

Supplementary Information. Heterogeneity within and among co-occurring foundation species increases biodiversity

Supplementary Table 1: Summary table 1 over 22 experiments.

Abbreviations: Exp = Experiment, Ele = Elevation, MSL = meter above mean sea level, Start and duration, Sea = Season (C = cold, W = Warm), S = Site, Long = longitude, Lat = latitude, 1FS = primary foundation species, 2FS = secondary foundation species, Mor = Morphology complexity value: 1 = simple, 2 = intermediate, 3 = complex, dMor calculated = delta morphology calculated, i.e. the complexity values of the sFS – pFS, dMor 2-levels = calculated dMor ranging from -1 to 2 reclassified to high vs. low complexity (e.g. see Test 1 in Supplement 2 - ‘Delta_mor2_all’). Numbers with asterisk were reclassified as ‘intermediate’ complexity in a 3-level classification (e.g., see Test 2 in Supplement 2 – ‘Delta_mor3’) and removed entirely from another high-vs-low complexity tests (e.g., see Test 3 in Supplement 2 - ‘Delta_mor2_few’).

Exp name in Fig.1	Habitat	Ele (m MSL)	Start date	Duration (days)	Sea	S1 Lat	S1 Long	S2 Lat	S2 Long	1FS	1FS unit Sampling	1FS Mor
1	Mangrove	0.2	23/10/2015	90	W	9.21858	-82.214	9.22180	82.20730	<i>Rhizophora mangle</i> (prop root)	Individual	1
2	Marsh	0.8	20/06/2018	96	W	31.4251	-81.2902	31.3921	81.27764	<i>Spartina alterniflora</i>	Area	2
3	Mud	0.5	15/10/2018	8	C	33.9358	-77.9438	33.9349	77.94447	<i>Diopatra cuprea</i> (mimic tube)	Individual	1
4	Mud	0.5	18/04/2019	11	W	33.9358	-77.9436	33.9349	77.94471	<i>Diopatra cuprea</i> (mimic tube)	Individual	1
5	Marsh	0.7	19/06/2016	120	W	34.7046	-76.7563	34.7182	76.67102	<i>Spartina alterniflora</i>	Area	2
6	Rocky reef	-2.0	24/06/2019	8	W	50.3068	-4.10949	50.3428	4.129120	<i>Laminaria hyperborea</i> (stipe)	Individual	1
7	Forest	10.0	6/07/2016	49	W	53.1524	8.161886	53.1553	8.154267	<i>Fagus sylvatica</i> (branch)	Individual	1
8	Rocky reef	-6.5	23/06/2018	34	W	43.4964	10.31871	43.4884	10.32410	<i>Halopithys incurve</i>	1 Individual	3
9	Rocky reef	-2.5	29/11/2016	14	W	-31.6892	115.6993	-31.688	115.6993	<i>Pseudoceratina</i> sp. (mimic)	Area	2
10	Sand	-0.8	8/29/2016	14	C	-35.0939	150.5617	-35.095	150.5791	<i>Anadara trapezia</i>	1 Individual	1
11	Mangrove	0.7	1/11/2016	11	W	-34.0245	151.1810	-34.021	151.1300	<i>Avicennia marina</i> (pneumatophores)	Individual	1
12	Mangrove	0.7	16/11/2016	15	W	-33.8262	151.1436	-33.817	151.1391	<i>Avicennia marina</i> (pneumatophores)	Individual	1
13	Mud	0.5	2/10/2016	14	C	-43.5549	172.7201	-43.554	172.7172	<i>Austrovenus stutchburyi</i>	1 Individual	1

14	Seagrass	0.2	21/07/2016	14	C	43.552477	172.7455	-43.549	172.7448	<i>Zostera muelleri</i>	Core	2
15	Seagrass	0.2	10/11/2016	14	W	-43.5523	172.7470	-43.548	172.7445	<i>Zostera muelleri</i>	Core	2
16	Rocky	-0.2	26/06/2018	14	C	-43.6186	172.7628	-43.6180	172.7640	Turf alga (AstroTurf mimic)	Area	2
17	Rocky reef	-0.2	26/06/2018	14	C	-43.6183	172.7631	-43.6180	172.7640	Turf alga (AstroTurf mimic)	Area	2
18	Rocky reef	0.1	10/01/2017	14	W	-43.6179	172.7642	-43.6178	172.7650	<i>Perna canaliculus</i>	Area	2
19	Mud	1.5	2/03/2017	21	W	-41.2283	173.3189	-41.2497	173.3120	<i>Xenostrobus pulex</i>	Area	2
20	Rocky reef	-0.2	28/12/2015	14	W	-42.4202	173.7050	-42.4340	173.6927	<i>Hormosira banksii</i>	<1 Individual	2
21	Rocky reef	-0.2	28/12/2015	14	W	-42.4202	173.7096	-42.4301	173.6924	<i>Cystophora scalaris</i>	<1 Individual	3
22	Rocky reef	-0.2	1/10/2015	14	C	-42.4203	173.7095	-42.4310	173.7200	<i>Cystophora scalaris</i>	<1 Individual	3

Supplementary table 1 continued.

Exp name in Fig.1	2FS	2FS Mimics	2FS Sampling	2FS Mor	dMor calculated	dMor 2-levels	dMor 3-levels
1	<i>Crassostrea gigas</i>	Shells - same materials, morphology, colour, texture as alive 2FS	>1 individuals	3	2	High	High
2	<i>Geukensia demissa</i>	Shells - same materials, morphology, colour, texture as alive 2FS	>1 individuals	2	0	Low	Low
3	<i>Gracilaria vermiculophylla</i>	Strings intertwined	1 individual	3	2	High	High
4	<i>Gracilaria vermiculophylla</i>	Strings intertwined	1 individual	3	2	High	High
5	<i>Crassostrea gigas</i>	Shells - same materials, morphology, colour, texture as alive 2FS	>1 individuals	3	1	High*	Inter
6	<i>Palmaria palmata</i>	Plastic sheet folded	1 individual	3	2	High	High
7	<i>Polypodium sp.</i>	Mesh intertwined	1 individual	3	2	High	High
8	<i>Jania rubens</i>	Nylon mesh folded	1 individual	3	0	Low	Low
9	<i>Caulerpa racemosa</i>	3d scanned model and 3d printed in plastic	>1 individuals	2	0	Low	Low
10	<i>Sirophysalis trinodis</i>	Strings intertwined	1 individual	3	2	High	High
11	<i>Saccostrea glomerata</i>	Shells - same materials, morphology, colour, texture as alive 2FS	>1 individuals	3	2	High	High
12	<i>Bostrychia/Caloglossa</i>	Plastic turf	>1 individuals	2	1	High*	Inter
13	<i>Gracilaria chilensis</i>	Strings intertwined	1 individual	3	2	High	High
14	<i>Ulva sp.</i>	Flagging tape folded	>1 individuals	2	0	Low	Low
15	<i>Ulva sp.</i>	Flagging tape folded	>1 individuals	2	0	Low	Low
16	<i>Undaria pinnatifida</i> (holdfasts)	3d scanned model and 3d printed in plastic	1 individual	2	0	Low	Low
17	<i>Durvillaea antarctica</i> (holdfast)	3d scanned model and 3d printed in plastic	1 individual	1	-1	Low	Low
18	<i>Undaria pinnatifida</i> (holdfasts)	3d scanned model and 3d printed in plastic	1 individual	2	0	Low	Low
19	<i>Capreolia implexa</i>	Plastic turf	>1 individuals	2	0	Low	Low
20	<i>Notheia anomala</i>	Plastic filaments	1 individual	3	1	High*	Inter
21	<i>Polysiphonia decepiens</i>	Strings intertwined	1 individual	3	0	Low	Low
22	<i>Polysiphonia decepiens</i>	Strings intertwined	1 individual	3	0	Low	Low

Supplementary Table 2. Bray-Curtis dissimilarity: Levine's tests for variance heterogeneity

See Supplementary Table 1 for details of specific experiments and complexity tests and the main paper for details of test factors and statistical tests. Abbreviations: See Supplementary Table 1 and OTU = operational taxonomic units.

<i>Factor</i>	<i>Group</i>	<i>Test Statistic</i>	<i>P</i>
<i>Amount</i>	OTU	7.5588	0.0067
<i>Function</i>		1.3525	0.2467
<i>Site</i>		0.7349	0.3927
<i>dMorphology-2level</i>		21.4670	0.0000
<i>dMorphology-3level</i>		21.4670	0.0000
<i>dMorphology-2 level short</i>		21.4670	0.0000
<i>Season</i>		0.5974	0.4435
<i>Amount</i>	Class	10.7547	0.0013
<i>Function</i>		1.5850	0.2100
<i>Site</i>		0.0489	0.8253
<i>dMorphology-2level</i>		22.0711	0.0000
<i>dMorphology-3level</i>		22.0711	0.0000
<i>dMorphology-2 level short</i>		22.0711	0.0000
<i>Season</i>		0.1109	0.7406

Supplementary Table 3. Bray-Curtis dissimilarity: Factorial Anova's

See Supplementary Table 1 for details of specific experiments and complexity tests and the main paper for details of test factors and statistical tests. Abbreviations: See Supplementary Table 1 and OTU = operational taxonomic units.

Morphology test	Group	Factor	SS	P	Df	F	P	% SS/ factor
dM-2levels	OTU	Amount	5380	0.000	1	28.6265	0.0000	17.1468
		Function	3421	0.000	1	18.2050	0.0000	10.9045
		dMorphology	21040	0.000	1	111.9616	0.0000	67.0632
		A x F	112	0.442	1	0.5947	0.4417	0.3562
		A x dM	1311	0.009	1	6.9757	0.0090	4.1783
		F x dM	38	0.654	1	0.2013	0.6542	0.1206
		A x F x dM	72	0.536	1	0.3845	0.5361	0.2303
		Total	62945		175			
	Class	Amount	4774	0.000	1	22.1109	0.0000	13.8913
		Function	2382	0.001	1	11.0322	0.0011	6.9310
		dMorphology	25517	0.000	1	118.1718	0.0000	74.2418
		A x F	61	0.597	1	0.2803	0.5972	0.1761
		A x dM	1521	0.009	1	7.0434	0.0087	4.4251
		F x dM	0	0.987	1	0.0003	0.9865	0.0002
		A x F x dM	115	0.467	1	0.5326	0.4665	0.3346
		Total	70646		175			
dM-3levels	OTU	Amount	5380	0.0000	1	28.3751	0.0000	16.8891
		Function	3421	0.0000	1	18.0452	0.0000	10.7406
		dMorphology	21053	0.0000	2	55.5227	0.0000	66.0952
		A x F	112	0.4437	1	0.5895	0.4437	0.3509
		A x dM	1385	0.0281	2	3.6524	0.0281	4.3479
		F x dM	403	0.3482	2	1.0617	0.3482	1.2639
		A x F x dM	99	0.7696	2	0.2624	0.7696	0.3123
		Total	62945		175			
	Class	Amount	4774	0.0000	1	23.5446	0.0000	12.7692
		Function	2382	0.0008	1	11.7476	0.0008	6.3712
		dMorphology	26835	0.0000	2	66.1685	0.0000	71.7718
		A x F	61	0.5856	1	0.2985	0.5856	0.1619
		A x dM	1898	0.0105	2	4.6807	0.0105	5.0771
		F x dM	1188	0.0562	2	2.9295	0.0562	3.1775
		A x F x dM	251	0.5398	2	0.6188	0.5398	0.6712
		Total	70646		175			
dM-2levels-short	OTU	Amount	4325	0.0000	1	25.2383	0.0000	15.5976
		Function	3591	0.0000	1	20.9561	0.0000	12.9511
		dMorphology	18097	0.0000	1	105.6039	0.0000	65.2643
		A x F	165	0.3283	1	0.9621	0.3283	0.5946
		A x dM	1343	0.0058	1	7.8358	0.0058	4.8426
		F x dM	175	0.3138	1	1.0219	0.3138	0.6316
		A x F x dM	33	0.6625	1	0.1913	0.6625	0.1183
		Total	52405		151			
	Class	Amount	4235	0.0000	1	23.0533	0.0000	11.8676
		Function	3257	0.0000	1	17.7336	0.0000	9.1291
		dMorphology	25926	0.0000	1	141.1415	0.0000	72.6583
		A x F	163	0.3482	1	0.8857	0.3482	0.4559

A x dM	1893	0.0016	1	10.3048	0.0016	5.3048
F x dM	181	0.3220	1	0.9874	0.3220	0.5083
A x F x dM	27	0.7014	1	0.1476	0.7014	0.0760
Total	62134		151			

Supplementary Table 4. Bray-Curtis dissimilarity: Anova's - Random site effects

See Supplementary Table 1 for details of specific experiments and complexity tests and the main paper for details of test factors and statistical tests. Abbreviations: See Supplementary Table 1 and OTU = operational taxonomic units.

<u>Response</u>	<u>Factor</u>	<u>SS</u>	<u>Df</u>	<u>F</u>	<u>P</u>
OTU	Sites	10.7709	1	0.030	0.863
	Total	62945.4	175		
Class	Sites	73.7287	1	0.182	0.670
	Total	70645.5	175		

Supplementary Table 5. Seasonal effect from repeated experiments: Levine's tests for variance heterogeneity

See Supplementary Table 1 for details of specific experiments and complexity tests and the main paper for details of test factors and statistical tests. Abbreviations: See Supplementary Table 1 and OTU = operational taxonomic units.

Response	Factor	Test Statistic	P
lnRR_Abu2	Amount	12.24788	0.0006
	Function	26.46143	0.0000
	Overall	13.77217	0.0000
	Season	<u>25.26719</u>	<u>0.0000</u>
lnRR_RichS2	Amount	8.261339	0.0045
	Function	10.20413	0.0016
	Overall	2.321539	0.0266
	Season	<u>0.410847</u>	<u>0.5222</u>
lnRR_RichC2 (Class)	Amount	2.165352	0.1426
	Function	0.280058	0.5972
	Overall	2.187116	0.0366
	Season	<u>10.68961</u>	<u>0.0013</u>
Dissimilarity OTU	Amount	2.461118	0.1235
	Function	6.32444	0.0155
	Overall	1.440566	0.2165
	Season	<u>0.597381</u>	<u>0.4435</u>
Dissimilarity Class	Amount	3.047635	0.0875
	Function	4.882661	0.0321
	Overall	1.314981	0.2685
	Season	0.110932	0.7406

Supplementary Table 6. Seasonal effect from repeated experiments: Factorial Anova's

See Supplementary Table 1 for details of specific experiments and complexity tests and the main paper for details of test factors and statistical tests. Abbreviations: See Supplementary Table 1 and OTU = operational taxonomic units.

Response	Factor	SS	DF	F	P
lnRR_Abu2	Amount	13.89735	1	19.13752	0.0000
	Function	8.933986	1	12.30266	0.0006
	Season	0.128594	1	0.177082	0.6743
	Amount x Function	0.131695	1	0.181353	0.6706
	Amount x Season	0.043148	1	0.059418	0.8077
	Function x Season	0.536244	1	0.738441	0.3911
	Amount x Function x Season	0.082562	1	0.113693	0.7363
	Explained	23.85932	7	4.693683	0.0001
	Error	153.2247	211		
lnRR_RichS2 (OTU)	Amount	0.623602	1	4.527272	0.0345
	Function	0.262965	1	1.909098	0.1685
	Season	0.035313	1	0.256366	0.6132
	Amount x Function	0.035155	1	0.255221	0.6139
	Amount x Season	0.179579	1	1.303719	0.2548
	Function x Season	0.000828	1	0.006011	0.9383
	Amount x Function x Season	0.046972	1	0.341009	0.5599
	Explained	1.188773	7	1.232907	0.2860
	Error	29.06384	211		
lnRR_RichC2 (Class)	Amount	0.043438	1	1.071402	0.3018
	Function	0.010382	1	0.256081	0.6134
	Season	0.038961	1	0.960972	0.3281
	Amount x Function	8.49E-05	1	0.002095	0.9635
	Amount x Season	0.006829	1	0.168427	0.6819
	Function x Season	0.00396	1	0.097668	0.7550
	Amount x Function x Season	0.010219	1	0.25204	0.6162
	Explained	0.113046	7	0.398324	0.9026
	Error	8.554632	211		
Dissimilarity Class	Amount	1262.483	1	5.456535	0.0246
	Function	1337.468	1	5.780626	0.0209
	Season	10.13467	1	0.043803	0.8353
	Amount x Function	32.7725	1	0.141645	0.7086
	Amount x Season	65.24641	1	0.281999	0.5983
	Function x Season	138.8533	1	0.600133	0.4431
	Amount x Function x Season	260.0497	1	1.123952	0.2954
	Explained	3107.008	7	1.918385	0.0920
	Error	9254.835	40		
Dissimilarity OTU	Amount	1145.486	1	6.304046	0.0162
	Function	1306.595	1	7.190687	0.0106
	Season	7.728083	1	0.042531	0.8377
	Amount x Function	36.75306	1	0.202266	0.6553
	Amount x Season	115.6849	1	0.636658	0.4296
	Function x Season	202.8181	1	1.116185	0.2971
	Amount x Function x Season	130.76	1	0.719622	0.4013
	Explained	2945.825	7	2.315999	0.0442
	Error	7268.26	40		

Supplementary Notes. R Codes.

```
library(lme4)
```

```
library(lmerTest)
```

```
library(MuMIn)
```

```
abc <- read.csv("E:/R/2021/FC_Data2.csv", header=T)
```

```
abc$Date_Start <- as.Date(abc$Date_Start, format = "%m/%d/%y")
```

```
abc$Amount <- as.factor(abc$Amount)
```

```
abc$Function <- as.factor(abc$Function)
```

```
abc$Delta_mor2_all <- as.factor(abc$Delta_mor2_all)
```

```
abc$Delta_mor2_few <- as.factor(abc$Delta_mor2_few)
```

```
abc$Delta_mor3 <- as.factor(abc$Delta_mor3)
```

```
abc2 <- subset(abc, lnRR_RichC!="NA")
```

```
lm1 <- lm(lnRR_RichC ~ Amount + Function + Delta_mor2_all + STD_2FS_DW + STD_1FS_DW + abs(Lat) + Long +  
Duration + Elevation + Season + Date_Start, data=abc2)
```

```
vif(lm1)
```

```
lmer1 <- lmer(lnRR_RichC ~ Amount + Function + Delta_mor2_all + Amount:Function + Amount:Delta_mor2_all +  
Function:Delta_mor2_all + STD_2FS_DW + STD_1FS_DW + abs(Lat) + Long + Duration + Elevation + Season +  
Date_Start + (1|Exp_name)+(1|Exp_name:Site), REML = FALSE, data=abc2)
```

```
summary(lmer1)
```

```
anova(lmer1)
```

```
options(na.action="na.fail")
```

```
m1 <- dredge(lmer1, evaluate=TRUE, rank="AICc", REML=F)
```

```
top <- get.models(m1, subset = 1)[[1]]
```

```
anova(top)
```

```
rb1 <- model.avg(m1, subset=delta <= 2, revised.var = TRUE)
```

```
summary(rb1)
```

```
confint(rb1)
```

```
importance(m1)
```