

Global change effects on plant communities are magnified by time and the number of global change factors imposed

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2
3 **Title: Global change effects on plant communities are magnified by time and**
4 **the number of global change factors imposed**

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137 **Abstract:** Global change drivers (GCDs) are expected to alter community structure and
138 consequently the services ecosystems provide. Yet few experimental investigations have
139 examined effects of GCDs on plant community structure across multiple ecosystem types, and
140 those that do exist present conflicting patterns. In an unprecedented global synthesis of over 100
141 experiments that manipulated factors linked to GCDs, we show that herbaceous plant community
142 responses depend on experimental manipulation length and number of factors manipulated. We
143 found that plant communities are fairly resistant to experimentally manipulated GCDs in the
144 short-term (<10 years). In contrast, long-term (≥ 10 year) experiments show increasing
145 community divergence of treatments from control conditions. Surprisingly, these community
146 responses occurred with similar frequency across GCD types manipulated in our database.
147 However, community responses were more common when three or more GCDs were
148 simultaneously manipulated, suggesting the emergence of additive or synergistic effects of
149 multiple drivers, particularly over long-time periods. In half of the cases, GCD manipulations
150 caused a difference in community composition without a corresponding species richness
151 difference, indicating that species reordering or replacement is an important mechanism of
152 community responses to GCDs and should be given greater consideration when examining
153 consequences of GCDs for the biodiversity-ecosystem function relationship. Human activities
154 are currently driving unparalleled global changes worldwide. Our analyses provide the most
155 comprehensive evidence to-date that these human activities may have widespread impacts on
156 plant community composition globally, which will increase in frequency over time and be
157 greater in areas where communities face multiple GCDs simultaneously.

158

159 **Keywords:** community composition, global change experiments, herbaceous plants, species

160 richness

161

162 **Significance Statement:** Accurate prediction of community responses to global change drivers

163 (GCDs) is critical, given the effects of biodiversity on ecosystem services. There is consensus

164 that human activities are driving species extinctions at the global scale, but debate remains over

165 whether GCDs are systematically altering local communities worldwide. Across 105

166 experiments that included over 400 experimental manipulations, we found evidence for a lagged

167 response of herbaceous plant communities to GCDs, caused by shifts in the identities and

168 relative abundances of species often without a corresponding difference in species richness.

169 These results provide evidence that community responses are pervasive across a wide variety of

170 GCDs on long-term temporal scales, and that these responses increase in strength when multiple

171 GCDs are simultaneously imposed.

172 /body

173 **Main Text:**

174 Human activities are driving unprecedented changes in many factors that may affect the
175 composition and functioning of plant communities. Determining the factors that cause alterations in
176 plant community structure is critical, as important ecosystem functions and services are influenced
177 by plant community composition (1, 2). Changes in resource availability (*e.g.*, atmospheric carbon
178 dioxide (CO₂), nitrogen (N), precipitation patterns) may have large consequences for plant
179 community structure worldwide (3). Yet our ability to interpret and predict plant community
180 responses to global change is complicated by many factors, such as the type of global change
181 driver (GCD) and the environmental context. Observational and experimental evidence has
182 demonstrated disparate and seemingly conflicting patterns of species richness responses to
183 environmental change across a variety of independent studies, meta-analyses, and large data
184 syntheses (4–11). As such, there is continued debate over whether local-scale biodiversity loss is
185 a worldwide trend (12–14). Moreover, recent studies (15, 16) advocate the use of multivariate
186 metrics (*e.g.*, Bray-Curtis dissimilarity) that account not only for changes in species number, but
187 also species identities and relative abundances to provide a more comprehensive picture of
188 composition responses to GCDs.

189 Both biotic (*e.g.*, shifts in competitive dominance or susceptibility to herbivores) and
190 abiotic (*e.g.*, environmental filtering) processes (17–19) have been invoked to explain how
191 GCDs affect plant community richness and composition at local scales, and it seems reasonable
192 to expect that plant community responses will vary across a broad array of GCDs (2, 15).
193 Resource additions (*e.g.*, nutrient additions) are predicted to reduce plant species richness and
194 alter plant community composition due to changes in competitive interactions among species for
195 the remaining limiting resources (*e.g.*, water or light) (7, 8, 20). In contrast, increased

196 environmental stress may have varying effects on plant community composition by either
197 shifting or increasing niche availability. For example, repeated removal of plant material through
198 haying (a common land use change in many herbaceous systems) may increase species richness
199 by increasing light availability and favoring species that can tolerate removal of aboveground
200 material. In contrast, increased drought or temperature stress may decrease plant species richness
201 as many species may not be able to persist under these novel conditions (7, 21). In addition to the
202 type of driver manipulated, the number of simultaneously imposed GCDs may also impact
203 community responses. Previous studies have shown that plant community responses may be
204 greater under multiple simultaneously imposed GCDs (22–24). In contrast, both empirical and
205 theoretical evidence suggests that ecosystem function responses have been shown to dampen
206 with increasing numbers of simultaneously imposed GCDs (25, 26), due to a canceling out of
207 positive and negative effects on functions such as productivity and nutrient cycling. Based on
208 these conflicting results, determining a generalizable pattern of the effects of multiple GCDs on
209 community responses is needed.

210 Here we examined results from 105 experiments conducted in grasslands around the
211 world that together provide data on over 400 experimental manipulations of GCDs to determine
212 whether we could identify general community response patterns across different types of
213 manipulations, the magnitude of the manipulations imposed, or the attributes of the ecosystems
214 where the experiments were conducted. In contrast to prior analyses, which have examined
215 patterns of community change based on observational data (5, 16, 27), we focused on
216 experiments because they provide an important baseline (control plots) that is critical for the
217 accurate assessment of community responses to GCDs by separating stochastic community shifts
218 from global change effects. By identifying generalities where they exist across complex

219 community patterns, we can make tangible progress toward prediction of future community
220 responses to GCDs occurring worldwide, which is needed to develop strategies for maintaining
221 the communities upon which many ecosystem services rely.

222 We used hierarchical Bayesian modeling to examine how herbaceous plant communities
223 responded to global change manipulations in 438 experimental treatments, encompassed within
224 105 experiments at 52 sites around the world using the Community Responses to Resource
225 Experiments [CoRRE] database (<https://corredata.weebly.com/>; see SI Appendix 2). The CoRRE
226 database was assembled from plant species composition data collected by hundreds of
227 researchers in field experiments across all continents except Antarctica, and includes 285,019
228 species occurrence records of 2843 species from 26,788 time points in experiments ranging in
229 duration from 3 to 31 years (Table 1; see SI Appendix 3). Global change treatments included
230 resource additions and removals (*e.g.*, nutrient additions, increased atmospheric CO₂, irrigation,
231 drought), as well as non-resource manipulations (*e.g.*, increased temperature, burning, mowing,
232 herbivore removals), and were designed to simulate predicted future global change scenarios in
233 different areas of the globe. We measured plant community responses in treatments relative to
234 controls using two commonly used metrics of community difference: (1) In Response Ratios
235 (lnRR) of plant species richness (*i.e.*, species number without regard to identity) and (2) species
236 composition responses in multivariate space using Bray-Curtis dissimilarities (encompassing
237 shifts in plant species identities and their relative abundances). We also briefly present results
238 from two additional richness metrics: percent difference of plant species richness from control to
239 treatment plots and lnRR of effective species number (e^H). Because these two metrics show
240 qualitatively identical results to lnRR of richness, we focus on lnRR of richness here for most
241 analyses. For all metrics, we investigated the temporal nature of the observed differences over

242 the length of each experiment, as well as whether these effects varied based on the site-level
243 (gamma) diversity or productivity of each experiment.

244 In experiments less than 10 years in duration, we found that plant communities are
245 relatively resistant to global change manipulations, with 79.5% and 77.0% of treatments showing
246 no richness or composition response, respectively (Table 2; Fig. 1a,f). In contrast in long-term
247 (≥ 10 years) experiments, fewer manipulations (50%) showed no difference in species richness
248 (Table 2). Importantly, 70.7% of long-term manipulations exhibited composition responses
249 (Table 2) and some communities experienced almost complete turnover after one to two decades
250 (composition responses close to 1.0; Fig. 1). The increased prevalence of community responses
251 in long-term experiments highlights the need for long-term data collection to better identify
252 community responses to GCDs. In approximately half of the cases (54.5%) where experimental
253 manipulations caused a composition shift through time, it occurred without a corresponding
254 richness response. Consequently, the multivariate plant community composition responses
255 observed here often reflect differences in species evenness, reordering of species ranks based on
256 relative abundances, or species replacement (turnover) (15). Future consideration of these
257 detailed community responses is warranted to (1) examine the temporal hierarchy of the response
258 (*i.e.*, is there an ordering to differences in evenness, reordering of species ranks, and turnover)
259 (2), and (2) move beyond using only richness differences as a metric of biodiversity (16).
260 Studying these detailed community shifts will provide important insight into how alterations in
261 ecosystem function with GCDs relate to compositional aspects of biodiversity.

262 When considering all manipulations regardless of experiment length, we find that the
263 community responses to global change manipulations varied in both direction and magnitude
264 (Fig. 1). When richness responded to experimental manipulations (22.3% of all manipulations), it

265 generally declined either linearly or asymptotically (Table 2; Fig. 1). Similarly, when
266 composition responded to experimental manipulations (35.6% of all manipulations), it generally
267 increased in dissimilarity from control plots (Table 2; Fig. 1). Interestingly, in a small subset of
268 the cases studied here (10.5% of richness and 10.1% of composition responses), community
269 responses to global change manipulations were parabolic, with the minimum or maximum of the
270 curve occurring within the study period, suggesting that the community responses in these sites
271 dampen over time (Table 2; Fig. 1). These parabolic trends were more often detected in the long-
272 term experiments and treatments that manipulated two or more factors. For richness responses,
273 these parabolic trends were nearly equally split amongst those that were concave down,
274 indicative of initial richness losses that later recovered due to immigration of new species or
275 recovery of previously lost species, and those that were concave up, indicative of initial richness
276 gains that later declined. In contrast, the parabolic trends in composition response were nearly all
277 concave up, demonstrating an initial divergence of treatment and control plots, followed by
278 convergence. The few cases of long-term convergence between treatment and control plots
279 stemmed from a shift in control plots towards the altered state exhibited in the treatments (see SI
280 Appendix 5). Overall, these parabolic trends caused by a shift in communities in control plots
281 suggests that human activities may currently be impacting the environment at a scale beyond the
282 scope of some experimental treatments, as has previously been demonstrated in global
283 observational data syntheses (5, 8, 25).

284 Across sites, we found that productivity was positively related to richness increases in
285 response to global change manipulations, while gamma diversity (site-level species number) had
286 no effect on the direction or magnitude of the richness or composition responses (see SI
287 Appendix 4). Hence, high productivity ecosystems appear more responsive to GCDs, possibly

288 due to the greater availability of resources and therefore niche space in such systems (28), or the
289 greater ability of species in these systems to respond to GCDs due to higher growth rates in
290 productive herbaceous systems (29). The greater community responsiveness at high productivity
291 sites may contribute to the maintenance of ecosystem function, as species with traits adapted to
292 the novel environmental conditions presented by global change scenarios increase in abundance
293 in these communities (30). However, higher abundances of species that are not functionally
294 similar to the existing community (2, 3, 5) would likely result in altered ecosystem function.

295 Declines in species richness are often attributed to decreased niche dimensionality with
296 alleviation of resource limitations (17) or increased environmental filtering (19), while richness
297 increases may be due to invasions or increased environmental heterogeneity (31). We did
298 observe richness differences in a few cases that may be attributable to these mechanisms. For
299 example, multiple resource additions may decrease niche dimensionality, leading to dominance
300 of a few competitive species and therefore richness declines (20). In contrast, multiple resource
301 additions can shift an ecosystem's stoichiometry to alter the relative availability of the most
302 limiting resource, and thus competitive interactions, thereby reducing species loss (32). Further,
303 resource additions may increase species invasions by relaxing environmental filters (33), again
304 reducing species loss. Nevertheless, in the majority of cases we found that global change
305 treatments altered community composition with no corresponding richness responses. These
306 results highlight the fact that, by not accounting for species identity species, richness does not
307 entirely capture community responses to GCDs (16). Indeed, species richness can stay constant
308 even with complete turnover in the identities of species within a community. Therefore,
309 multivariate metrics of species abundances are needed to assess complex community responses
310 to GCDs (15).

311 Interestingly, we did not find differences in richness or composition responses based on
312 the type of global change driver applied (Table 3). Our results differ from previous meta-
313 analyses that show stronger richness losses with N additions than other GCDs (7). However, we
314 did find that global change manipulations that simultaneously manipulated three or more GCDs
315 were significantly more likely to show richness and composition responses than treatments that
316 only manipulated one or two GCDs (Table 3; Fig. 3). These results are consistent with previous
317 studies examining community responses to GCDs (22–24), but contrast with trends observed for
318 ecosystem function responses to multiple GCDs from two previous studies, which tend to show
319 damped responses with increasing factors manipulated (25, 26). This difference highlights the
320 need to examine how differences in community composition relate to altered ecosystem function
321 (2, 15, 25).

322 While on average the effects of N addition on plant communities were not stronger than
323 other global change treatments, we did find that the absolute level of N added interacted with
324 mean annual precipitation (MAP) to influence richness responses (Fig. 4; see SI Appendix 6).
325 Specifically, richness declined with increasing N added at sites with low MAP, and increased
326 with increasing N added at sites with high MAP (Fig. 4a; see SI Appendix 6). In contrast, the
327 magnitude of rainfall manipulations did not affect the richness or composition responses (Fig. 4;
328 see SI Appendix 6). These results conflict with previous analyses of richness responses to N
329 deposition, which show a decline in richness with increasing precipitation and N deposition (34).
330 This discrepancy may be due to the high magnitude of N added in some of our experiments,
331 more akin to nutrient runoff from agricultural fields than atmospheric deposition. Together, these
332 results point towards co-limitation of species richness across ecosystems (34, 35), and highlight
333 the need to address potential threshold responses of community responses to resource

334 manipulations.

335 Although this analysis includes the effects of a wide variety of global change
336 manipulations on plant communities, many combinations of GCDs potentially important to
337 global change were under-represented or missing from our analysis, reflective of their lack of
338 study worldwide. These include combinations that are posited to have large impacts on the
339 biosphere, such as the combined consequences of increased nutrient availability and altered
340 precipitation patterns (36). Further, the geographic scope of global change experiments is
341 primarily constrained to the northern hemisphere (see SI Appendix 3). Experiments that
342 incorporate higher order interactions at sites worldwide are critical for accurately predicting how
343 communities will respond globally to predicted GCDs (25). Despite these limitations, our results
344 clearly demonstrate that changes in plant community composition may be expected across a wide
345 range of GCDs over the coming decades.

346 In conclusion, our comprehensive analysis finds that plant community structure is
347 frequently altered by a broad array of GCDs, and that these effects are largely only detectable
348 over long (≥ 10 year) time scales. These community responses occurred at similar frequencies
349 across the wide variety of GCDs examined in this study, but were more prevalent when three or
350 more GCDs were manipulated simultaneously, representative of real-world situations where one
351 GCD rarely operates in isolation. In about half of the cases where compositional responses were
352 observed, they occurred without corresponding differences in species richness, indicating that
353 coexistence mechanisms may be maintained in the face of changing environmental conditions, or
354 that competitive displacement is slower than the time scales of these experiments. Rather than
355 species gains or losses, in many cases community responses appear to be due to the abundances
356 of species tracking environmental conditions through reordering within the existing community

357 or colonization from a regional species pool. Determining the functional consequences of these
358 broad-scale community responses to GCDs demands investigation into the identities and traits of
359 species that are most responsive to global environmental change (2, 37).

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370

371 **Author contributions:** Author contributions are listed in SI Appendix 1 of the supplementary
372 material. Briefly, KJK and MLA conceived of the research in discussion with NPL, FI, EG,
373 GRH, SEK, DSJ, and KRW. All co-authors but two provided data used in analyses. Analyses
374 were conducted by KJK, MLA, NPL, FI, and ER. KJK wrote the manuscript, with input from all
375 co-authors.

376

377 **List of Supplementary Material**

378 Materials and Methods

379 Appendix 1 – Table of coauthor contributions.

380 Appendix 2 – Table of experiment information.

381 Appendix 3 – Map of experiment locations.

382 Appendix 4 – Experiment-level predictors of richness and composition responses.

- 383 Appendix 5 – Driver of parabolic richness and composition responses.
- 384 Appendix 6 – Regression coefficients of treatment magnitude effect on community differences.
- 385 Appendix 7 – Experiment and Site Acknowledgements.

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474

475 **Figure Legends**

476 Figure 1. Experimental global change manipulations drive temporal differences in plant
477 community composition. Richness responses (a-e) are measured as the ln Response Ratio (lnRR)
478 in richness between treatment and control plots within a year; positive values indicate net species
479 gains in treatment plots relative to control plots, while negative values indicate net species losses.
480 lnRR richness response has a lower bound of -1 and no upper bound. Composition responses (f-j)
481 are measured as the Euclidean distance between centroids of control and treatment plots within a
482 year in a PCoA based on a Bray-Curtis dissimilarity matrix; composition response is bounded by
483 0 and 1. Responses are grouped among five possible shapes, indicated along the left-side of the
484 panels. For all panels, lines correspond to models for 438 individual global change treatments
485 responses across 105 experiments. For all lines, slopes and intercepts are plotted as zero when
486 95% credible intervals (CI) of parameters include zero. Values in parentheses are percentages of
487 studies exhibiting a particular response shape across all experiments (*i.e.*, not considering
488 experiment length). Percentage responses for short-term vs long-term experiments can be found
489 in Table 2.

490

491 Figure 2: Across all datasets, the proportion of significant temporal plant community responses
492 (lnRR richness and composition differences) to global change treatments do not vary by the type
493 of global change manipulation imposed. Single-factor global change manipulations are
494 categorized into treatment types (CO₂=increased atmospheric CO₂; drought=reduced
495 precipitation; irrigation=increased precipitation; precip. vari.=variation in precipitation timing,
496 but not amount; nitrogen=nitrogen additions; phosphorus=phosphorous additions;
497 temperature=increased temperature; mow=mowing aboveground biomass; herbivore

498 rem.=removal of above- and/or below-ground herbivores; plant manip.=one time manipulation
499 of plant community through seed additions or diversity treatments at the start of the experiment).

500

501 Figure 3: Across all datasets, the proportion of significant temporal plant community responses
502 (lnRR richness and composition differences) to global change treatments vary by the number of
503 treatments simultaneously imposed. Global change manipulations are categorized into treatment
504 categories (R=single resource; N=single non-resource; R*R=two-way interactions with both
505 treatments manipulating resources; N*N=two-way interactions with both treatments
506 manipulating non-resources; R*N=two-way interactions with one resource and one non-resource
507 manipulation; R*R*R=three or more way interactions with all treatments manipulating
508 resources; and 3+=three or more way interactions with both resource and non-resource
509 manipulations). Significant differences in the proportion of significant richness and composition
510 responses among treatment categories are indicated by letters as determined by Fisher's exact
511 test for all pairwise combinations.

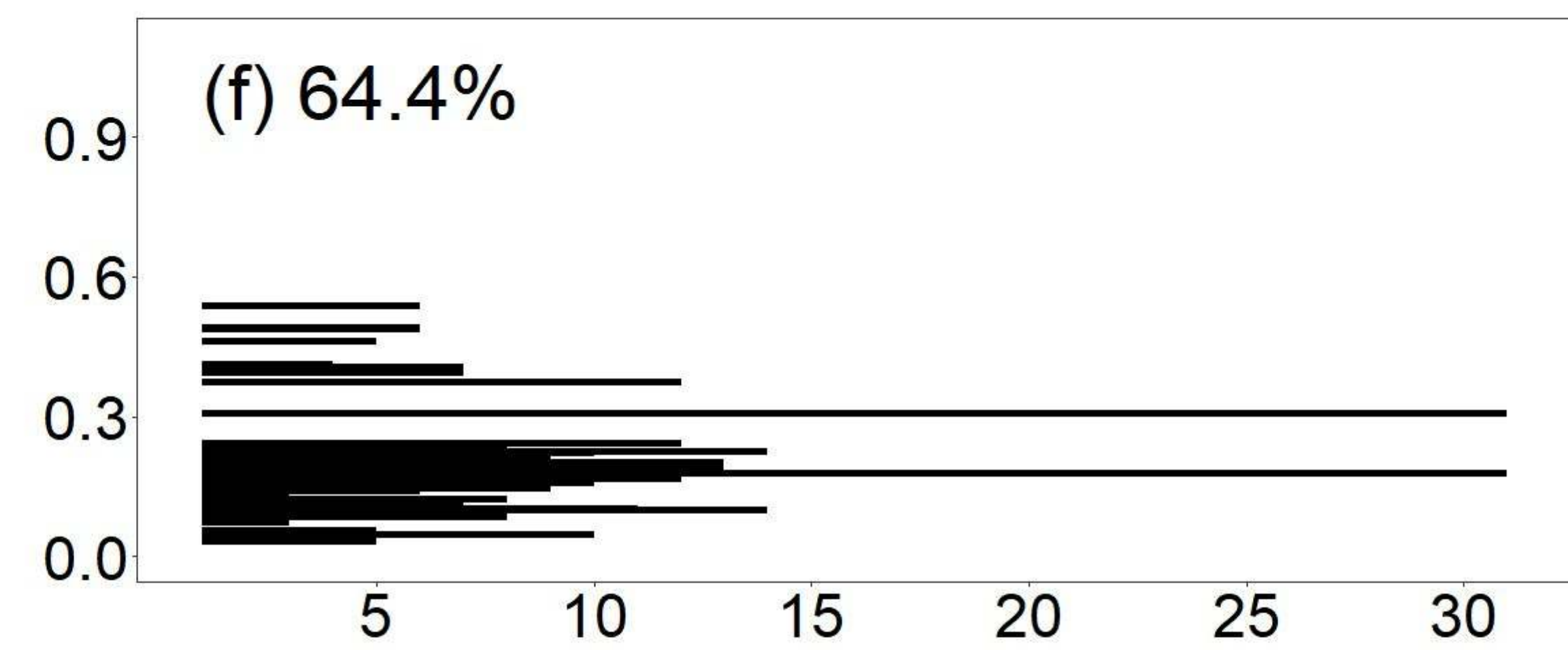
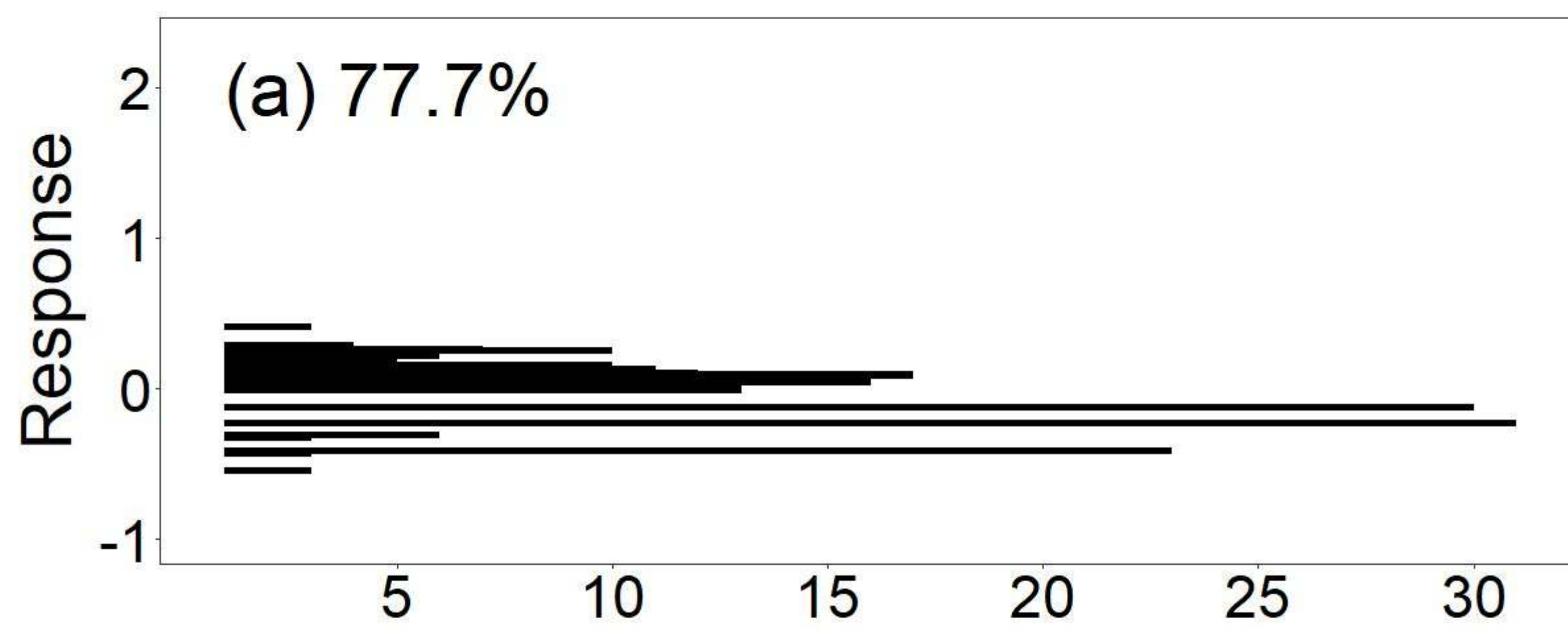
512

513 Figure 4: Differences in (a-c) richness and (d-f) plant composition to the magnitude of (a, d)
514 nitrogen (N) addition treatments, (b, e) drought manipulation treatments, and (c, f) irrigation
515 manipulation experiments. Points represent treatment responses for each experiment at each site
516 in the final year of treatment, and lines indicate Bayesian regressions between treatment
517 magnitude and richness or composition responses where significant. Points and lines are colored
518 by site-level mean annual precipitation (MAP) where the independent effect of MAP was
519 significant, and lines are colored by MAP where the interactive effect between MAP and
520 treatment magnitude was significant.

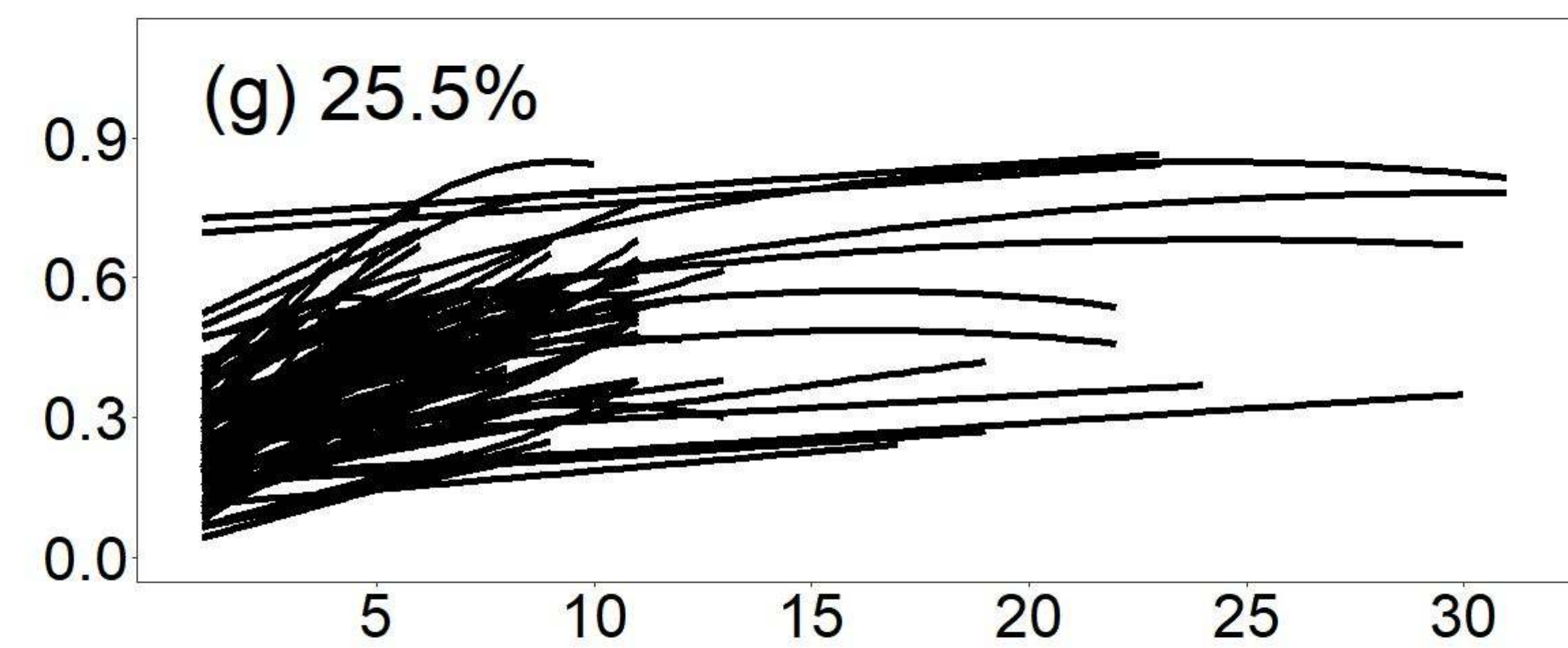
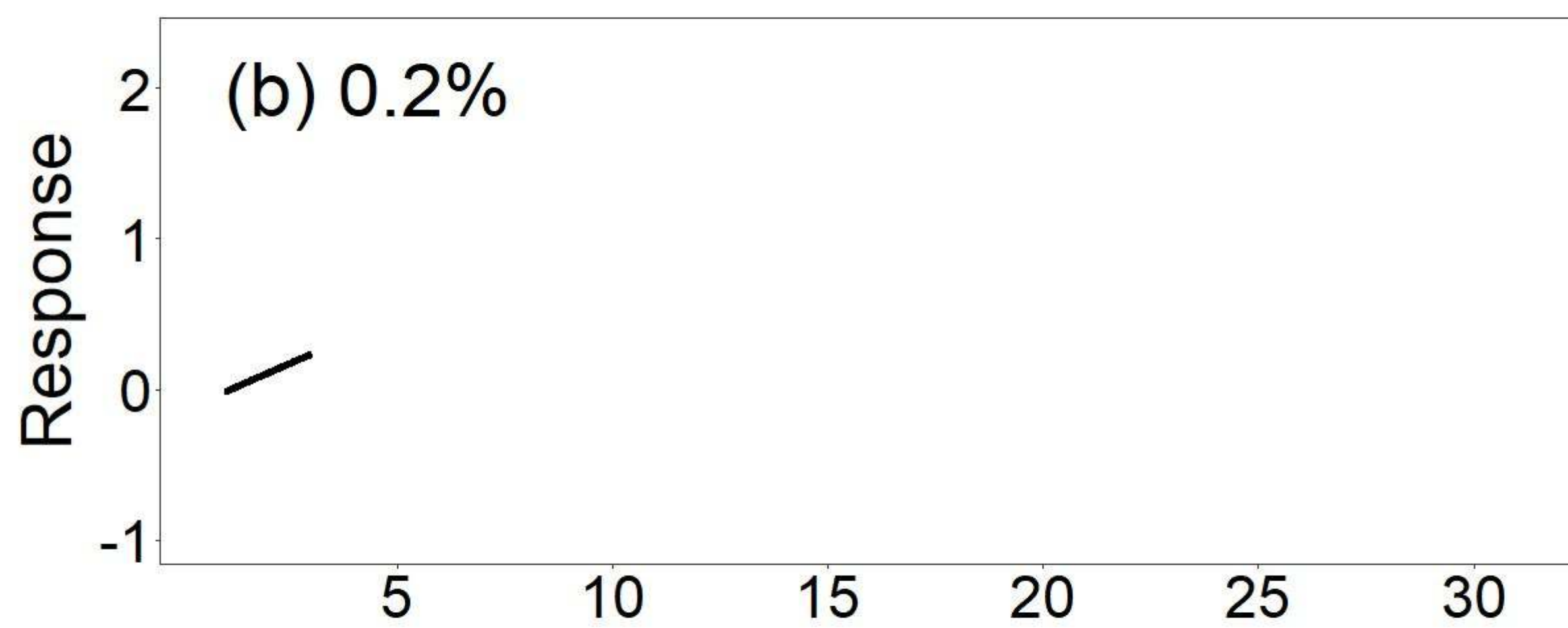
InRR Richness Response

Composition Response

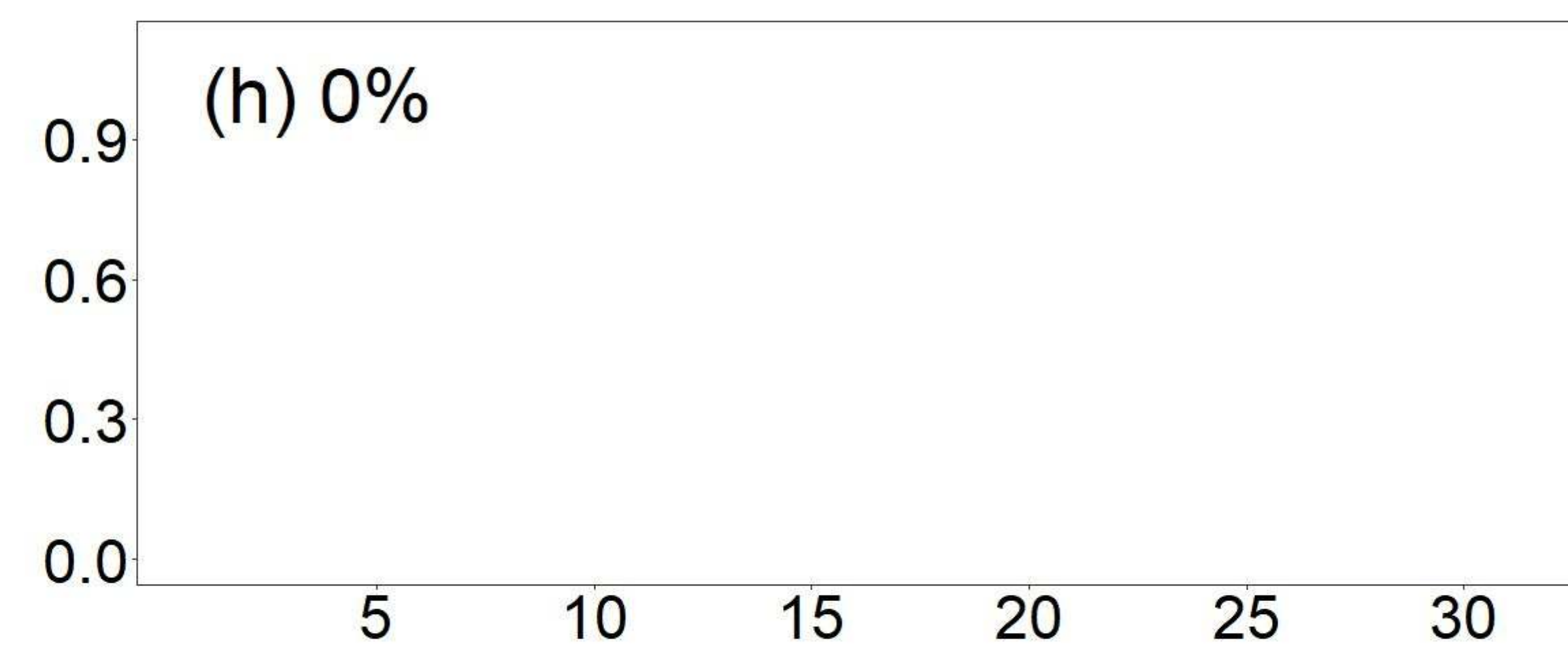
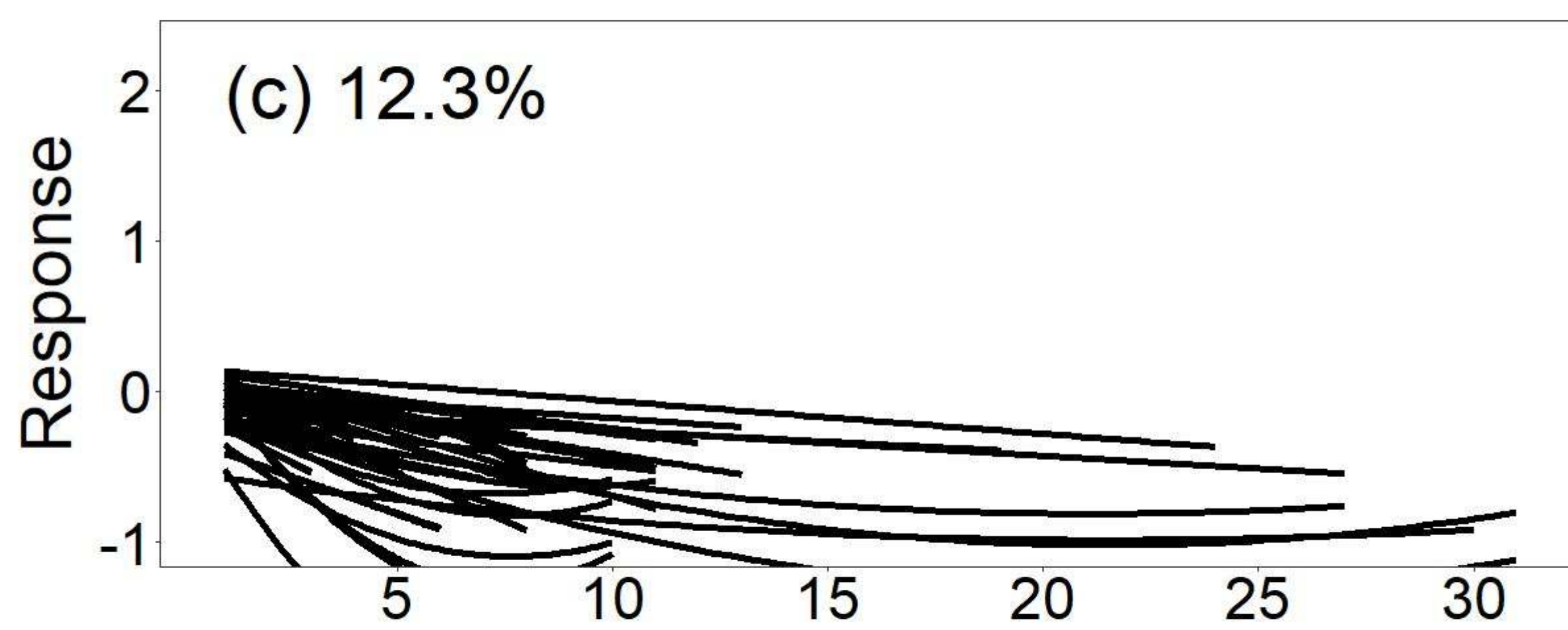
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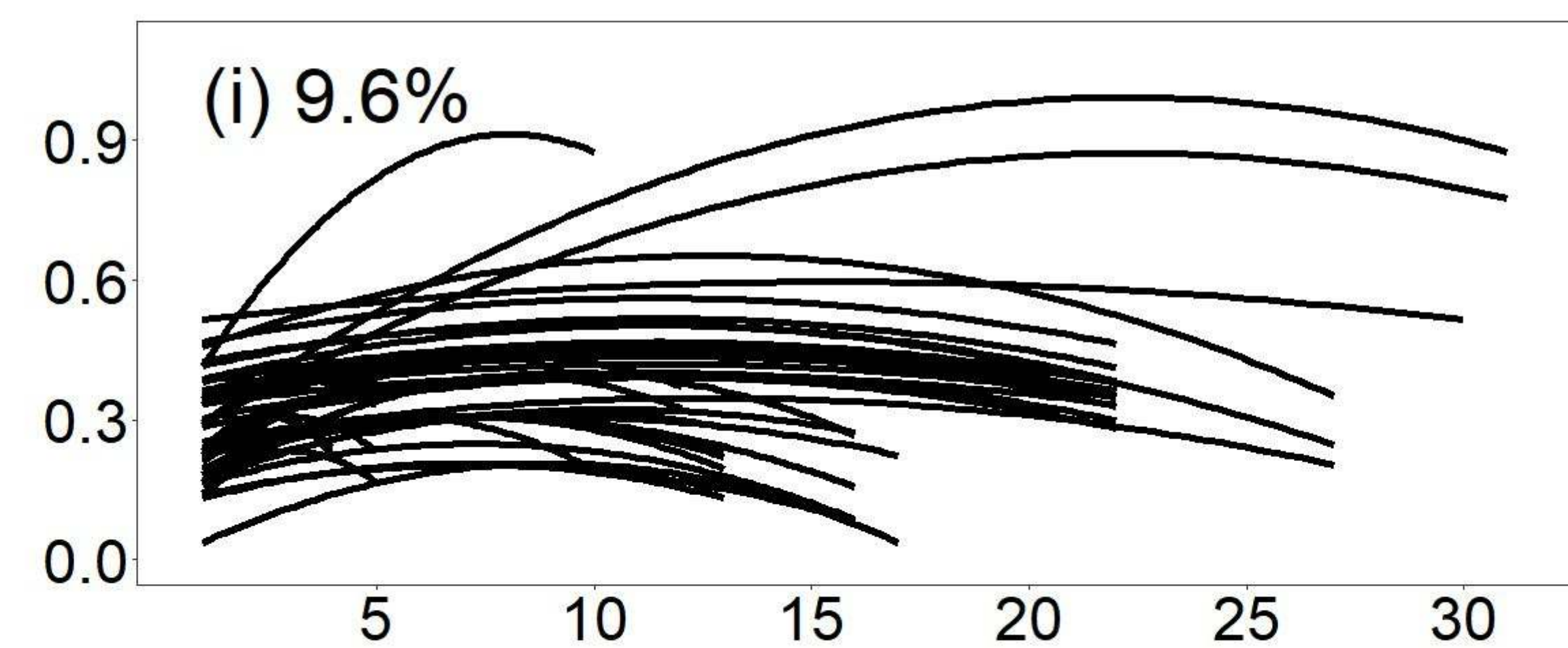
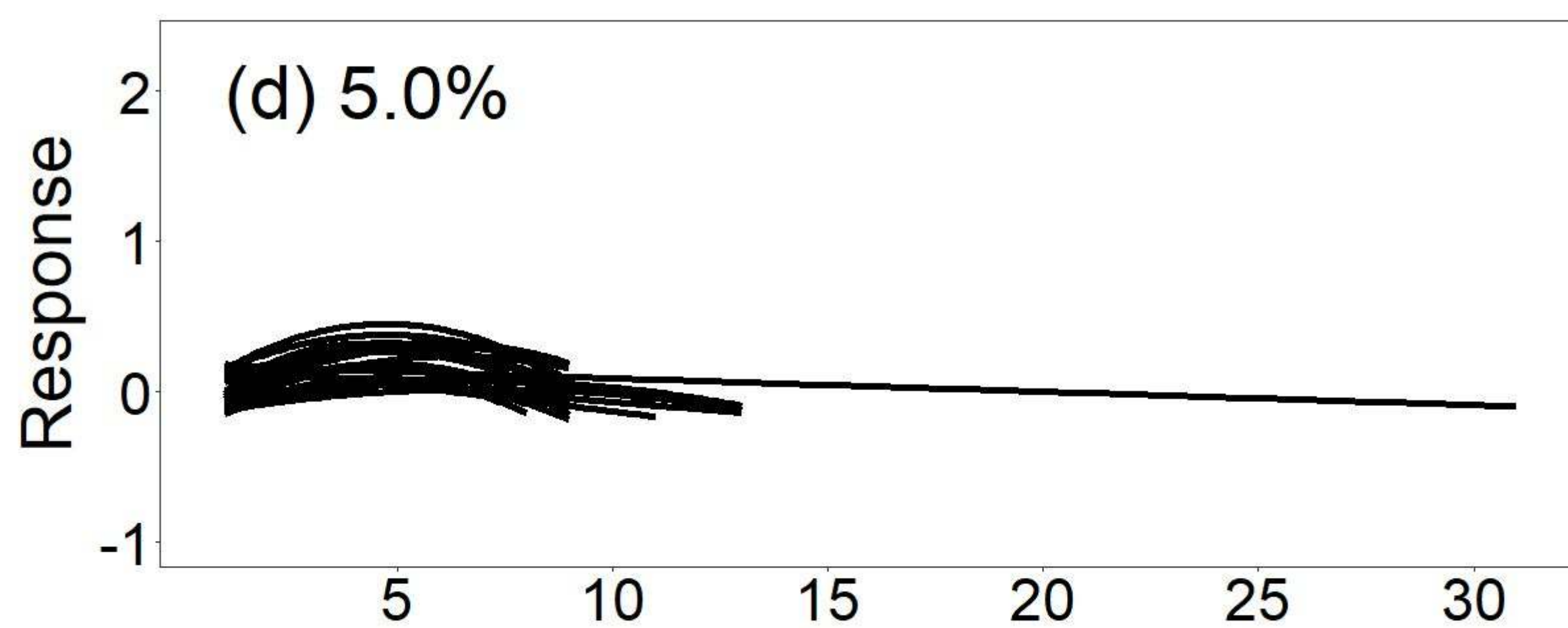
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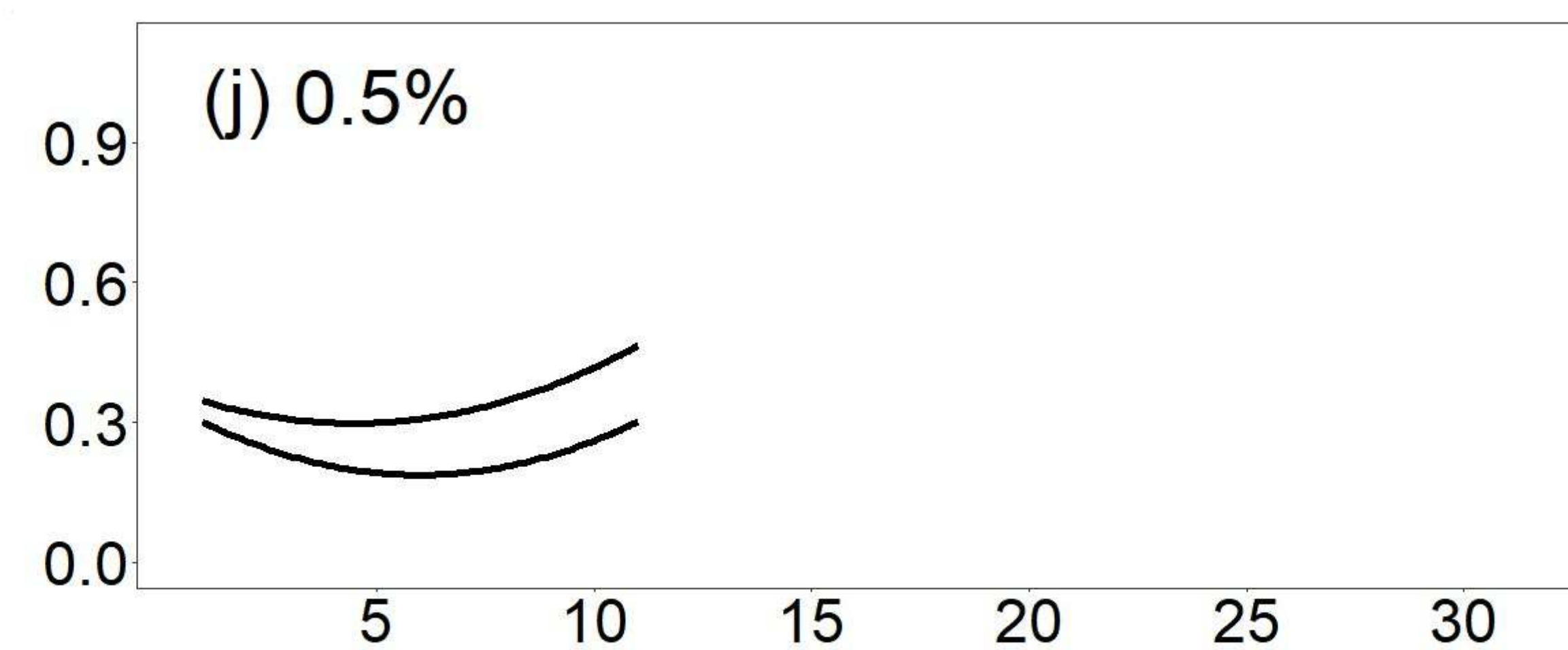
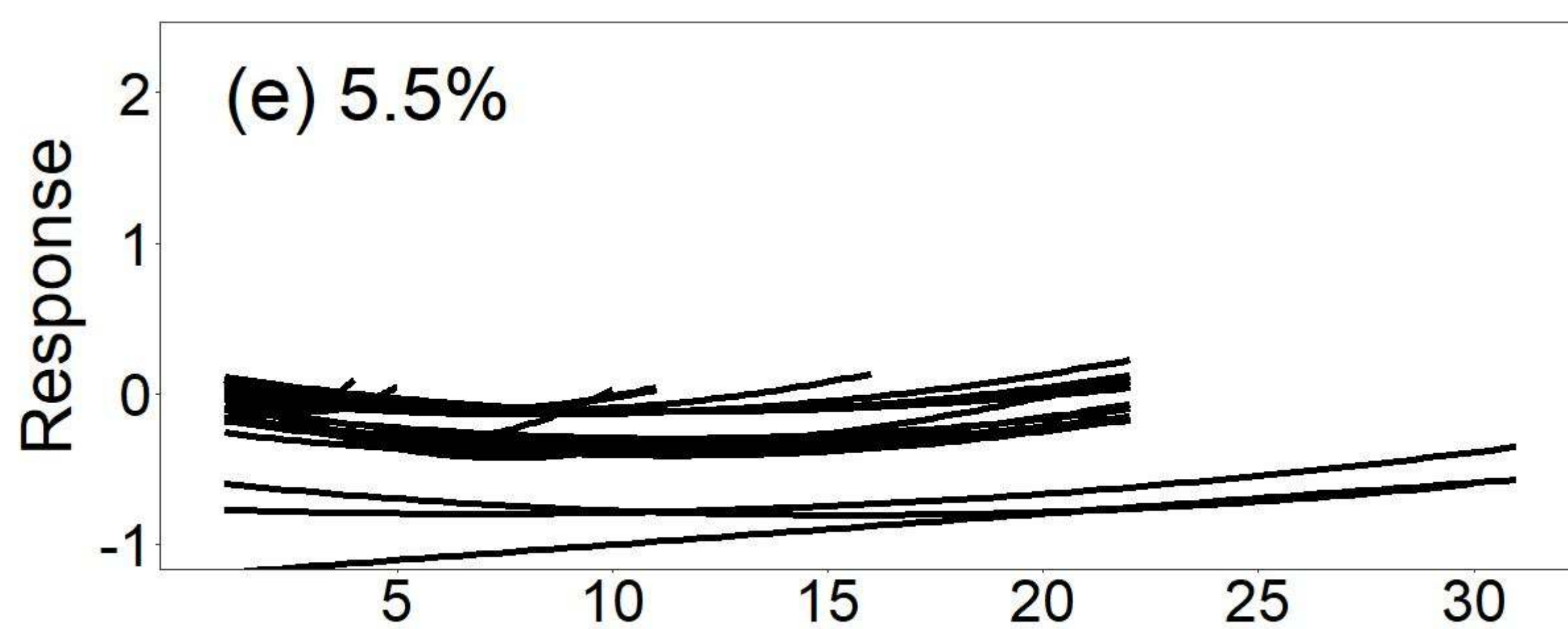
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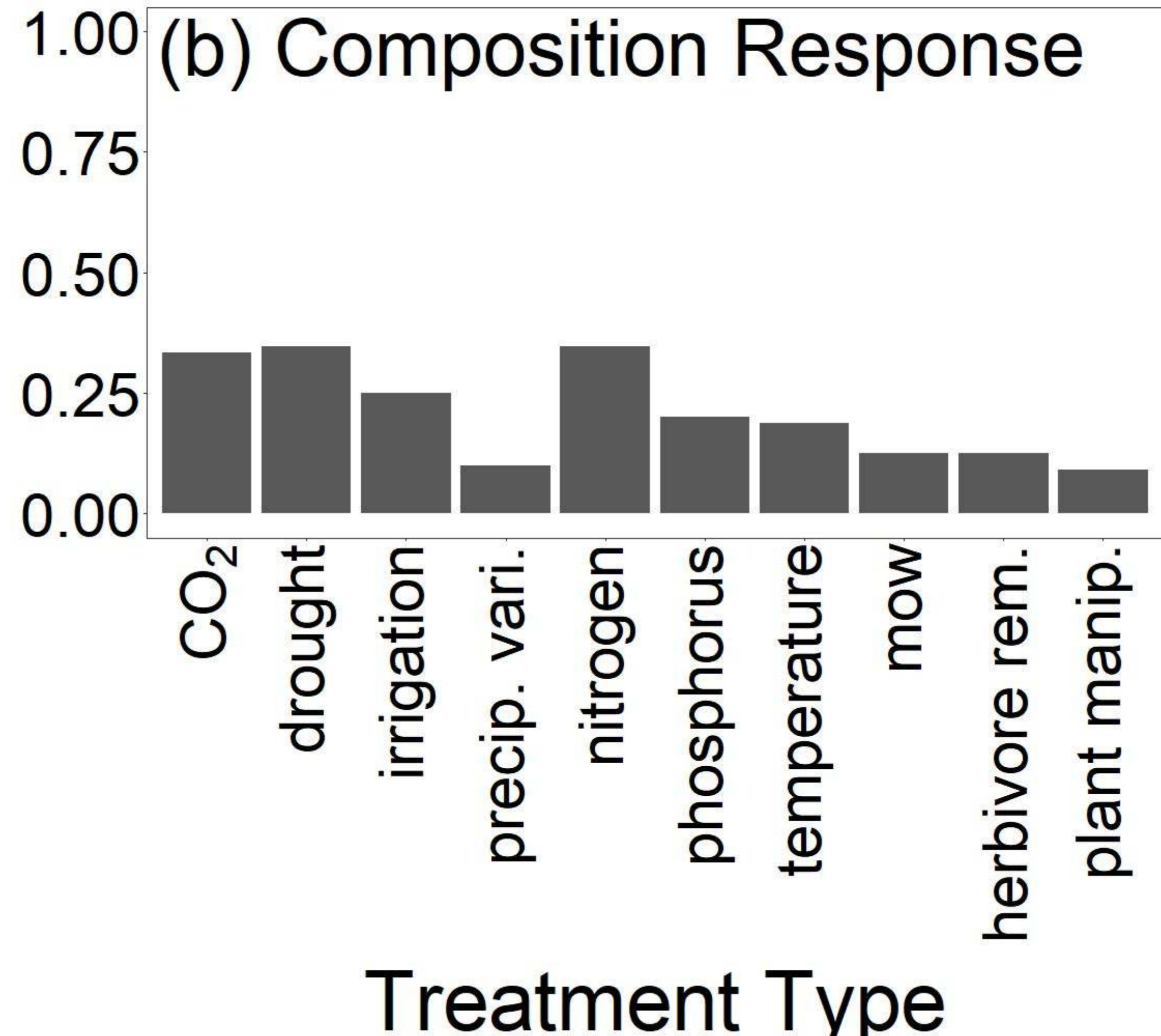
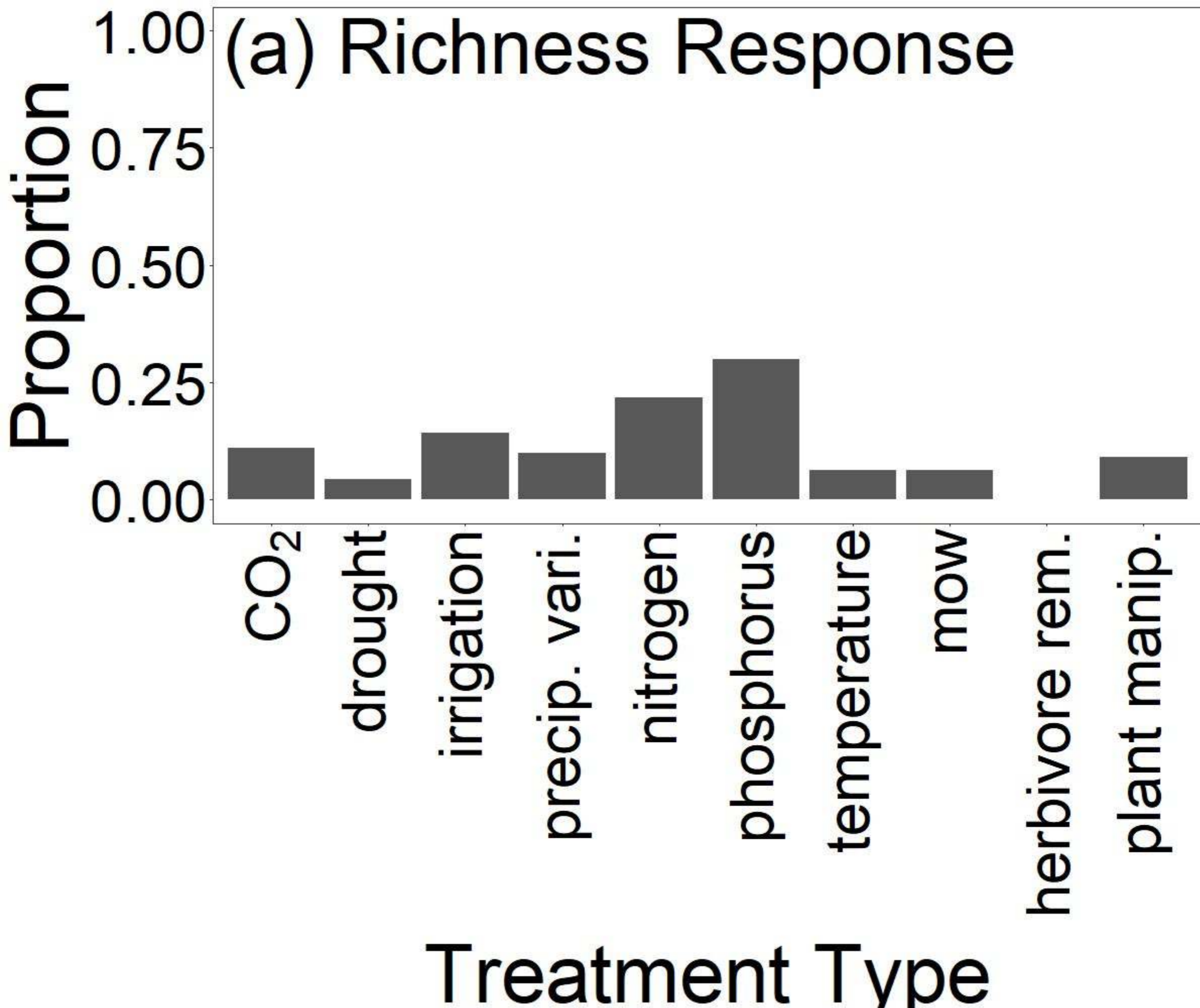


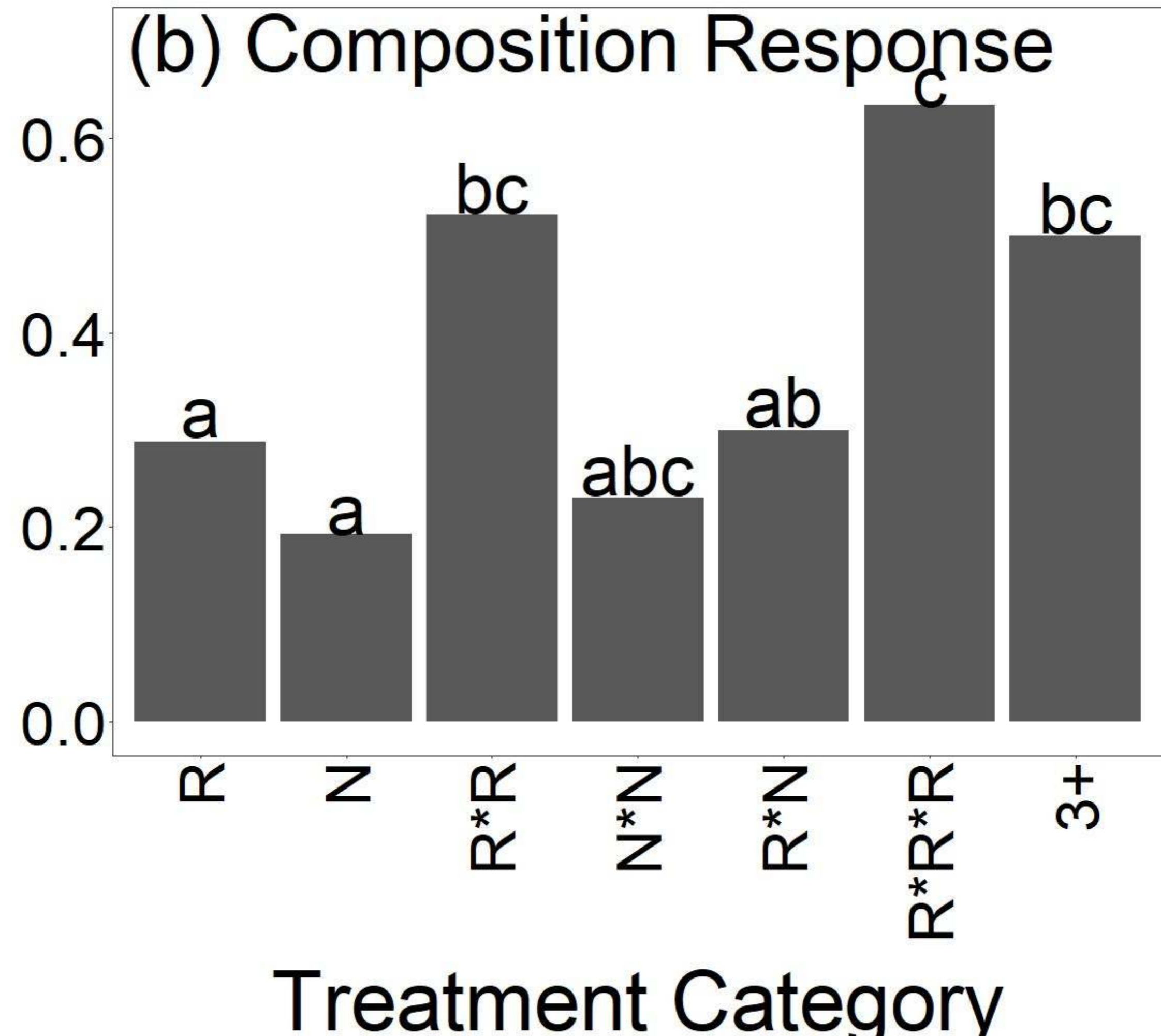
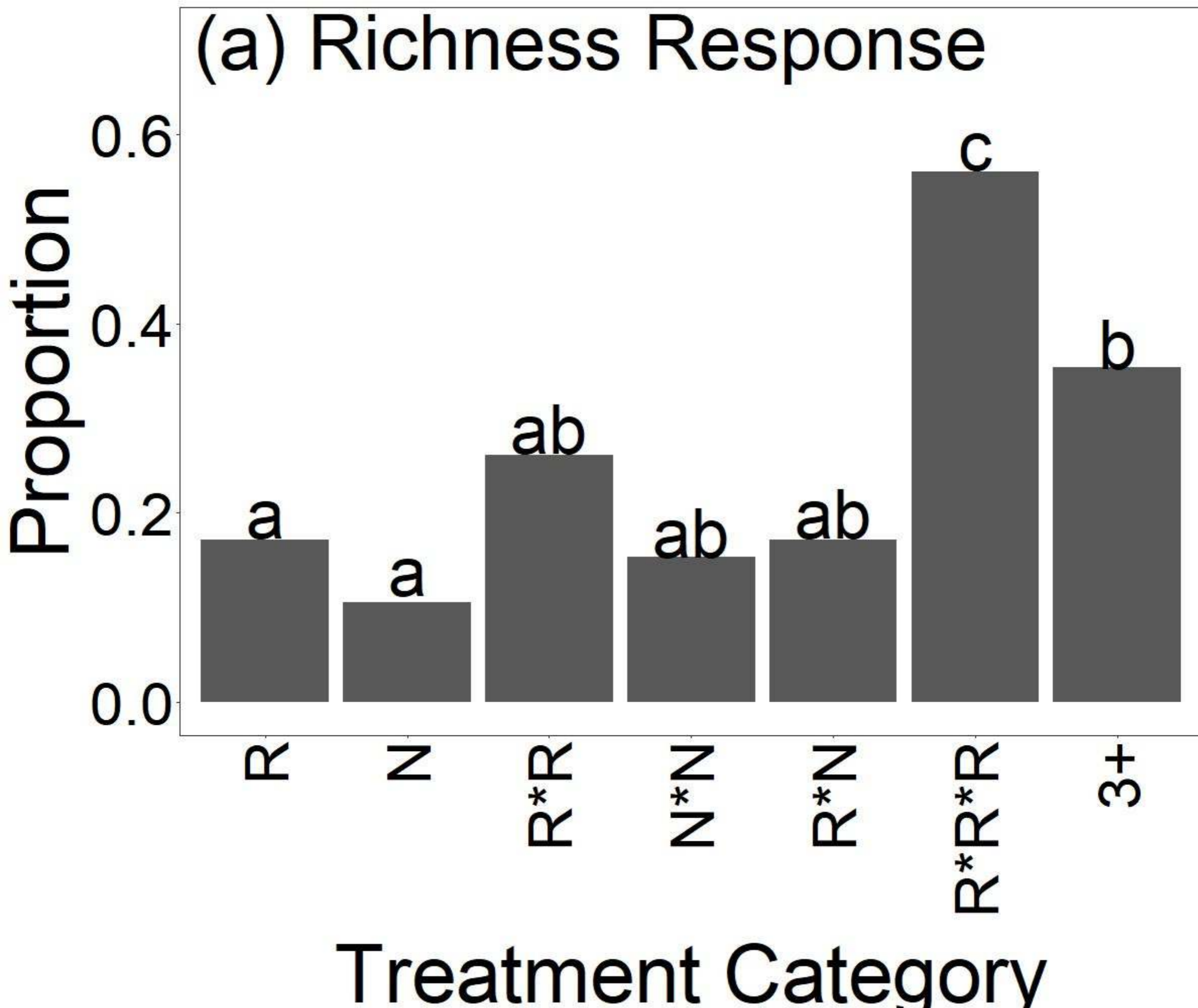
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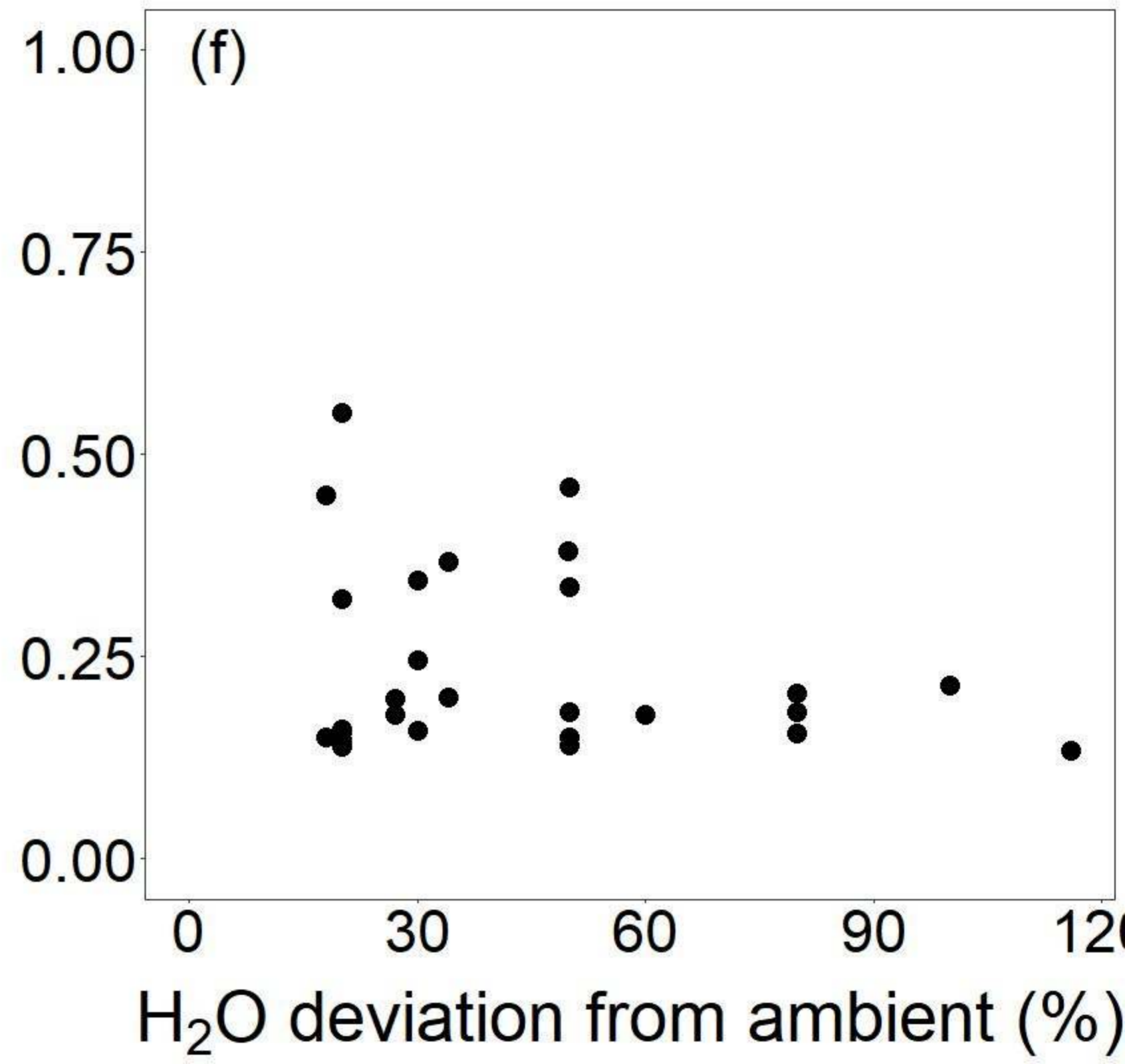
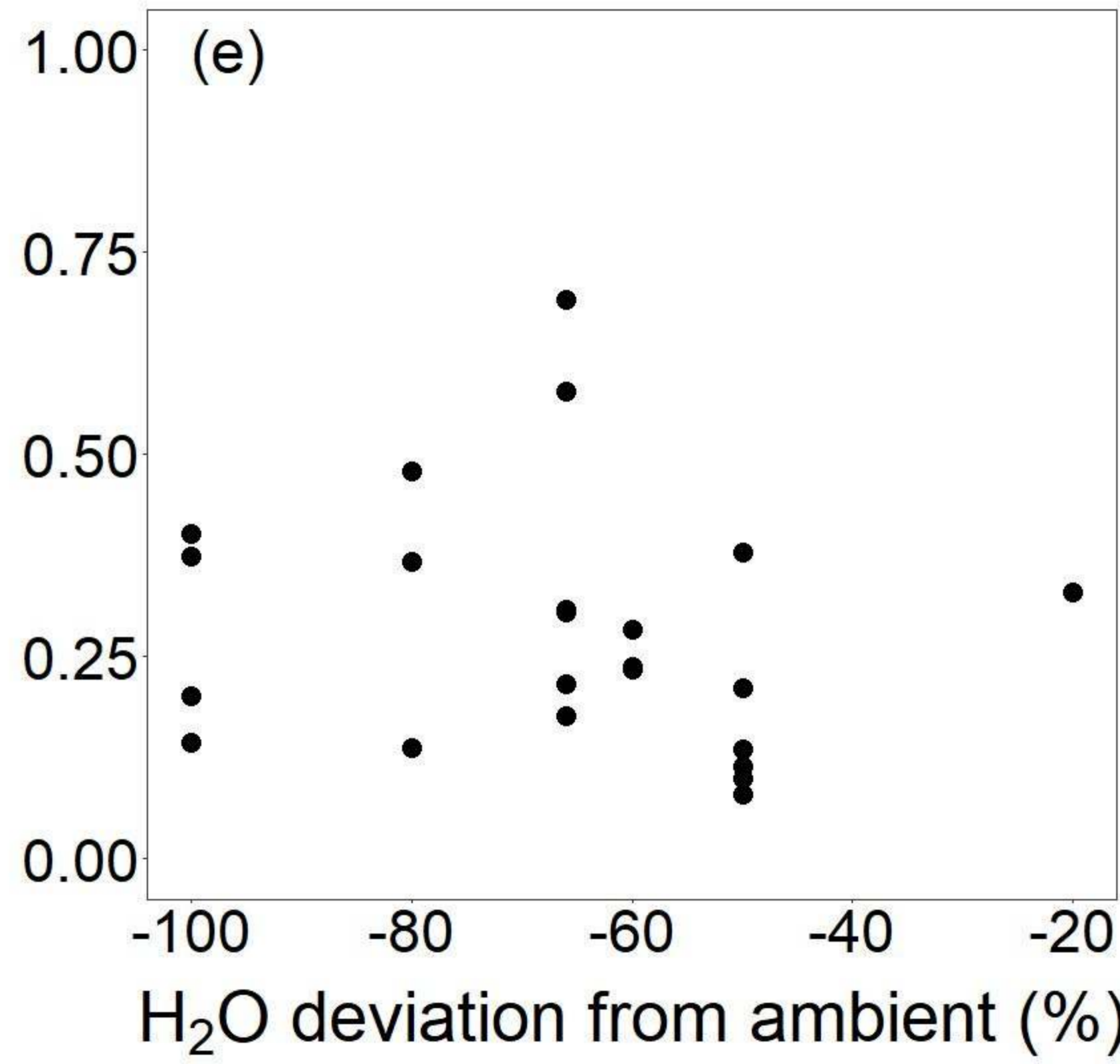
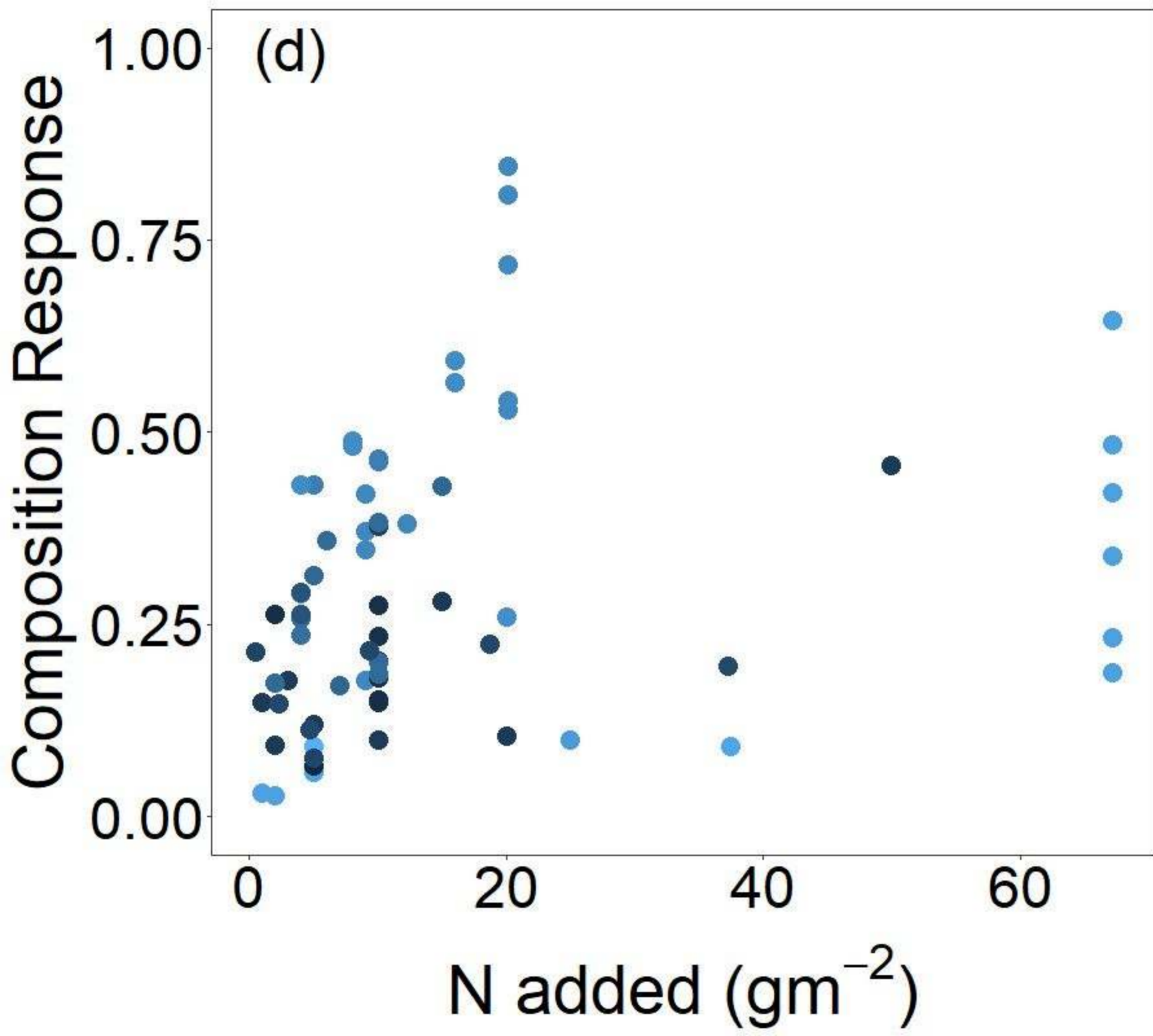
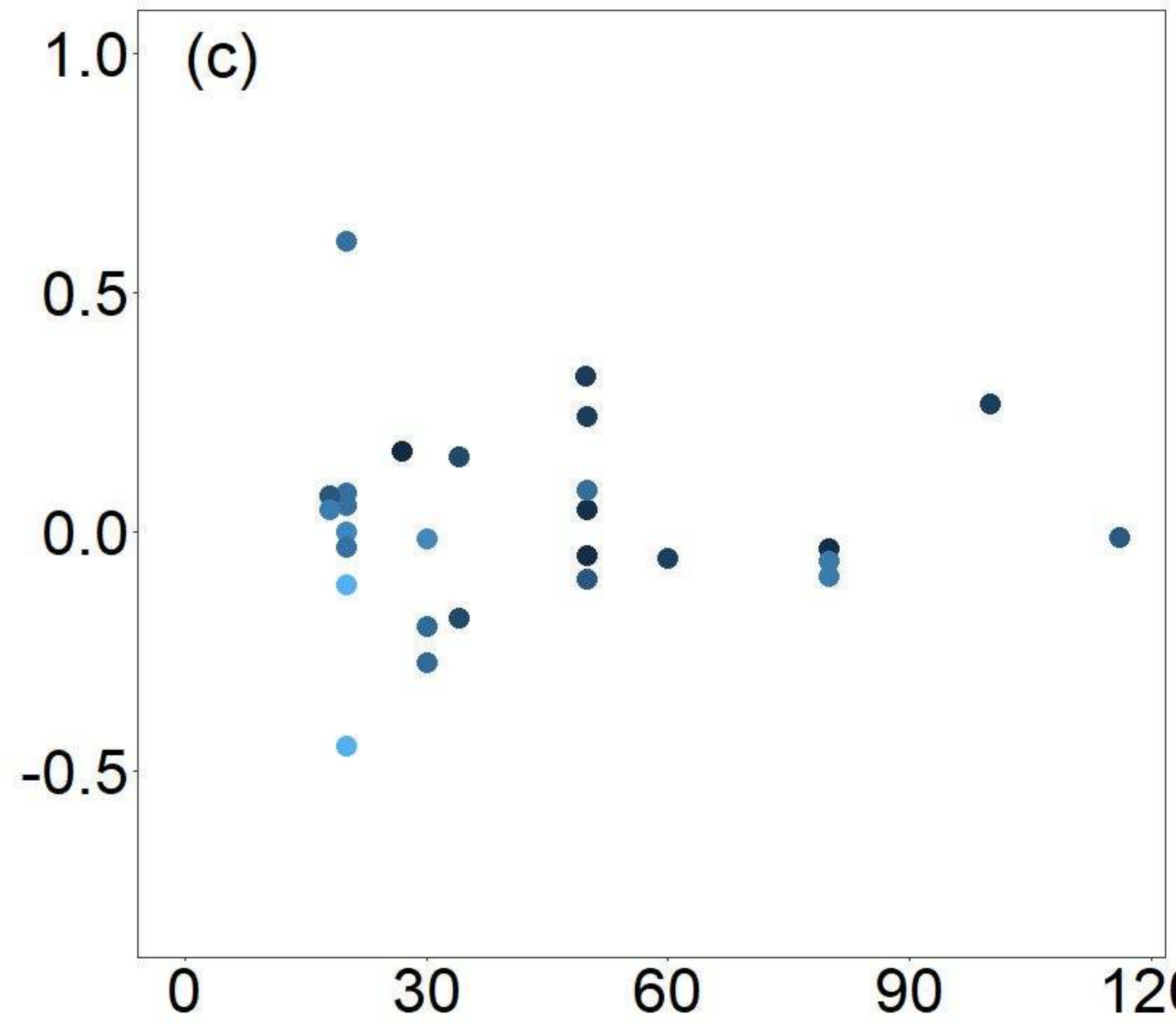
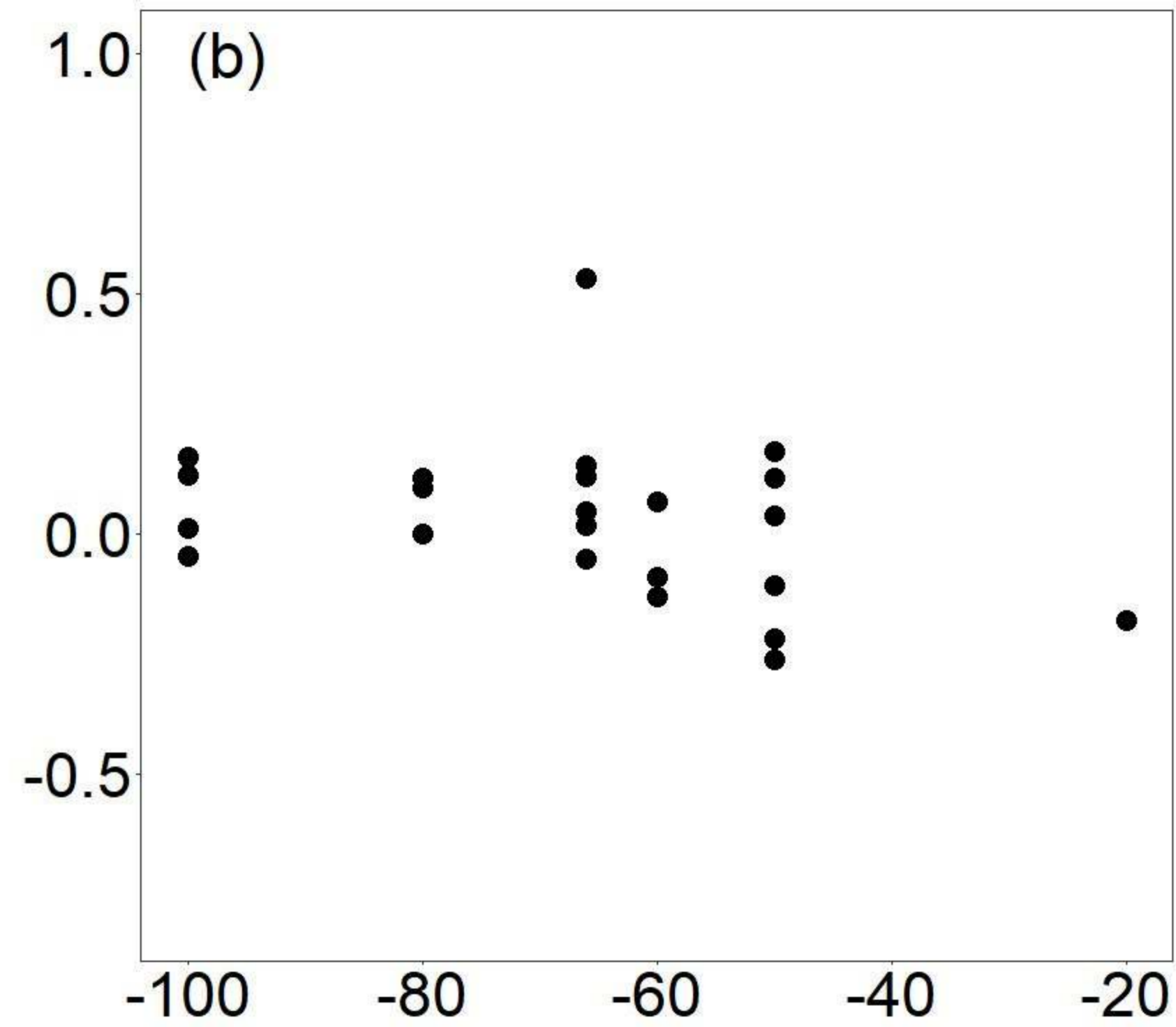
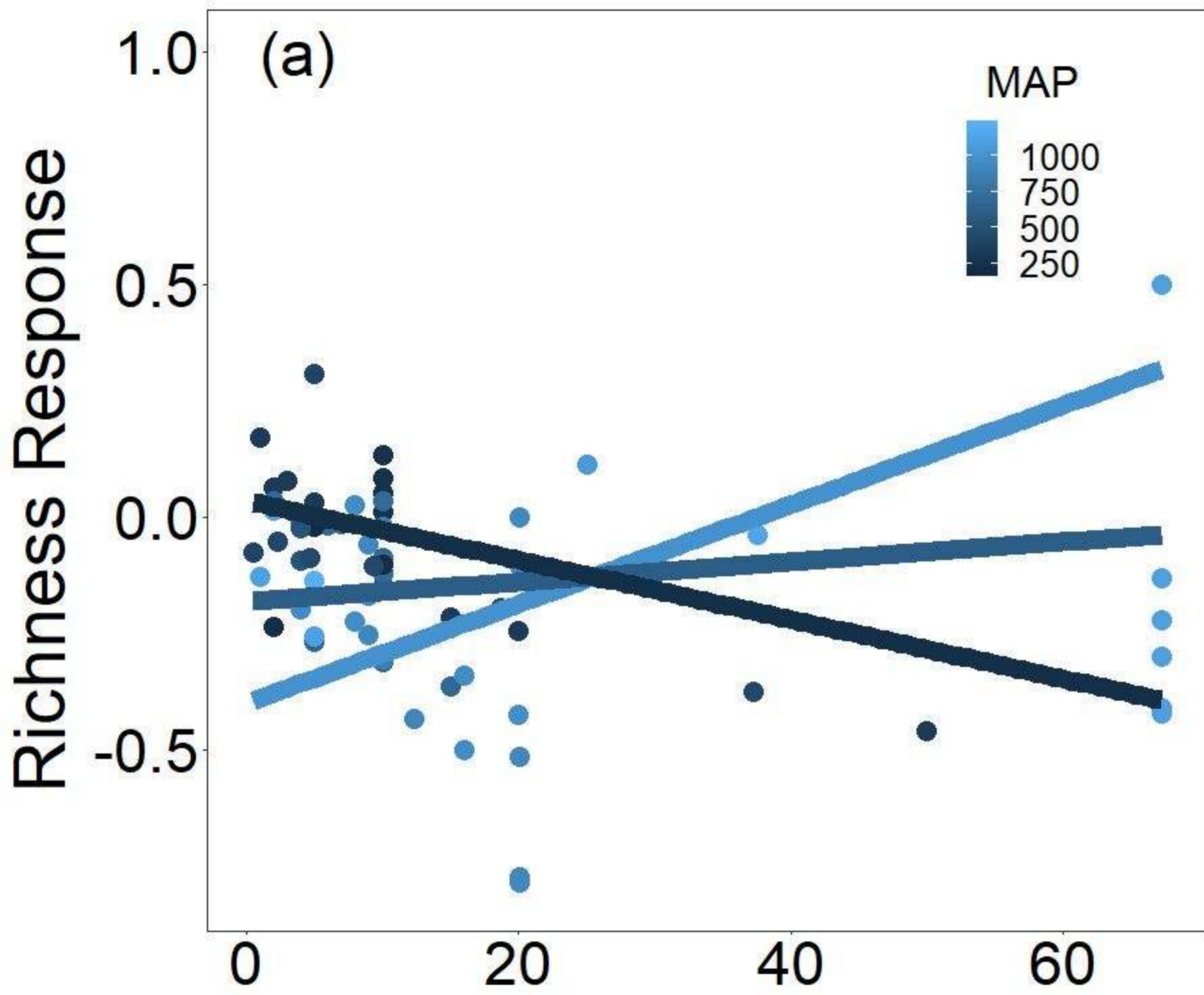


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1 Table 1: Summary statistics of experiments (N=105) included in the data synthesis. See methods
2 for variable descriptions.

3

Variable	minimum	mean	maximum
Experiment Length (# years)	3	8	31
Number of Manipulations	1	2	5
Gamma Diversity (# species)	3	31	79
Aboveground Biomass (g m ⁻² yr ⁻¹)	1.5	349	1415
MAP (mm)	183	714	1526
MAT (°C)	-12	8	22

4

1 Table 2: Summary of the response shape of the richness (lnRR Richness, % Diff Richness),
 2 effective species number (lnRR eH), and composition differences across 438 treatments included
 3 in the data synthesis. Shown are percentages (with numbers in parentheses) of responses falling
 4 into each of 9 shape categories, split by experiment length into those less than 10 year (N=322
 5 responses) and those greater than or equal to 10 years (N=116 responses) in length. Note that
 6 these percentages differ from Figure 1, which presents percentages of each response shape across
 7 all experiments regardless of length. See methods for response variable descriptions.
 8

Response Shape		lnRR Richness % (#)	% Diff. Richness % (#)	lnRR eH % (#)	Composition Diff. % (#)	
< 10 Years	no response	87.0 (280)	79.5 (256)	80.7 (259)	77.0 (248)	
	linear increase	0.3 (1)	2.8 (9)	2.5 (8)	20.8 (67)	
	delayed increase	0.0 (0)	0.0 (0)	0.3 (1)	0.0 (0)	
	asymptotic increase	0.0 (0)	0.0 (0)	0.6 (2)	0.0 (0)	
	linear decrease	6.5 (21)	9.0 (29)	8.4 (27)	0.0 (0)	
	delayed decrease	0.6 (2)	0.3 (1)	0.9 (3)	0.0 (0)	
	asymptotic decrease	0.0 (0)	0.6 (2)	0.0 (0)	0.0 (0)	
	concave down	5.0 (16)	5.9 (19)	6.2 (20)	2.2 (7)	
	concave up	0.6 (2)	1.9 (6)	0.3 (1)	0.0 (0)	
	≥ 10 Years	no response	50.0 (58)	41.4 (48)	44.0 (51)	29.3 (34)
		linear increase	0.0 (0)	0.9 (1)	1.7 (2)	22.4 (26)
delayed increase		0.0 (0)	0.0 (0)	0.0 (0)	4.3 (5)	
asymptotic increase		0.0 (0)	0.0 (0)	0.0 (0)	12.1 (14)	
linear decrease		16.4 (19)	19.0 (22)	21.6 (25)	0.0 (0)	
delayed decrease		0.0 (0)	0.0 (0)	0.0 (0)	0.0 (0)	
asymptotic decrease		9.5 (11)	13.8 (16)	11.2 (13)	0.0 (0)	
concave down		5.2 (6)	8.6 (10)	7.8 (9)	30.2 (35)	

concave
up

19.0 (22)

16.4 (19)

13.8 (16)

1.7 (2)

9

1 Table 3: Across all datasets, temporal plant community responses (lnRR richness and
2 composition differences) to global change treatments do not vary by treatment type among single
3 resource or non-resource manipulations (richness: $X^2=12.47$, $df=11$, $p=0.330$; composition:
4 $X^2=9.42$, $df=11$, $p=0.583$), but do vary by treatment category among multi-factorial
5 manipulations (richness: $X^2=21.85$, $df=6$, $p=0.001$; composition: $X^2=15.78$, $df=6$, $p=0.015$).
6 Across only long-term (≥ 10 years) datasets, temporal plant community responses to global
7 change treatments do not vary by treatment type among single resource or non-resource
8 manipulations (richness: $X^2=3.36$, $df=10$, $p=0.972$; composition: $X^2=4.21$, $df=10$, $p=0.938$) or
9 treatment category among multi-factorial manipulations (richness: $X^2=3.01$, $df=6$, $p=0.808$;
10 composition: $X^2=1.39$, $df=6$, $p=0.967$). For the long-term experiments, exclusion of treatment
11 types or categories with fewer than 3 replicates did not qualitatively affect the results. Number
12 and proportion of each treatment type/category that showed a significant temporal response to
13 experimental global change manipulations. Significant ($p<0.05$) differences in the proportion of
14 richness and composition responses among treatment categories indicated by letters as
15 determined by Fisher's exact test for all pairwise combinations.
16

	Treatment Type/Category	Total Possible Responses	# Richness Responses	Proportion Significant Richness Responses	# Composition Responses	Proportion Significant Composition Responses
Treatment Type	CO ₂	9	1	0.11	3	0.33
	drought	23	1	0.04	8	0.35
	irrigation	28	4	0.14	7	0.25
	precip. variability	10	1	0.10	1	0.10
	nitrogen	69	15	0.22	24	0.35
	phosphorus	20	6	0.30	4	0.20
	other resource	4	0	0.00	0	0.00
	temperature	16	1	0.06	3	0.19
	mowing/clipping	16	1	0.06	2	0.13
	herbivore removal	8	0	0.00	1	0.13
	plant manipulation	11	1	0.09	1	0.09
	other non-resource	6	3	0.50	4	0.67
	Treatment Category	single resource	163	28	0.17 ^a	47
single non-resource		57	6	0.11 ^a	11	0.19 ^a
resource*resource		46	12	0.26 ^{ab}	24	0.52 ^{bc}
non-res.*non-res.		13	2	0.15 ^{ab}	3	0.23 ^{abc}
resource*non-res.		70	12	0.17 ^{ab}	21	0.30 ^{ab}
3+ resources		41	23	0.56 ^c	26	0.63 ^c
#+ res. and non-res.		48	17	0.35 ^b	24	0.50 ^{bc}
OVERALL	438	100	0.23	156	0.36	

17