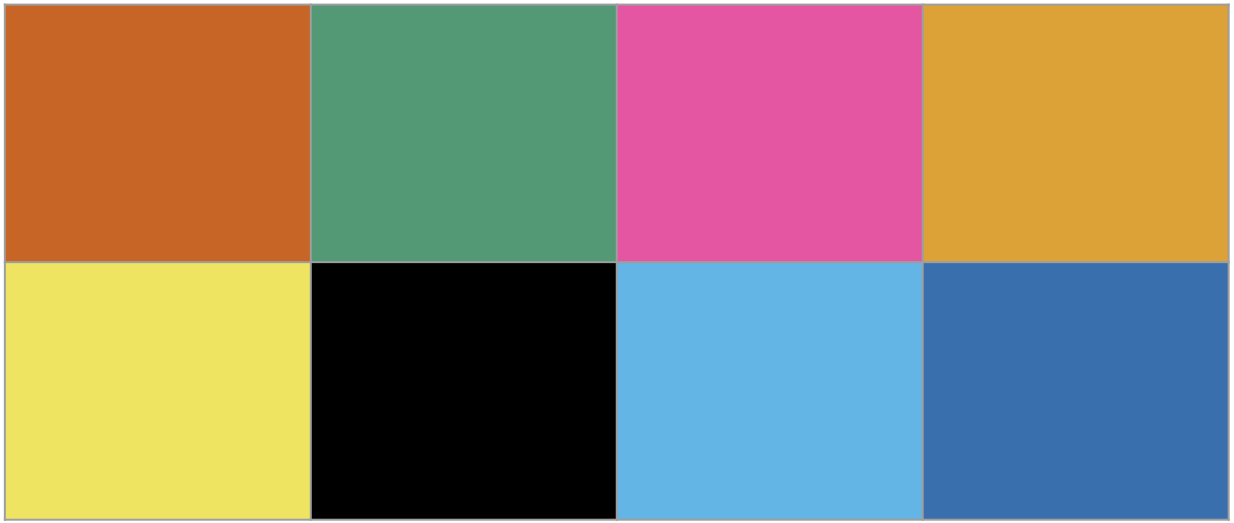
Small

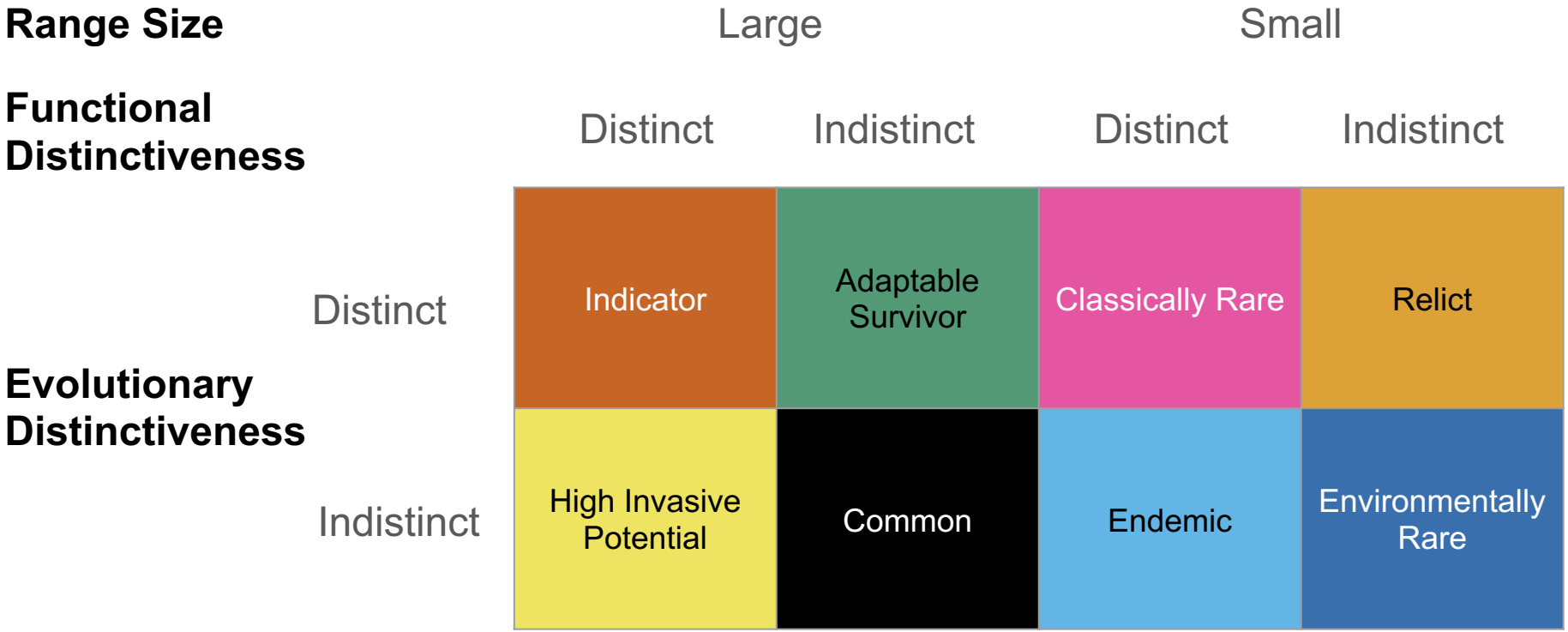
Range Size

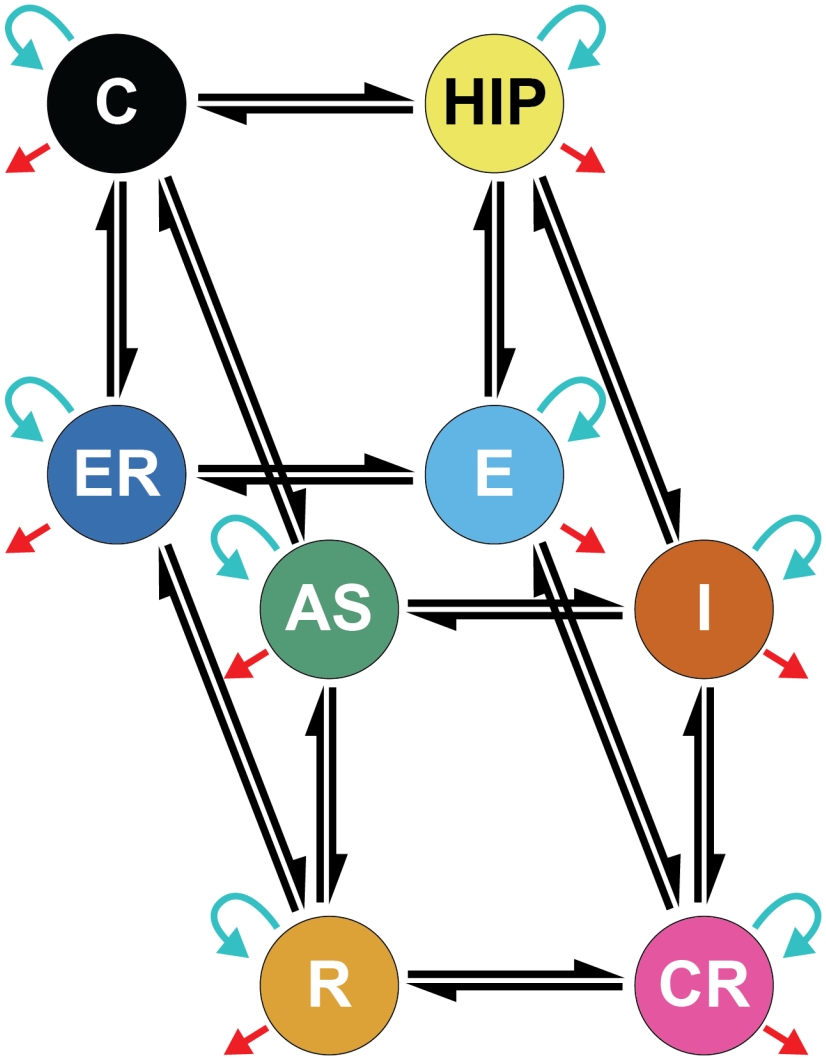
Functional Distinctiveness



Range Size	Large		Small	
Functional Distinctiveness	Distinct	Indistinct	Distinct	Indistinct
Distinct				
Evolutionary Distinctiveness				
Indistinct				




Range Size
Large
Small
Functional Distinctiveness
Distinct
Indistinct
Distinct
Indistinct
Evolutionary Distinctiveness
Distinct
Indistinct
Indicator
Adaptable Survivor
Classically Rare
Relict
High Invasive Potential
Common
Endemic
Environmentally Rare


C
HIP
ER
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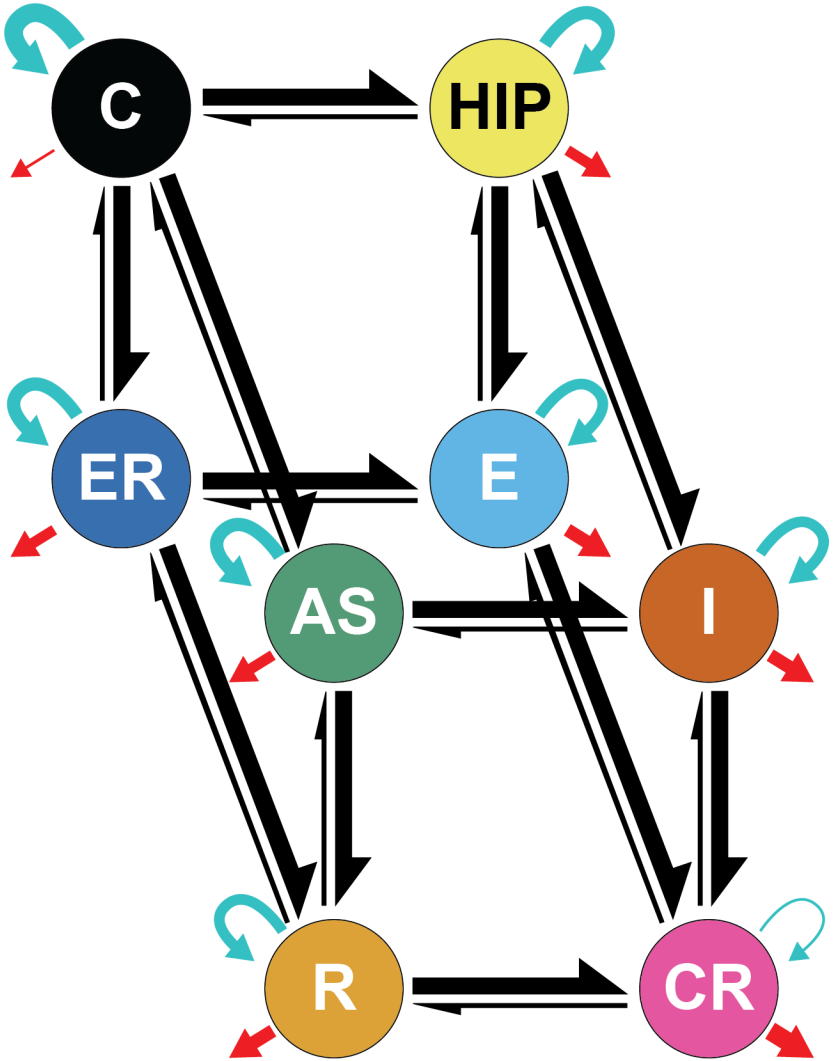
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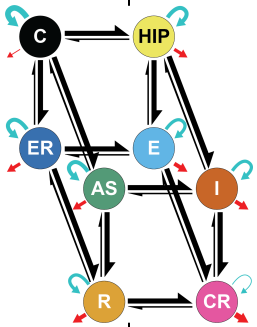
C
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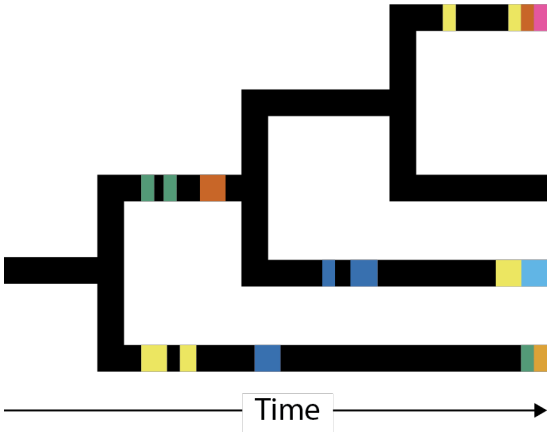
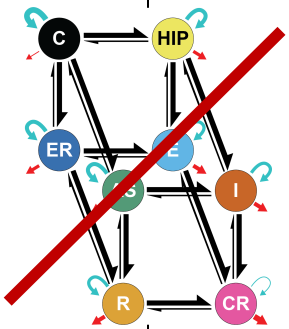
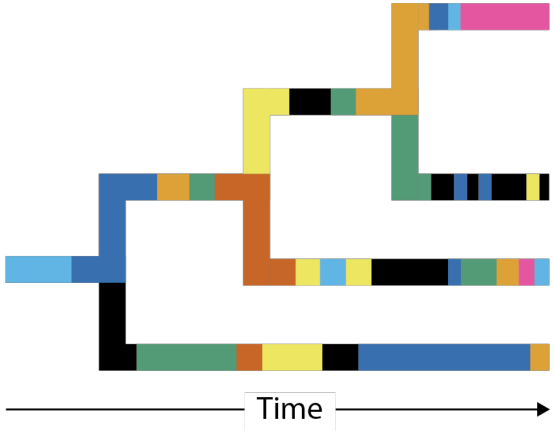

Time


C
HIP
ER
I
R
CR

Time


Time

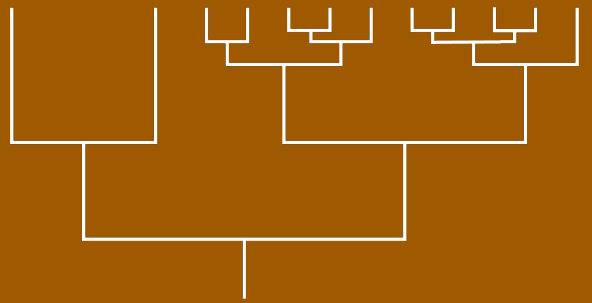
Exploring the evolution of rarity

1

Where?

2

How?



Exploring the evolution of rarity

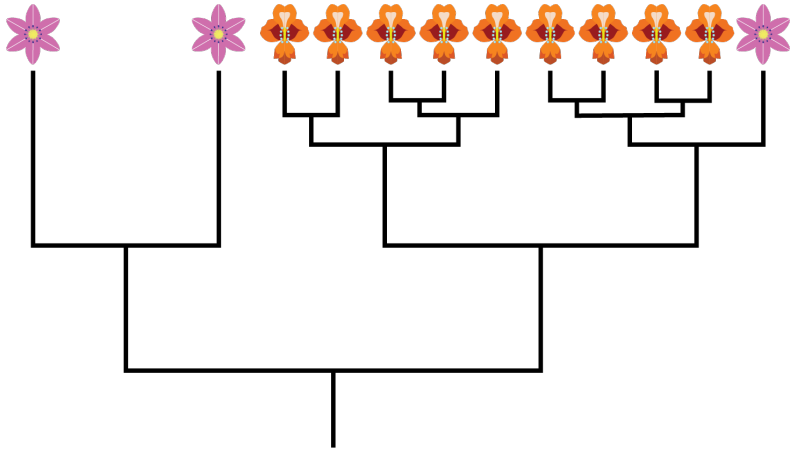
1

Where?

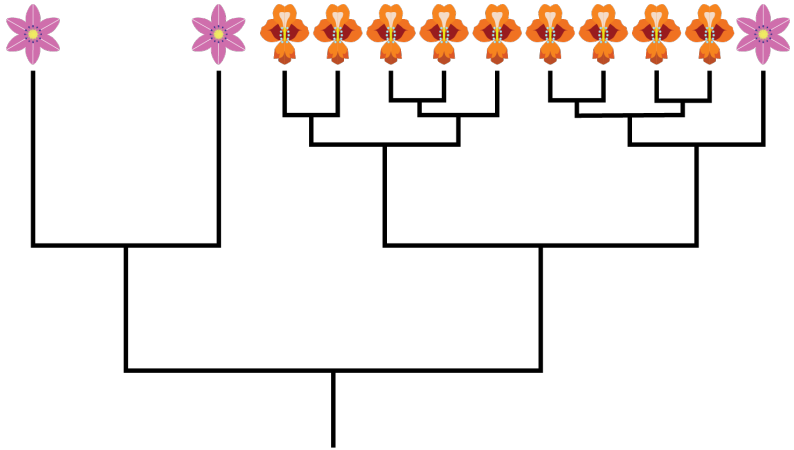
2

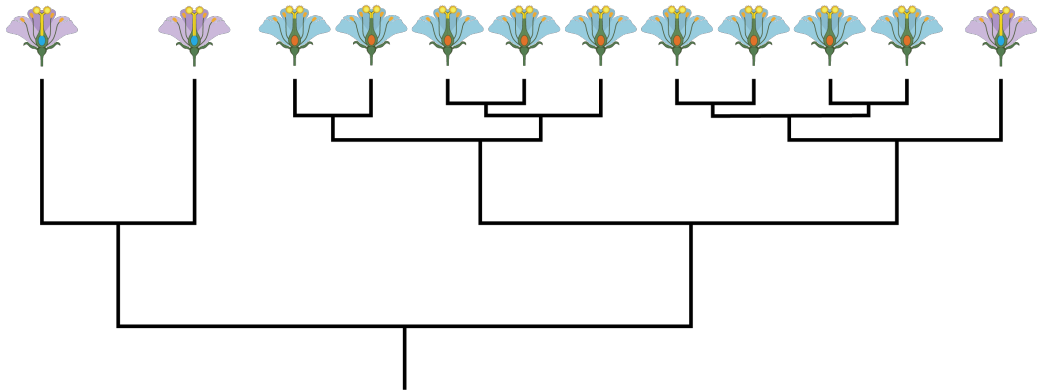
How?

Is rarity correlated with differential diversification?



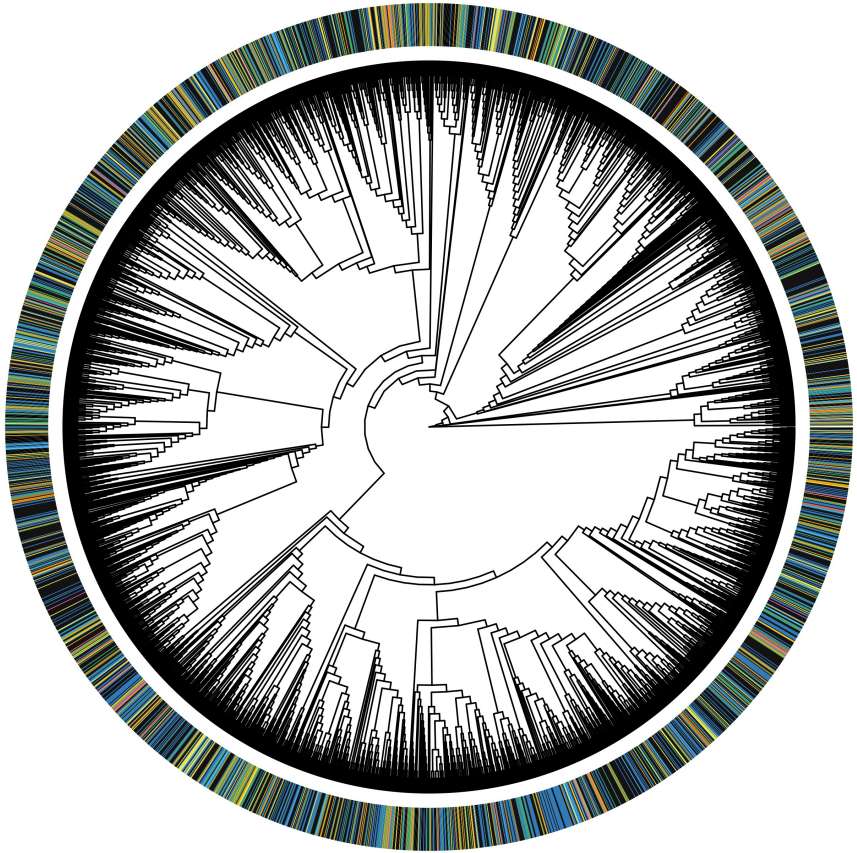
O’Meara, Smith et al. 2016. *Proc R Soc Lond B Biol Sci*

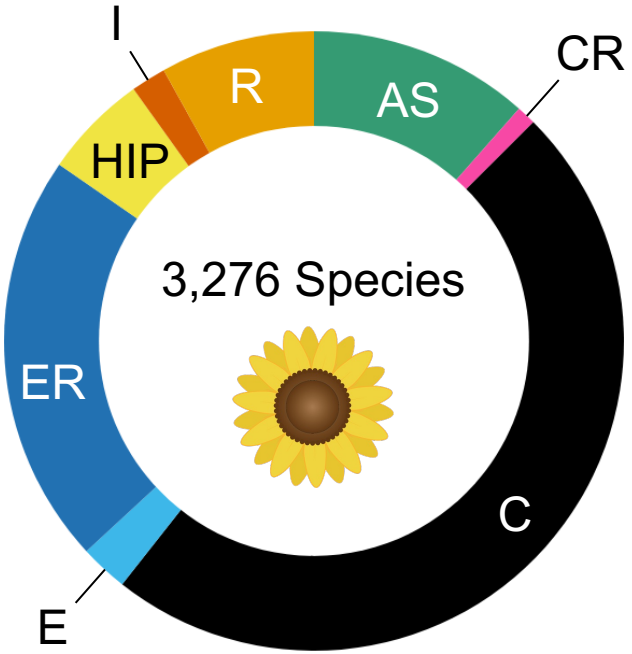




O’Meara, Smith et al. 2016. *Proc R Soc Lond B Biol Sci*

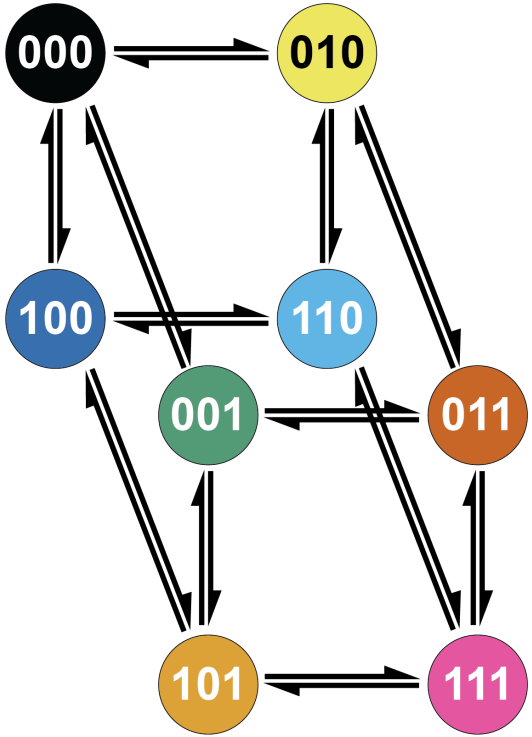
Goldberg et al. 2010. *Science*




I
R
AS
CR
HIP
3,276 Species
ER
C
E

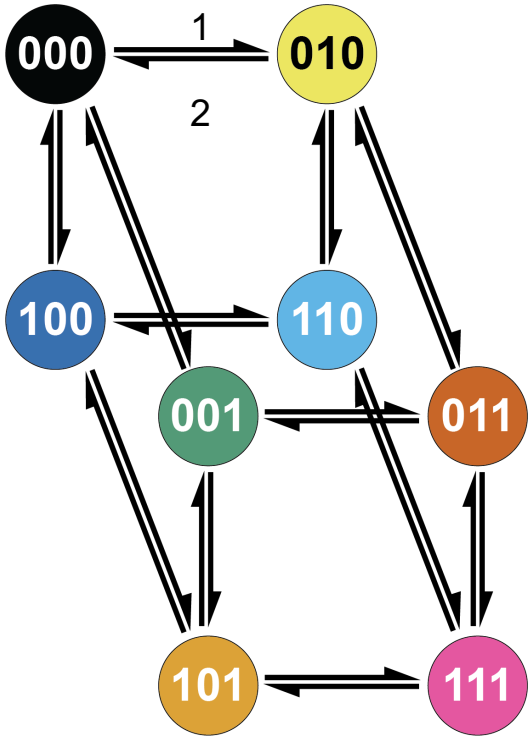
Geo Fun Phy

0 1 0 1 0 1



Geo Fun Phy

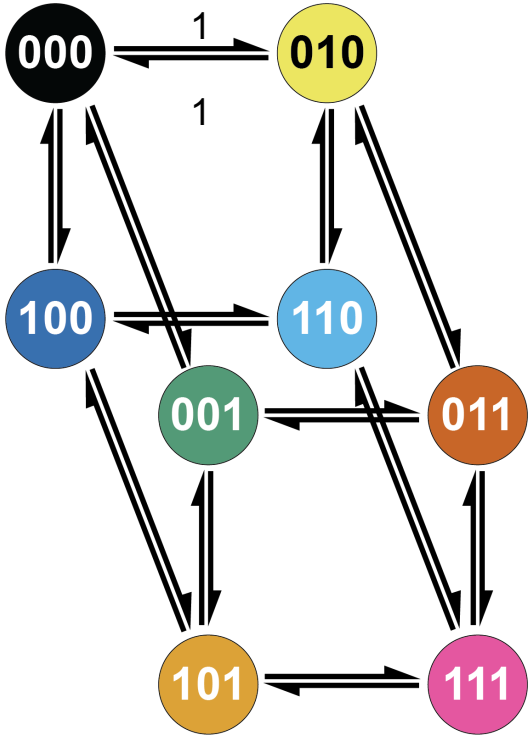
0 1 0 1 0 1



	001	111	000	110	100	010	011	101
001		-	G	-	-	-	S	V
111	-		-	J	-	-	T	W
000	A	-		-	M	P	-	-
110	-	D	-		N	Q	-	-
100	-	-	H	K		-	-	X
010	-	-	I	L	-		U	-
011	B	E	-	-	-	R		-
101	C	F	-	-	O	-	-	

Geo Fun Phy

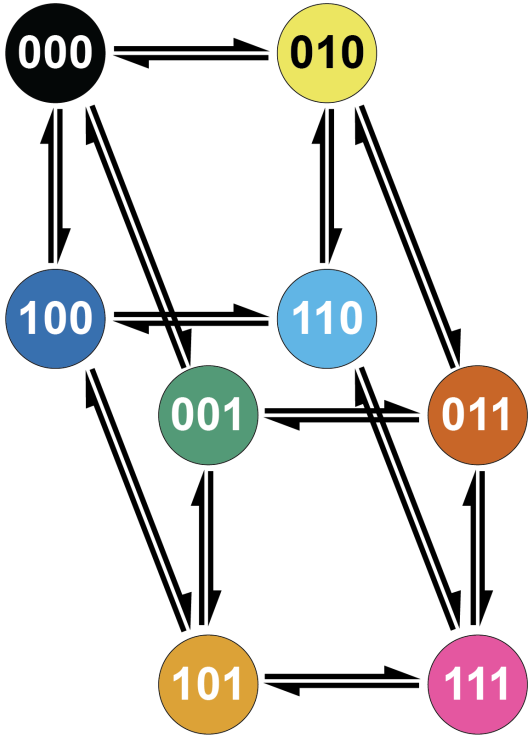
0 1 0 1 0 1



	001	111	000	110	100	010	011	101
001		-	a	-	-	-	b	c
111	-		-	d	-	-	e	f
000	a	-		-	g	h	-	-
110	-	d	-		i	j	-	-
100	-	-	g	i		-	-	k
010	-	-	h	j	-		l	-
011	b	e	-	-	-	l		-
101	c	f	-	-	k	-	-	

Geo Fun Phy

0 1 0 1 0 1

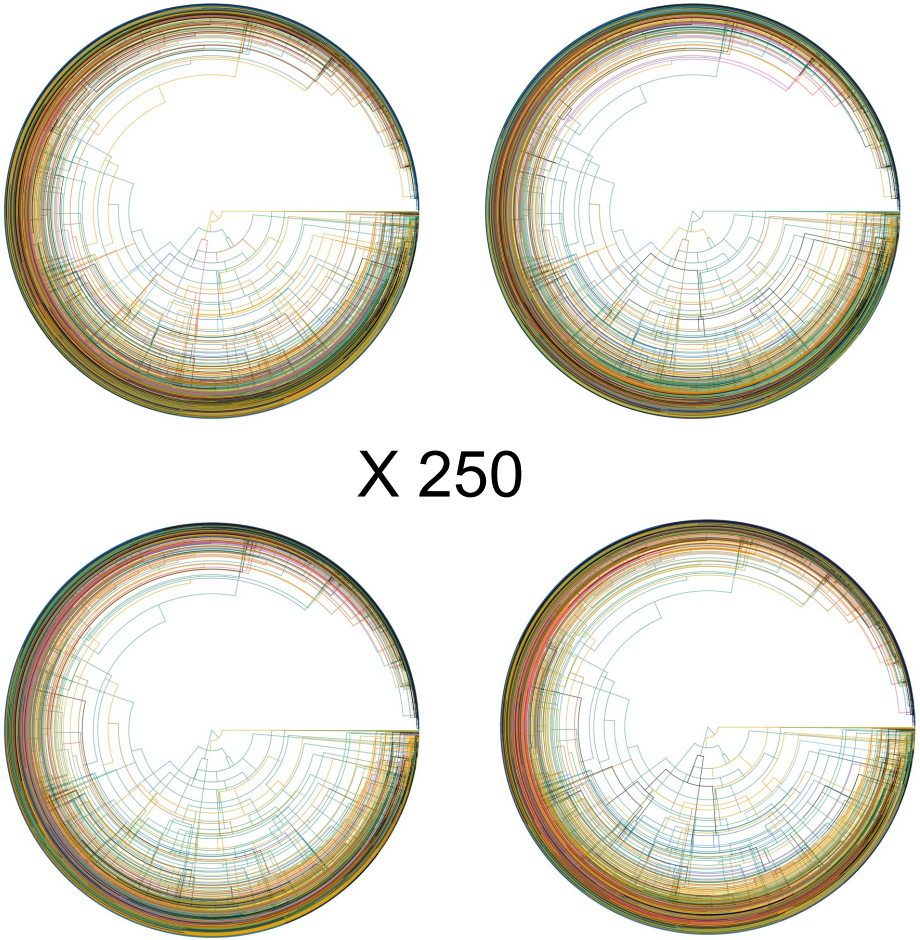


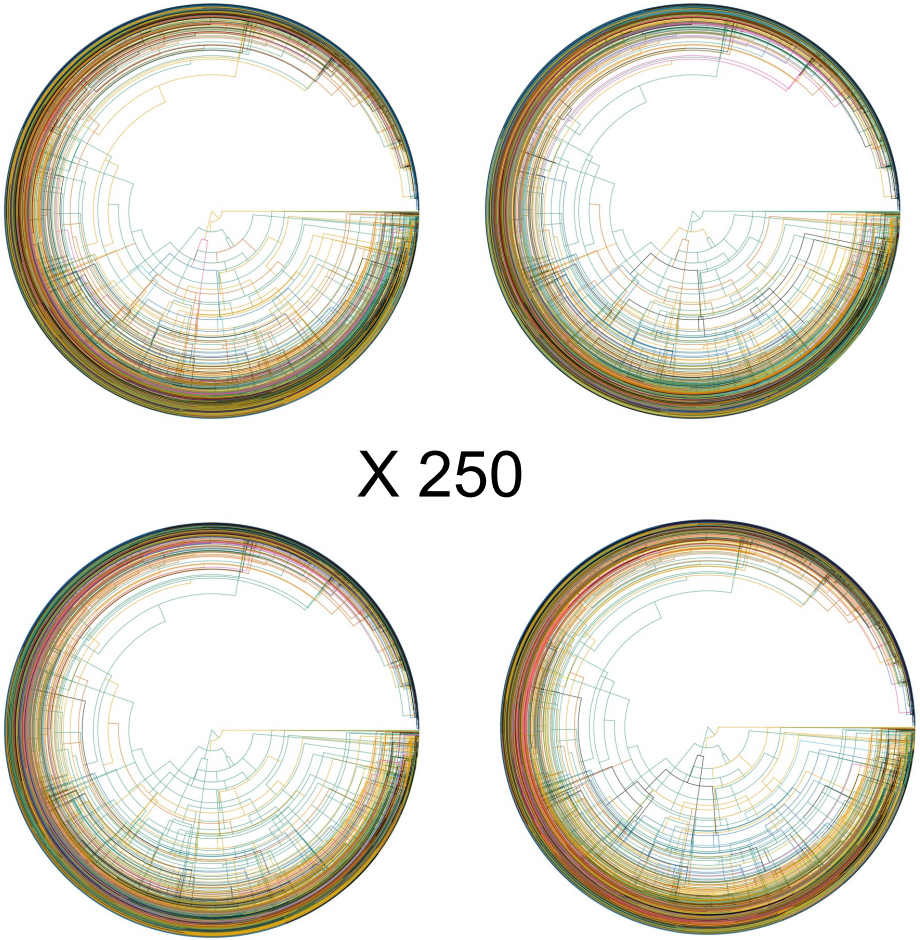
1 ARD

	001	111	000	110	100	010	011	101
001		-	G	-	-	-	S	V
111	-		-	J	-	-	T	W
000	A	-		-	M	P	-	-
110	-	D	-		N	Q	-	-
100	-	-	H	K		-	-	X
010	-	-	I	L	-		U	-
011	B	E	-	-	-	R		-
101	C	F	-	-	O	-	-	

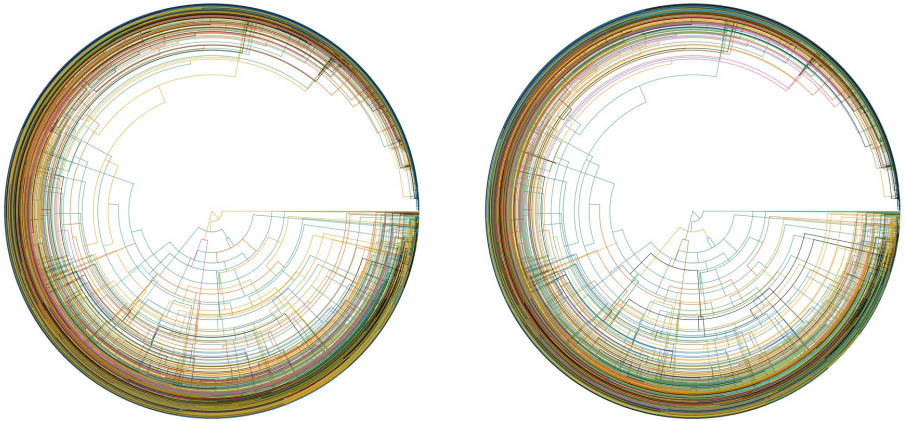
2 SYM

	001	111	000	110	100	010	011	101
001		-	a	-	-	-	b	c
111	-		-	d	-	-	e	f
000	a	-		-	g	h	-	-
110	-	d	-		i	j	-	-
100	-	-	g	i		-	-	k
010	-	-	h	j	-		l	-
011	b	e	-	-	-	l		-
101	c	f	-	-	k	-	-	

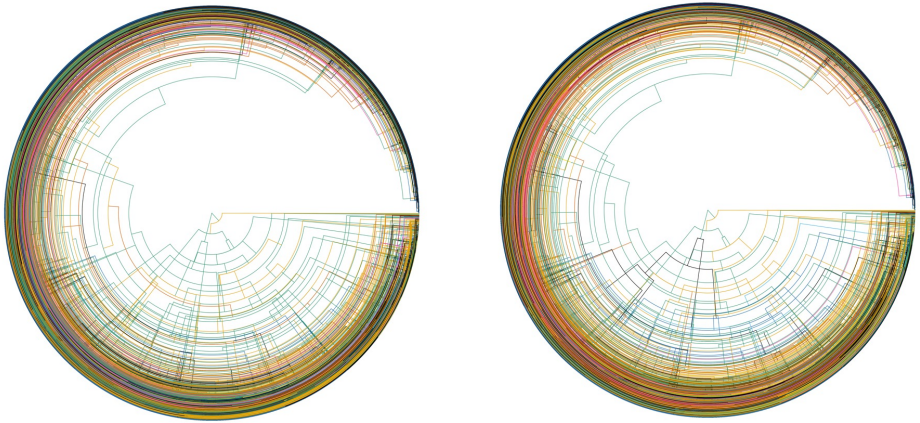

X 250



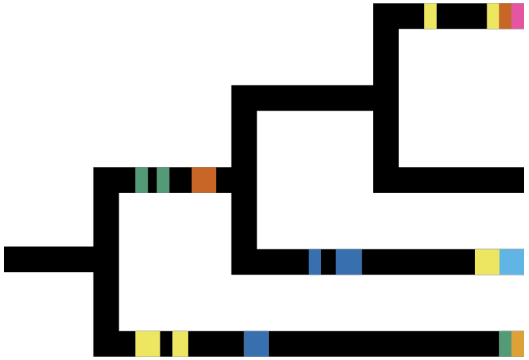
Proportion of Time Spent in Rarity State

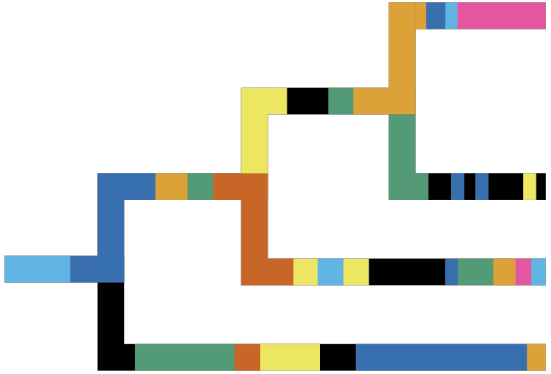


X 250



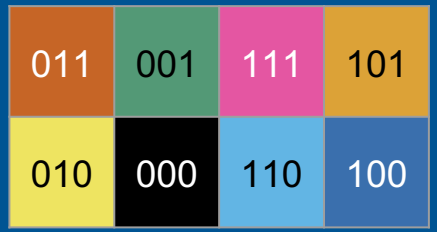
Proportion of Time Spent in Rarity State





Model Selection & Caveats

Discrete Character Evolution

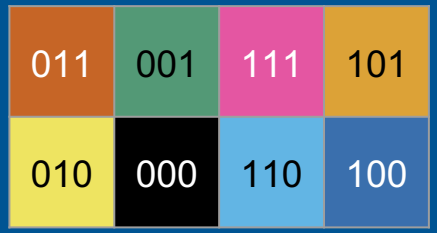


Dispersal-Extinction-Cladogenesis

Speciation and Extinction

Model Selection & Caveats

Discrete Character Evolution



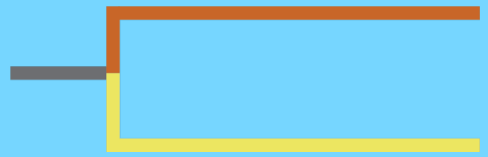
Dispersal-Extinction-Cladogenesis

Speciation and Extinction

Model Selection & Caveats

Discrete Character Evolution

Dispersal-Extinction-Cladogenesis

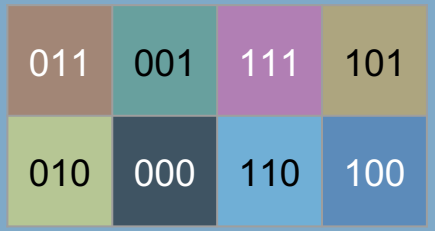


~ 1.3% of angiosperm diversity

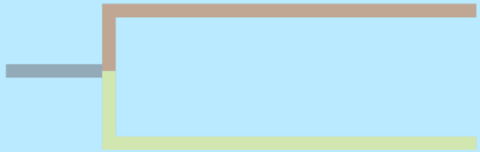
Speciation and Extinction

Model Selection & Caveats

Discrete Character Evolution

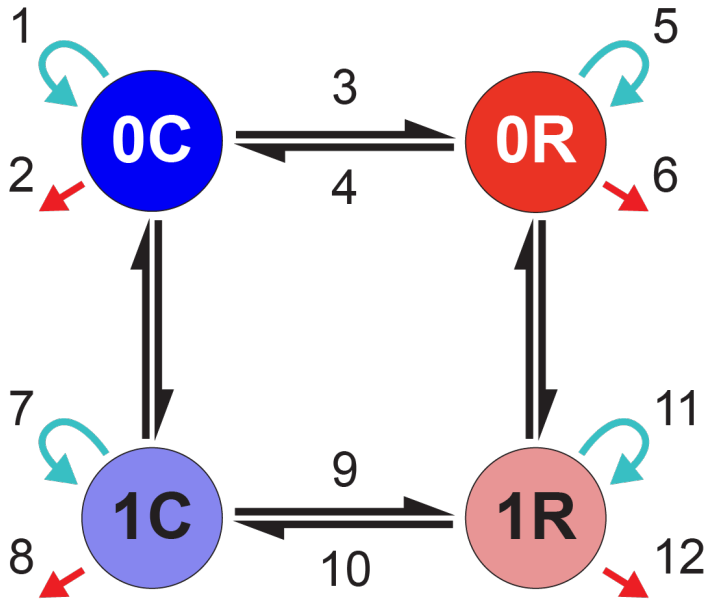


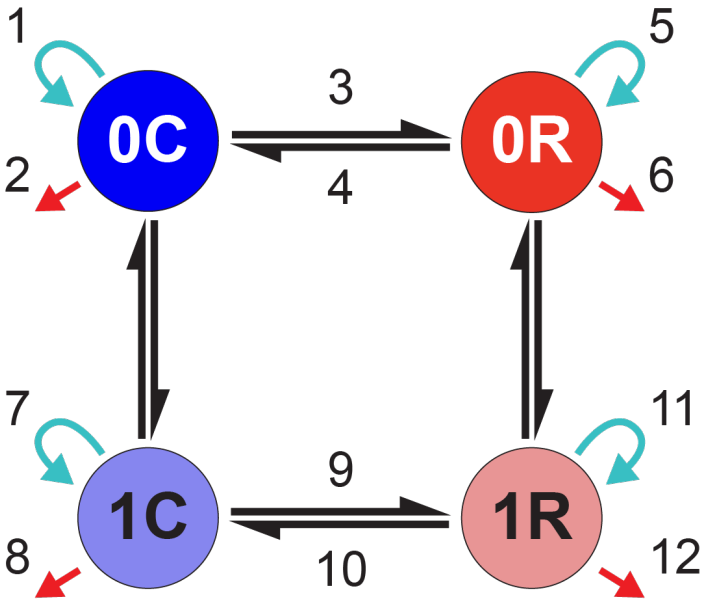
Dispersal-Extinction-Cladogenesis



~ 1.3% of angiosperm diversity

Speciation and Extinction


1
5
3
0C
0R
2
4
6
7
11
9
1C
1R
8
10
12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0C
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1C
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10
1R
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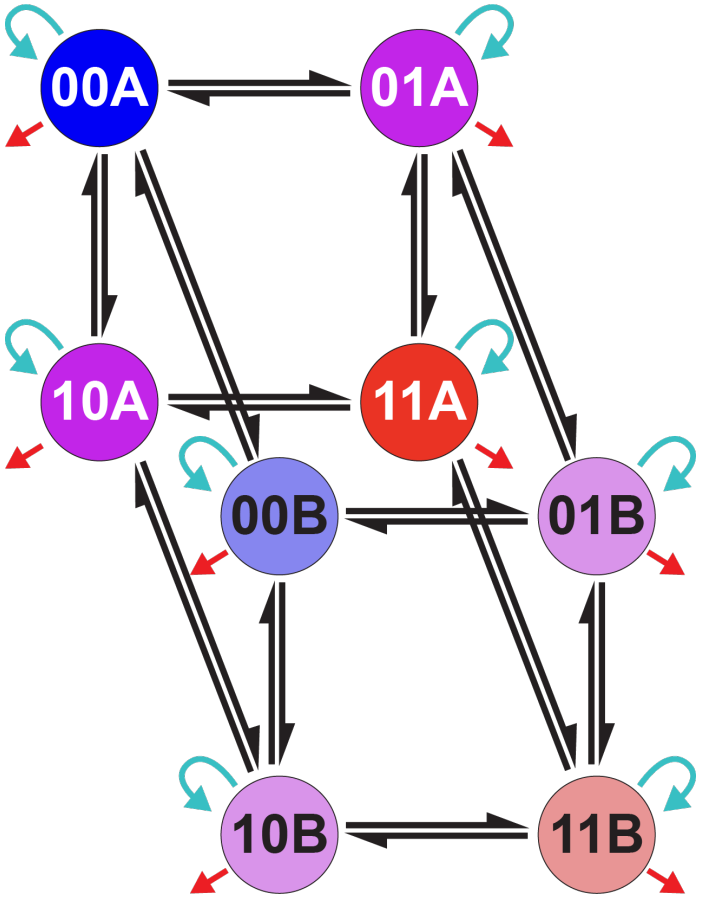
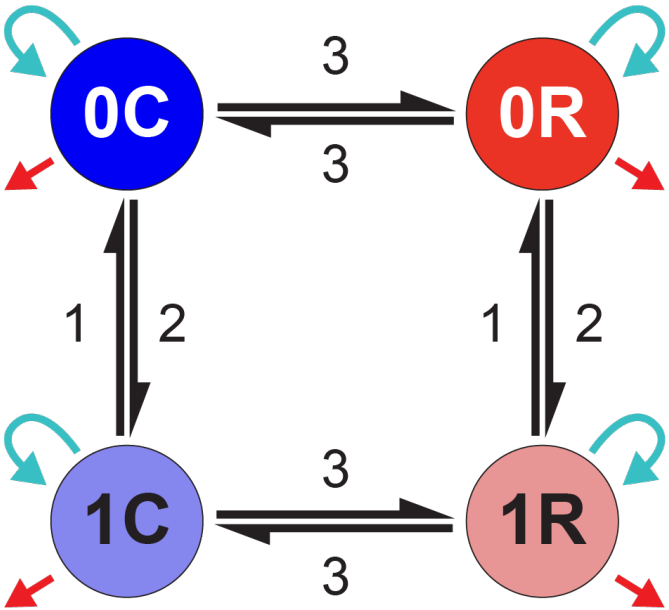

00A
01A
10A
11A
00B
01B
10B
11B

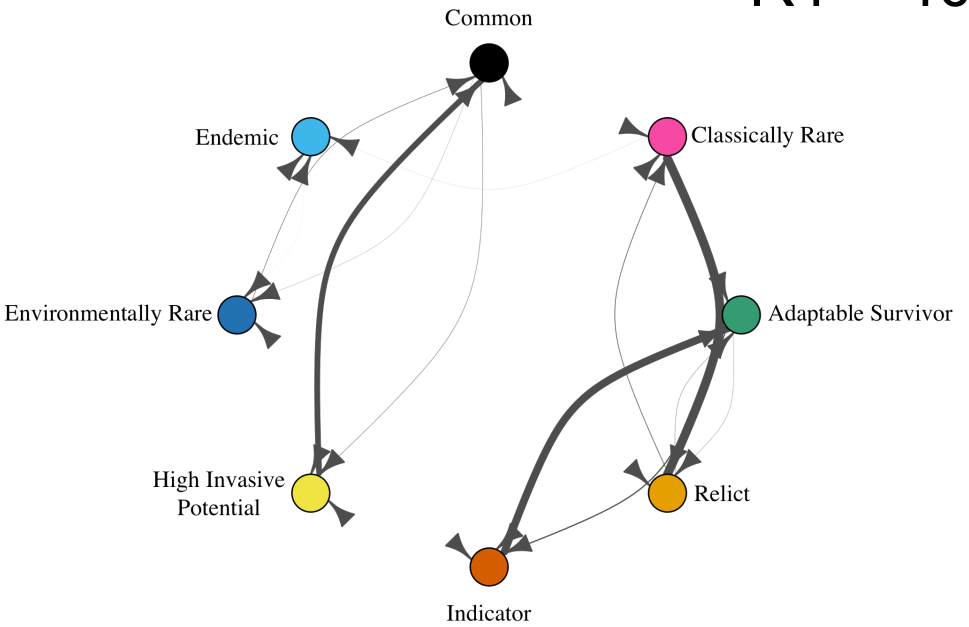


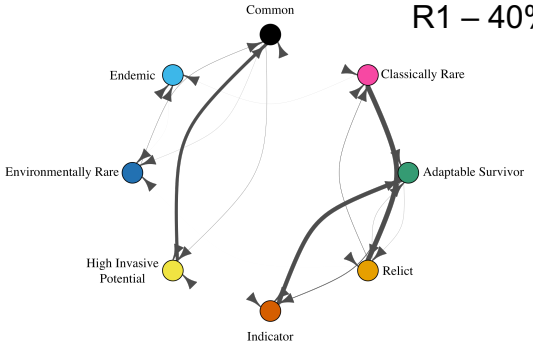
CID-4	Turnover	Eps
0C	A	A
1C	A	A
0R	B	B
1R	B	B

SID-2	Turnover	Eps
0C	A	A
1C	B	B
0R	A	A
1R	B	B

Model	Parameters	Hidden States	Tip Fog	ΔAIC
ER	1	1	1.99%	1202
ARD	6	1	0.24%	412
SYM	20	1	1.75%	1179
SYM	24	1	1.21%	784
ARD	20	1	1.11%	904
ARD	24	1	0.29%	385
ARD	46	2	0.15%	164
ARD	50	2	0.08%	125
SYM	26	2	0.70%	478
SYM/ARD	38	2	0.17%	178
ARD	76	3	0.03%	61
ARD	107	4	0.0000001%	0
ARD	139	5	0.0000001%	18

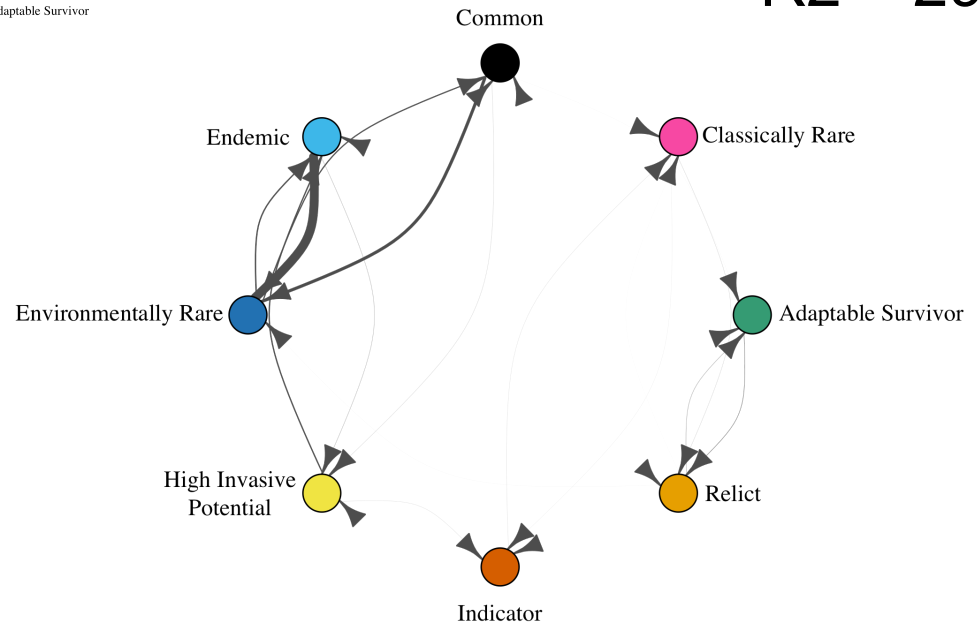
R1 – 40%

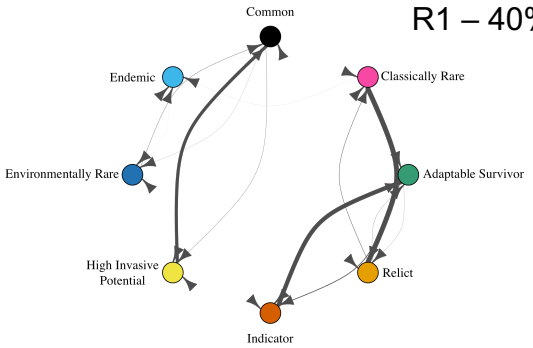

Common
Endemic
Classically Rare
Environmentally Rare
Adaptable Survivor
High Invasive Potential
Relict
Indicator


Common
Endemic
Classically Rare
Environmentally Rare
Adaptable Survivor
High Invasive Potential
Relict
Indicator

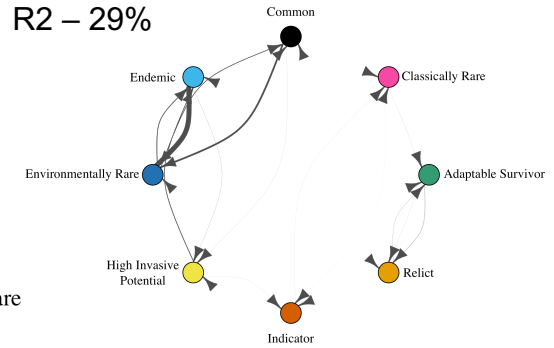
R1 – 40%

R2 – 29%

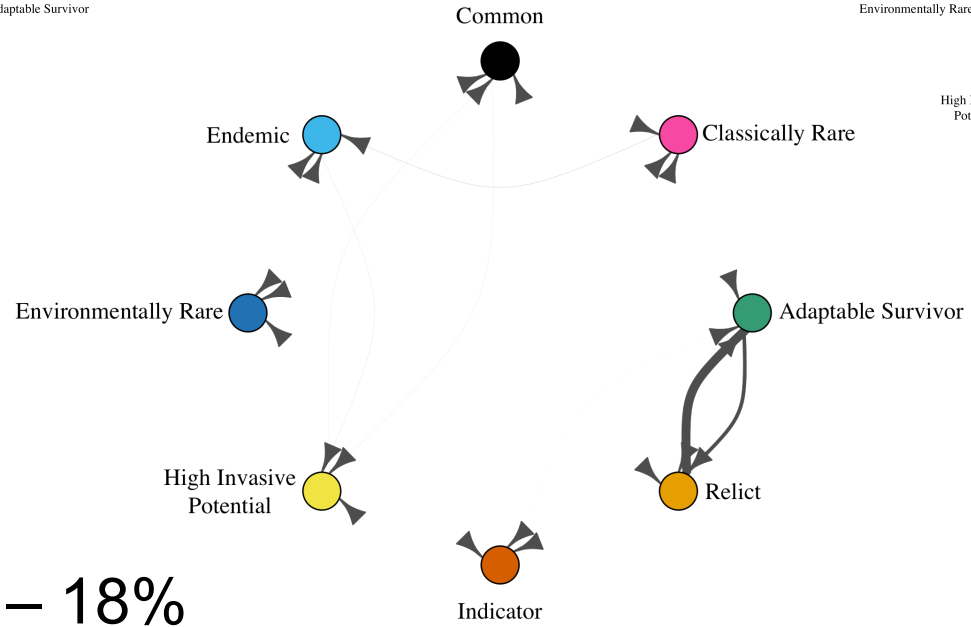

Common
Endemic
Classically Rare
Environmentally Rare
Adaptable Survivor
High Invasive Potential
Relict
Indicator



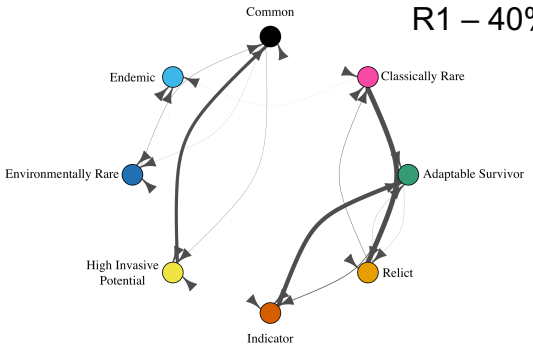
R1 – 40%



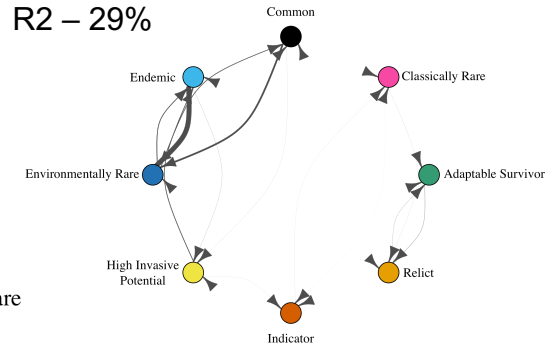
R2 – 29%



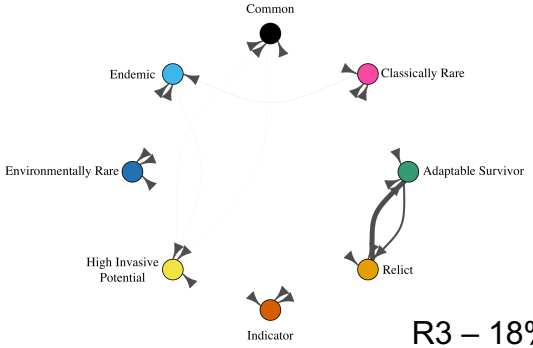
R3 – 18%



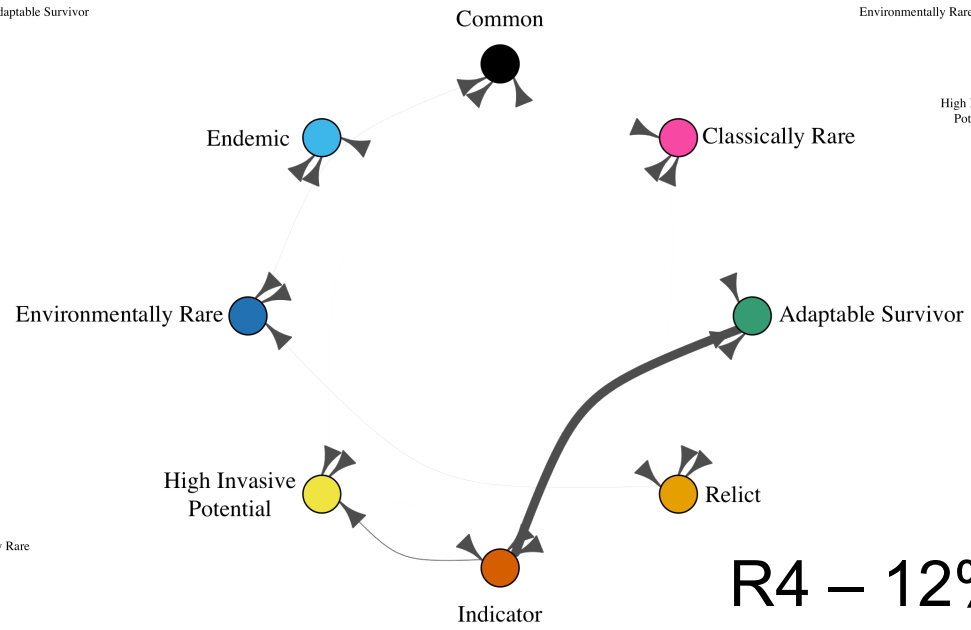
R1 – 40%



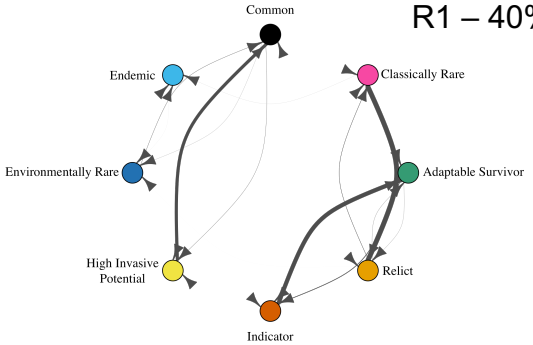
R2 – 29%



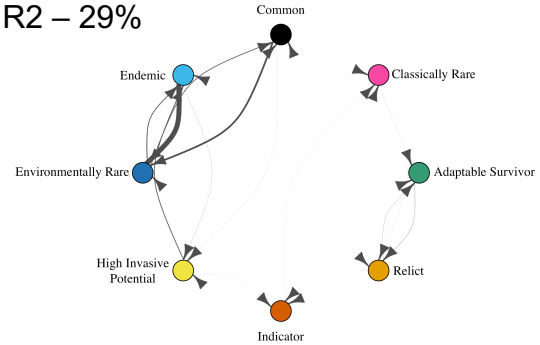
R3 – 18%



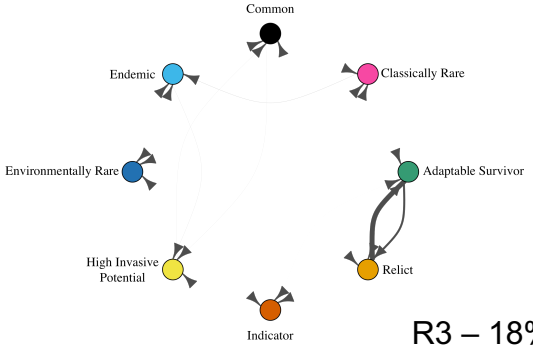
R4 – 12%



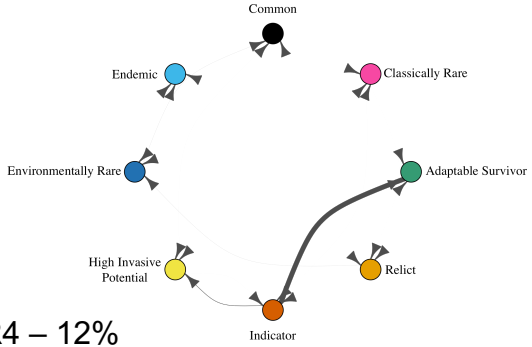
R1 – 40%



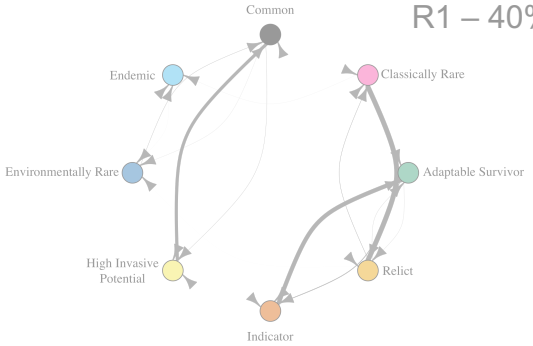
R2 – 29%



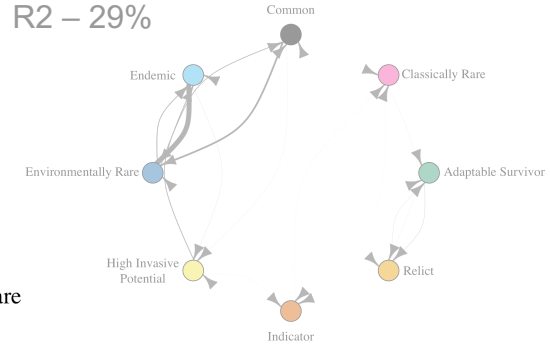
R3 – 18%



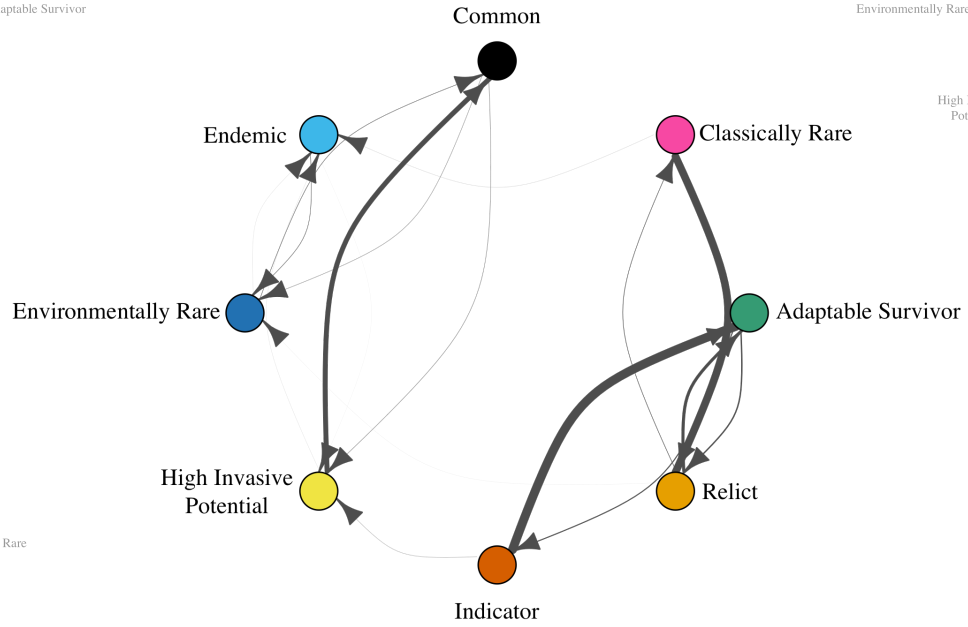
R4 – 12%

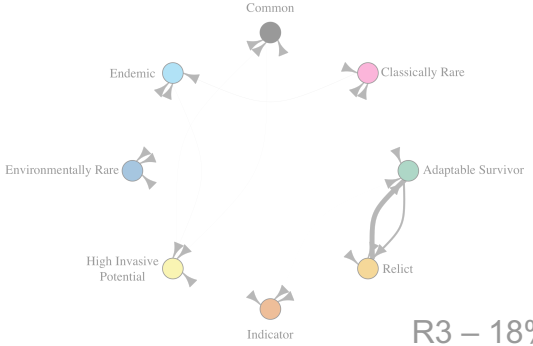


R1 – 40%

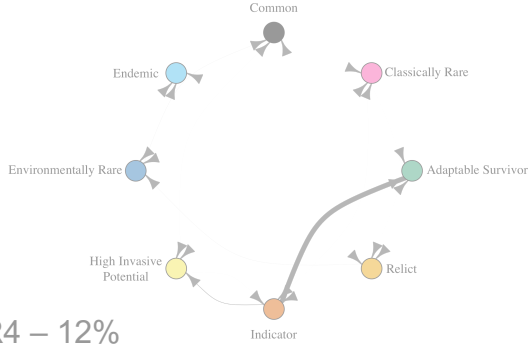


R2 – 29%

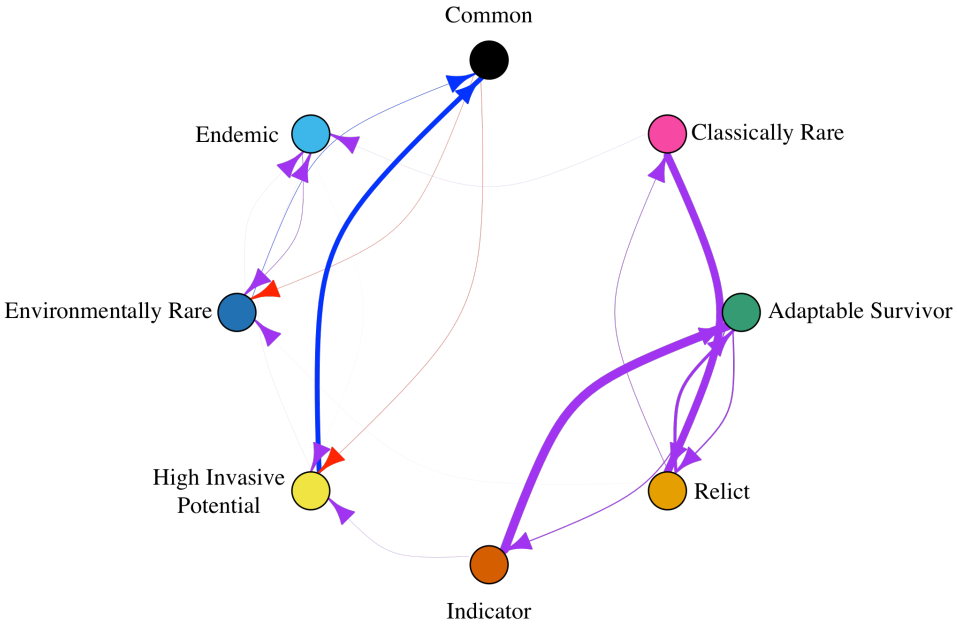


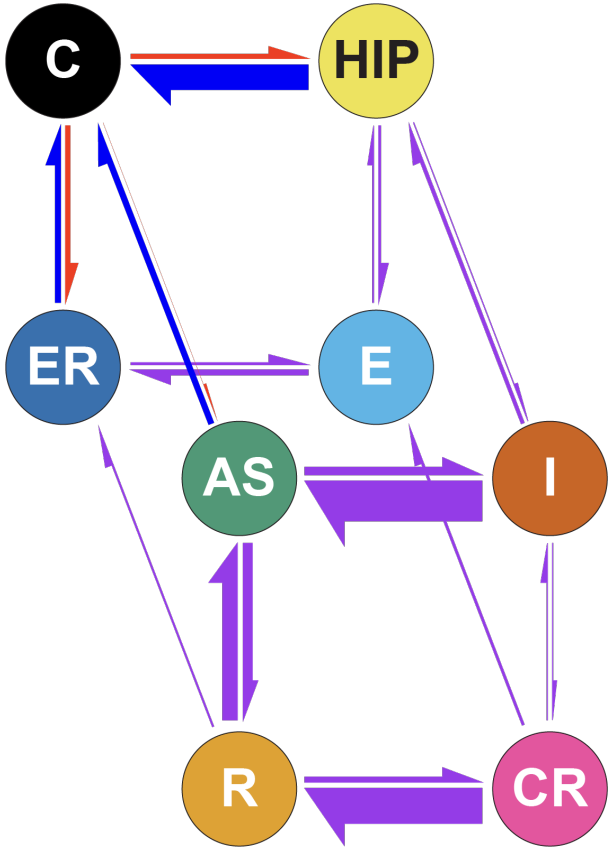


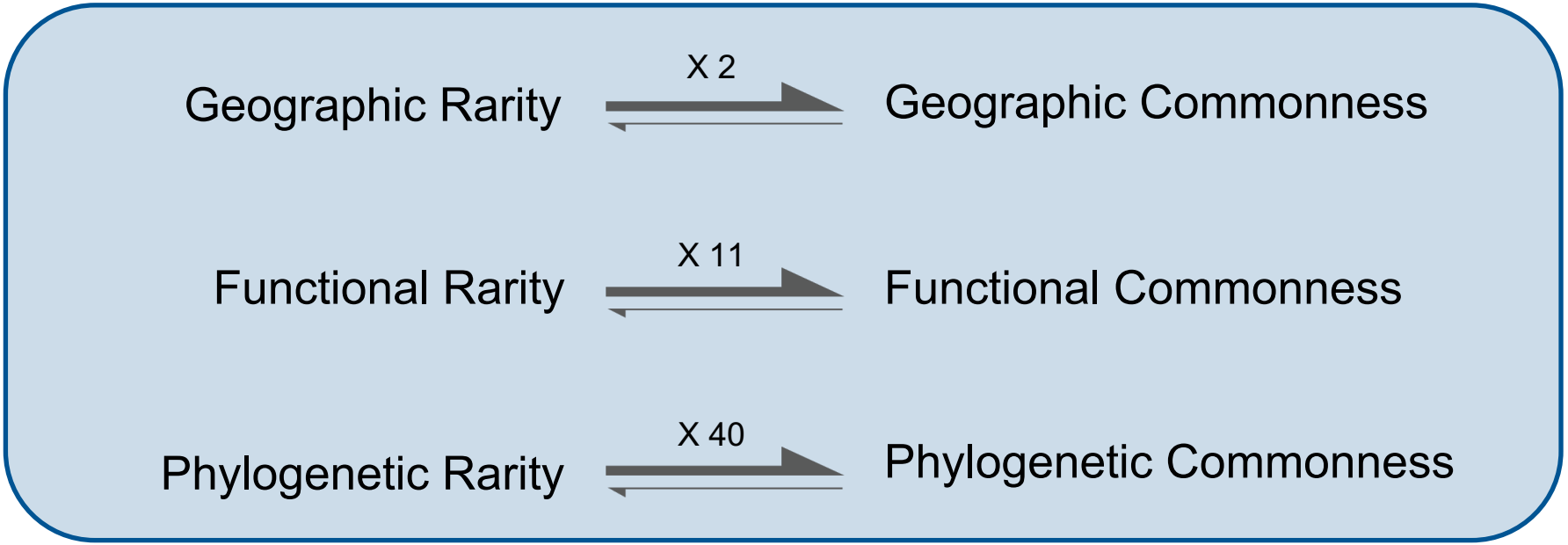
R3 – 18%

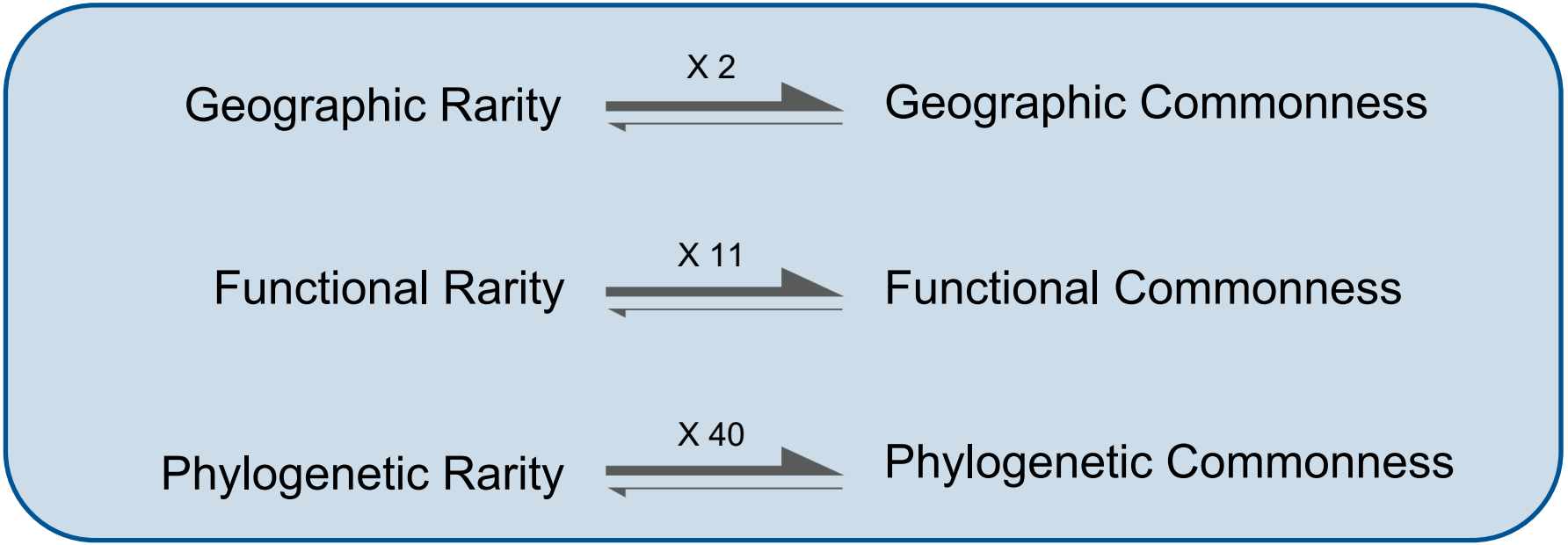


R4 – 12%


Common
Endemic
Classically Rare
Environmentally Rare
Adaptable Survivor
High Invasive Potential
Relict
Indicator


C
HIP
ER
E
AS
I
R
CR

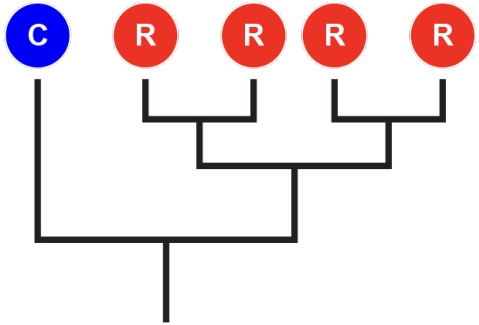

Geographic Rarity
X 2
Geographic Commonness
Functional Rarity
X 11
Functional Commonness
Phylogenetic Rarity
X 40
Phylogenetic Commonness



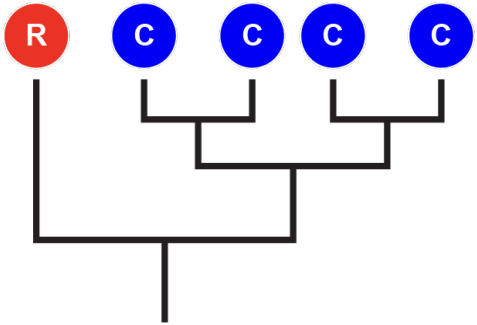
1

Rarity is a **dominant** state characterized by many single step, **rapid transitions** between rarity types or to commonness

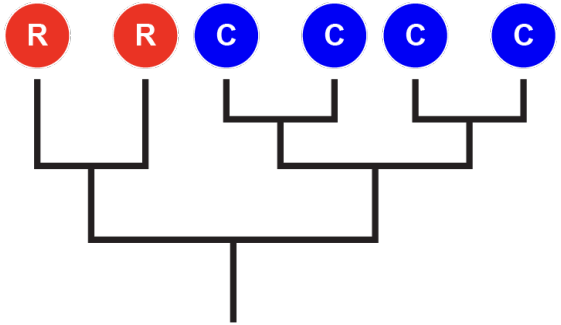
Geographic Rarity



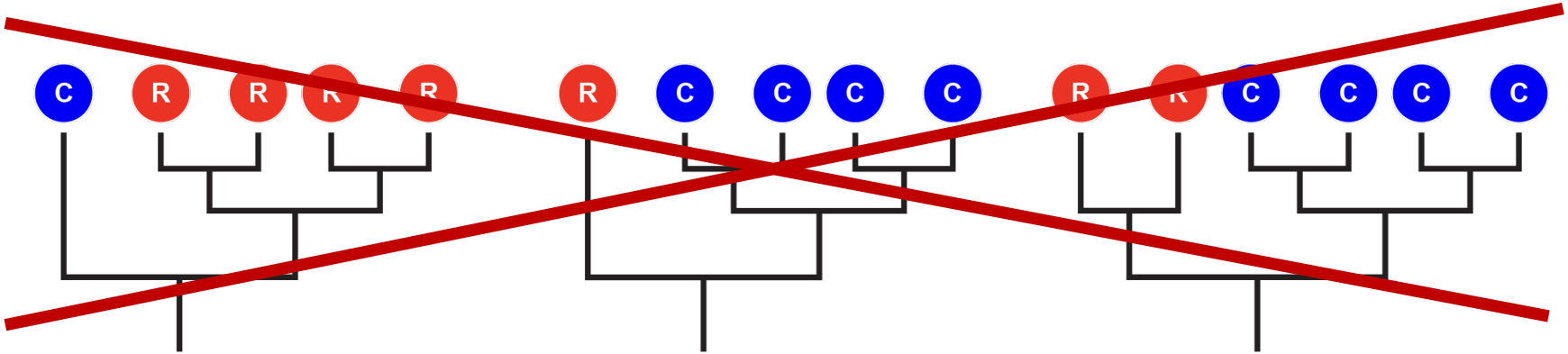
Functional Rarity



Phylogenetic Rarity



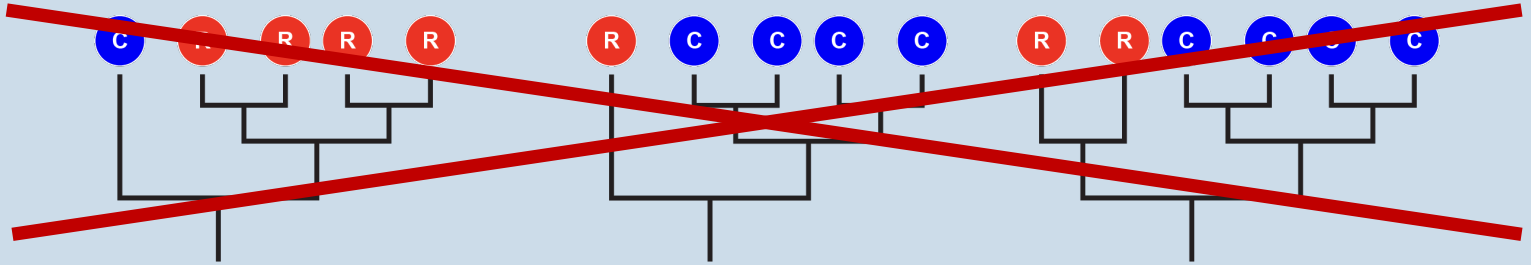
Geographic Rarity Functional Rarity Phylogenetic Rarity



Model	ΔAICc
CID-4	0
SID-2	108

2

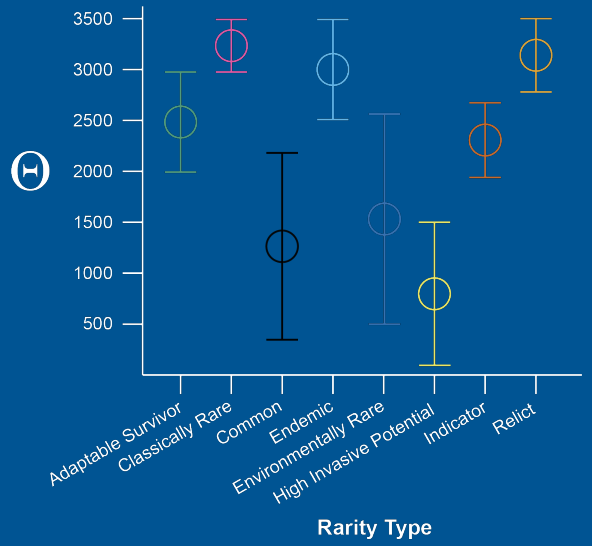
Rarity is **not** correlated with differential diversification.
Rarity does **not** persist via increased speciation, but it is **not** correlated with increased extinction either.

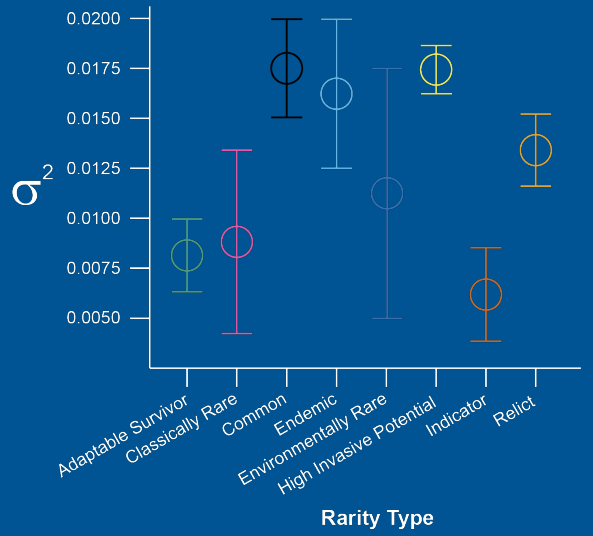


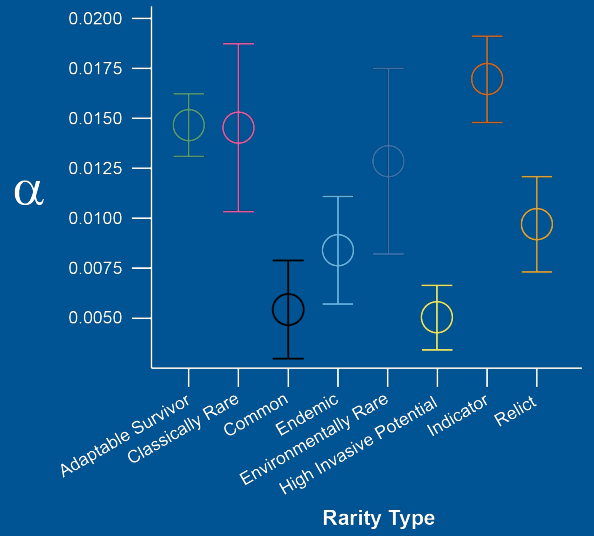
Model	ΔAICc
CID-4	0
SID-2	108

Future Directions

Example Output*







* Not based on real data

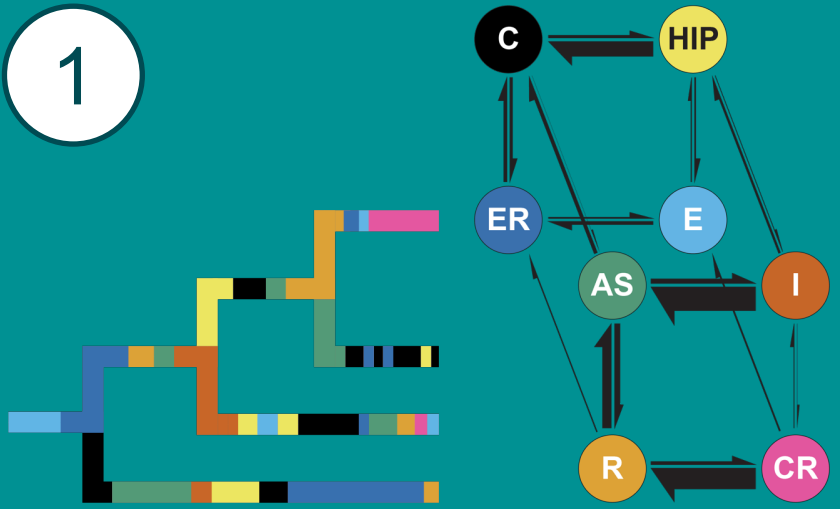
In Summary

1

2

In Summary

1

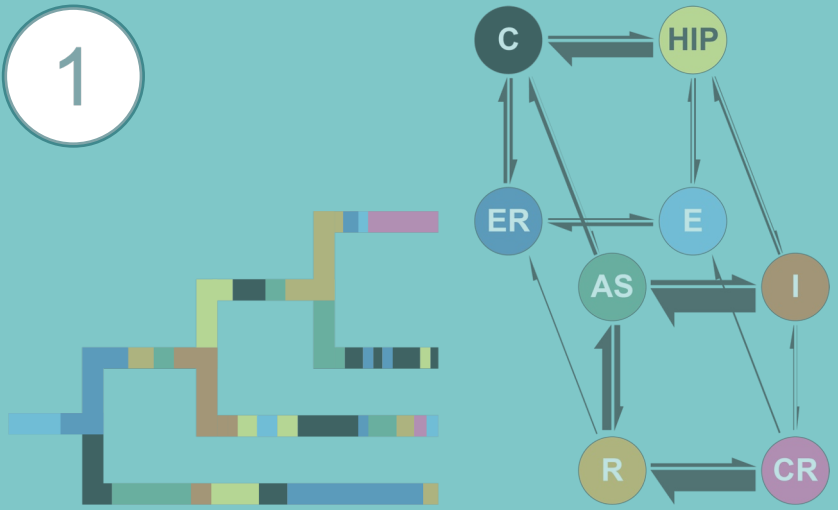


Rarity is a frequent state characterized by rapid transitions between rarity types

2

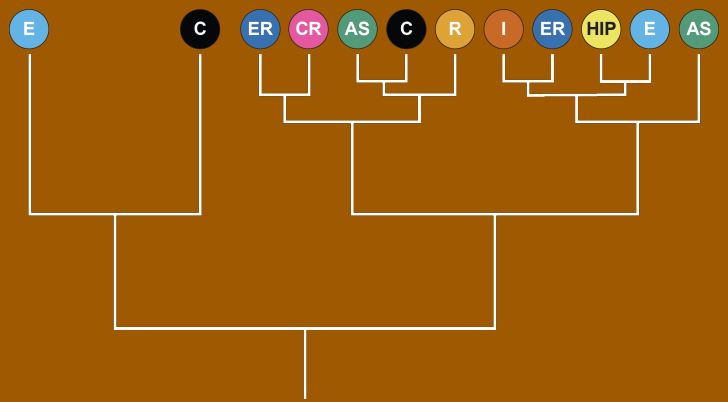
In Summary

1



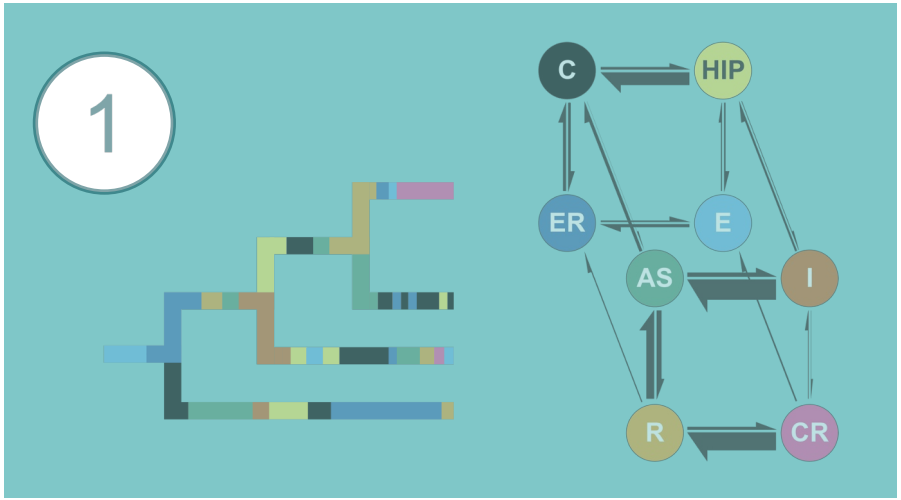
Rarity is a frequent state characterized by rapid transitions between rarity types

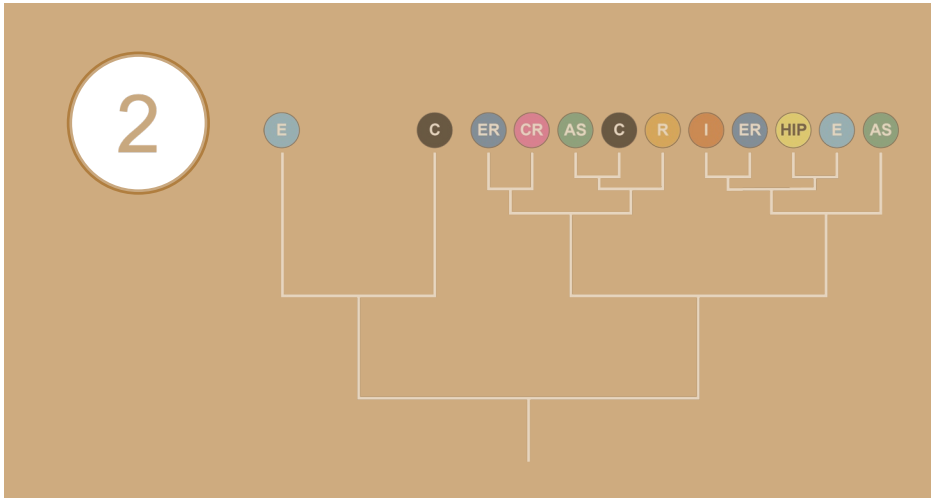
2



Surprisingly, rarity is not correlated with differential diversification

In Summary





Rarity is not a static endpoint, nor a precursor to extinction, but rather a frequent and dynamic state

Thank you!

Beaulieu Lab

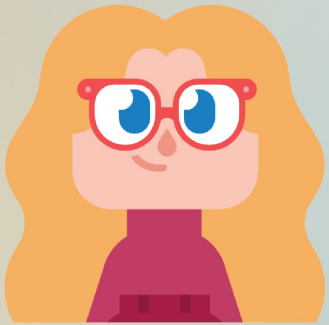
O'Meara Lab

Bailey Lab

NSF

Society of Systematic Biologists

THE UNIVERSITY OF TENNESSEE KNOXVILLE



anytko@vols.utk.edu

Thank you!

Beaulieu Lab

O'Meara Lab

Bailey Lab

NSF

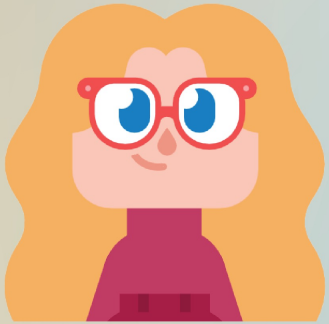
Society of Systematic Biologists

THE UNIVERSITY OF TENNESSEE KNOXVILLE

GeoFunPhy R Package

A tool to classify the multidimensional rarity of species

https://github.com/anytko



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Thank you!

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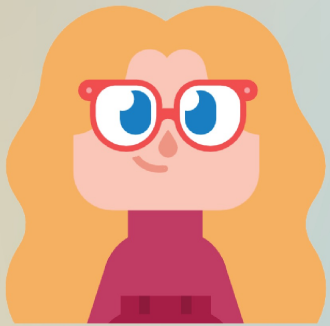
O'Meara Lab

Bailey Lab



Look for upcoming articles in TREE & Ecology Letters

anytko@vols.utk.edu

Questions?

Rarity Type	Prop. of time	Prop. of tips
Adaptable Survivor	14.2%	11.5%
Classically Rare	11.8%	1%
Common	12.9%	48.1%
Endemic	14.9%	2.5%
Environmentally Rare	13.6%	21.5%
High Invasive Potential	11.8%	5.5%
Indicator	11.1%	1.8%
Relict	9.7%	8.1%

Indicator

Cornus alternifolia

Adaptable Survivor

Acacia stricta

Classically Rare

Macrolobium angustifolium

Relict

Eucalyptus coccifera

High Invasive Potential

Pinus pinaster

Common

Campanula sibirica

Endemic

Cryptocarya alba

Environmentally Rare

Poa colensoi