Supplementary materials

Brief climate description

In a brief climate analysis, for the areas located in the Serra de Nogueira, the data obtained by the Celas Udometer Station ((03P/01UG) was consulted and for the areas located in the Montesinho Natural Park, the data obtained by the Montesinho Udometer Station (02Q/01UG), available on the National Water Resources Information System (SNIRH), was consulted. According to the data available for the Serra de Nogueira study areas, it can be seen that from 2005 (penultimate year with records: 612.1 mm) to 2020 (last year with records: 764.9 mm) there was an increase of 152.8 mm in annual rainfall. For the study areas in the PNM, given the latest available data, 2006 was a year with high levels of rainfall (1091 mm), 2018 was the year since records began (1932) with the lowest annual rainfall with 244 mm, 2019 saw an increase of 517 mm, with 761.5 mm and 2022 (the last year with records) saw an increase in rainfall with 915.5 mm (154 mm more than 2019). Since there have been records (from 1932 onwards) for annual rainfall, it has been observed that until 1966 the rainfall values were higher for the PNM region and from 1967 onwards there was a reversal, with higher rainfall values in the Serra de Nogueira region, just as there was a loss of continuity in the records each year for the two regions, which will also have an influence on the interpretation of the data in terms of the annual rainfall trend in these regions (Figure S1).

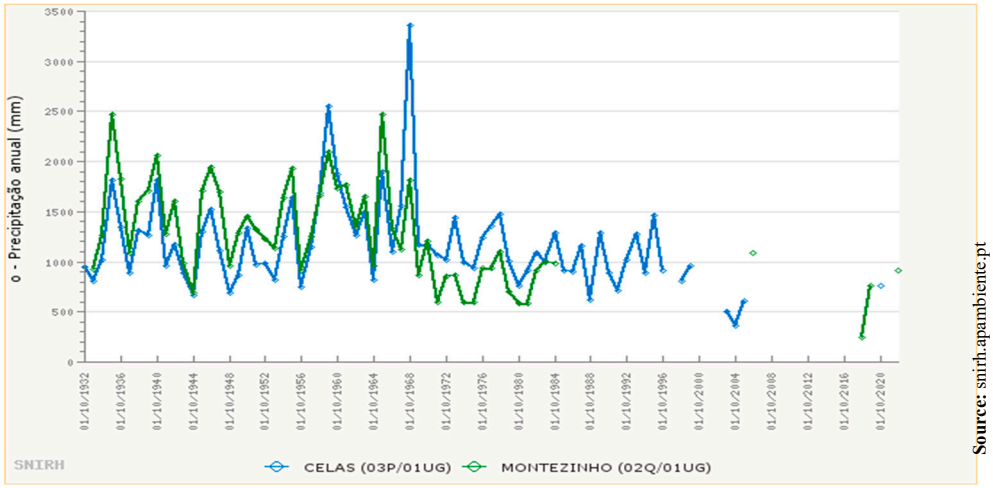


Figure S1. Annual rainfall records (mm) at Celas Station (03P/01UG) and Montesinho Station (02Q/01UG)

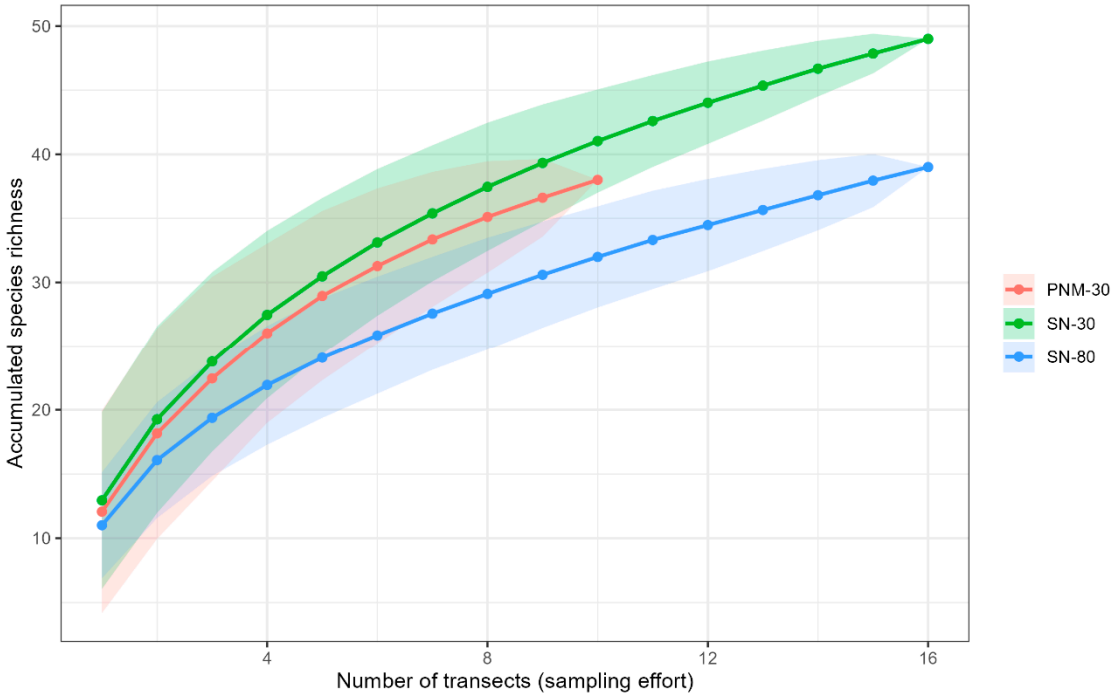


Figure S2. Species accumulation curves by forest type.Species–transect accumulation curves for PNM-30, SN-30, and SN-80 built from incidence (presence/absence) per transect. Solid lines show the mean expected richness as transects accumulate; shaded ribbons are 95% CIs. Axes: x = number of transects (sampling effort), y = accumulated species richness. Curves approaching an asymptote and overlapping CIs at the same effort indicate sufficient and comparable sampling among groups; divergence suggests effort or compositional differences.

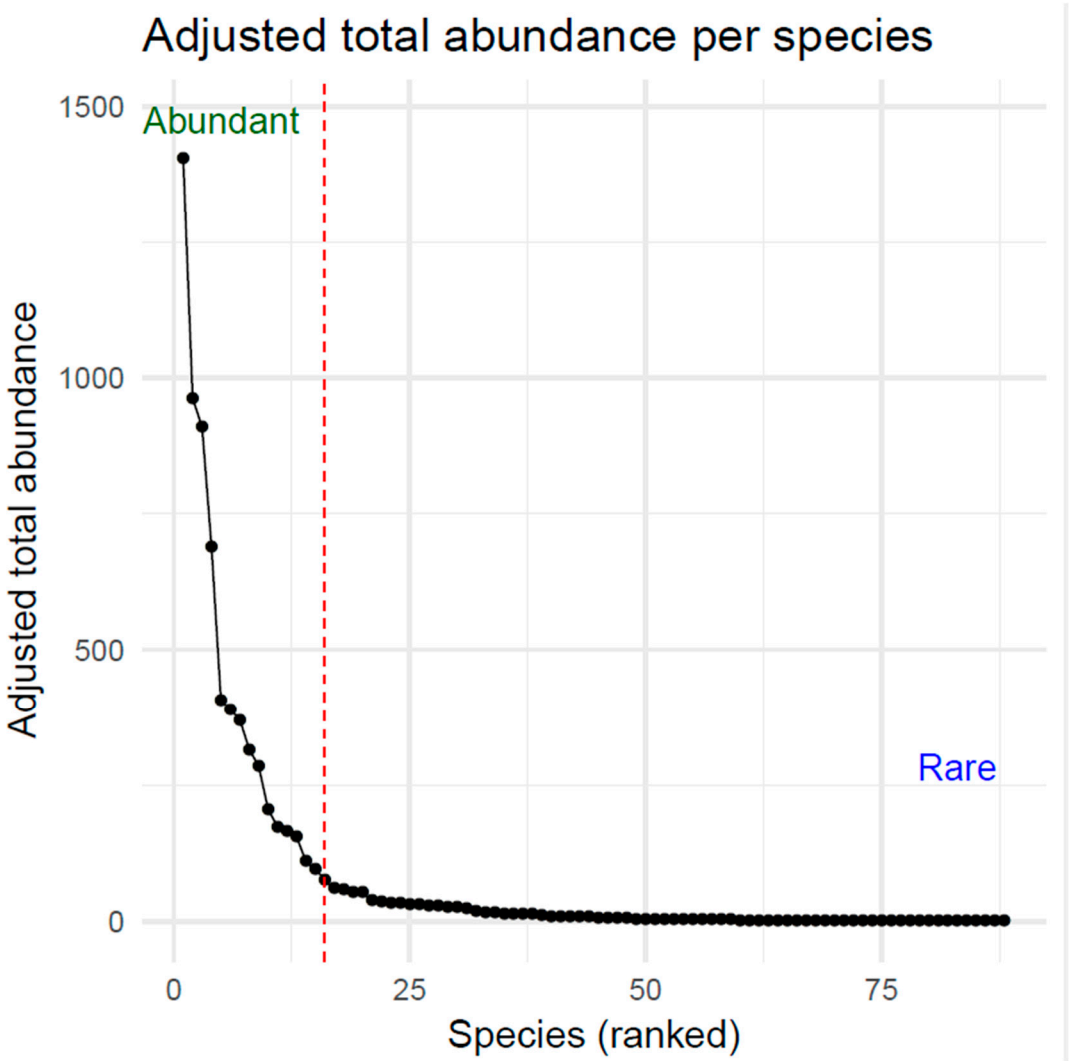
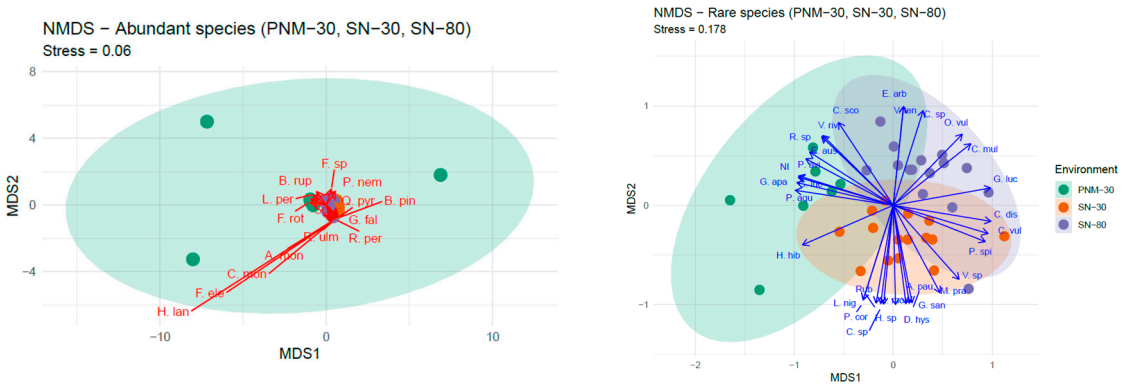


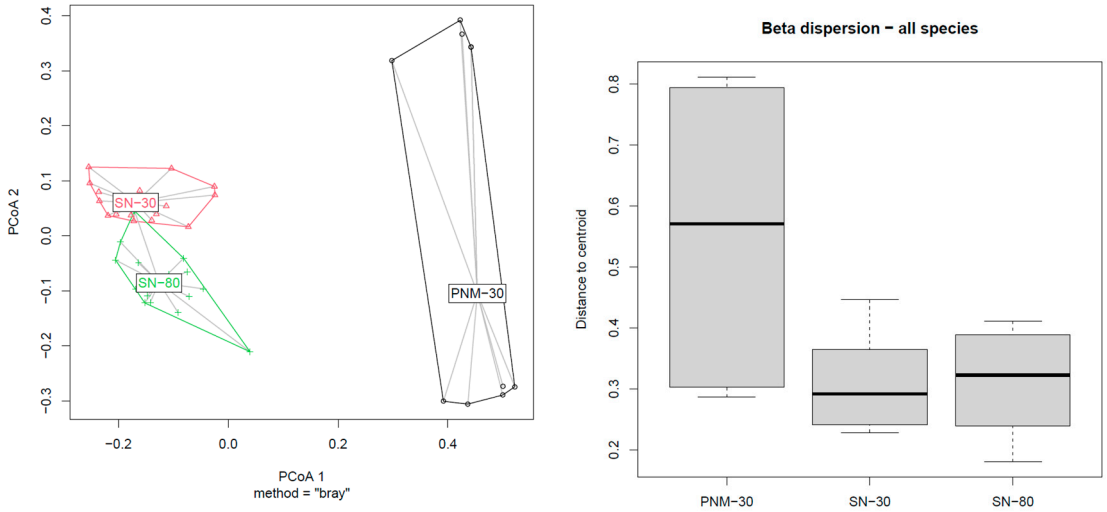
Figure S3. Total abundance of each species, ranked from most to least frequent, pondered by the number of sampling plots in the different areas. A red dashed line indicates the threshold (n = 80) used to distinguish between 'abundant' (left) and 'rare' species (right).



(a) (b)

Figure S4. Non-metric multidimensional scaling (NMDS) ordination plots based on Bray–Curtis dissimilarity of plant species. (a) Abundant species (>80 records); (b) Rare species (≤80 records). Points represent transects, filled by the three oak forest areas located in Serra de Nogueira (SN) and Natural Park of Montesinho (PNM) untouched for 30 (SN-30, PNM-30) or 80 years (SN-80). Ellipses indicate 95% confidence intervals around environments. Blue arrows represent the direction and strength of species most

strongly associated with the ordination axes. Stress values are indicated in each panel. Plants abbreviations are in Table S1.



(a) (b)

Figure S5. Multivariate dispersion (PERMDISP) among environments based on Bray–Curtis distances calculated from log-transformed species abundance data. Distances to group centroids (environmental groups) in multivariate space (a) and corresponding boxplot (b).

Table S1. Number of records for each plant species identified in Quercus pyrenaica forests in the Natural Park of Montesinho (PNM) and Serra da Nogueira (SN), with stand ages of 30 years (PNM-30, SN-30) and 80 years (SN-80). Records are classified as Abundant (>80 records) or Rare (≤80 records). For each species, the genus, family, abundance group, total number of records, and the number of occurrences per environment are shown. Abb: abbreviations used in ordination plots.

Abb	Identification	Genera	Family	Group	Total	PNM-30	SN-30	SN-80
F. ele	*Festuca elegans*	*Festuca*	Poaceae	Abundant	1404	1	862	541
B. pin	*Brachypodium pinnatum*	*Brachypodium*	Poaceae	Abundant	910	0	520	390
Q. pyr	*Quercus pyrenaica*	*Quercus*	Fagaceae	Abundant	848	192	192	464
F. rot	*Festuca rothmaleri*	*Festuca*	Poaceae	Abundant	431	431	0	0
R. per	*Rubia peregrina*	*Rubia*	Rubiaceae	Abundant	406	0	189	217
P. nem	*Poa nemoralis*	*Poa*	Poaceae	Abundant	315	0	249	66
F. sp	*Festuca* sp	*Festuca*	Poaceae	Abundant	284	0	0	284
Soi	Soil			Abundant	278	185	0	93
B. rup	*Brachypodium rupestre*	*Brachypodium*	Poaceae	Abundant	231	231	0	0
G. fal	*Genista falcata*	*Genista*	Fabaceae	Abundant	196	15	126	55
C. mon	*Crataegus monogyna*	*Crataegus*	Rosaceae	Abundant	173	0	18	155
H. lan	*Holcus lanatus*	*Holcus*	Poaceae	Abundant	165	0	0	165
R. ulm	*Rubus ulmifolius*	*Rubus*	Rosaceae	Abundant	141	24	93	24
A. mon	*Arenaria montana*	*Arenaria*	Caryophyllaceae	Abundant	105	8	45	52
C. vul	*Clinopodium vulgare*	*Clinopodium*	Lamiaceae	Rare	72	7	41	24
L. per	*Lonicera periclymenum* ssp *hispanica*	*Lonicera*	Caprifoliaceae	Rare	61	58	3	0
E. arb	*Erica arborea*	*Erica*	Ericaceae	Rare	59	3	0	56
H. mol	*Holcus mollis*	*Holcus*	Poaceae	Rare	54	0	54	0
C. sco	*Cytisus scoparius*	*Cytisus*	Fabaceae	Rare	47	18	13	16
G. apa	*Galium aparine*	*Galium*	Rubiaceae	Rare	38	28	10	0

Abb	Identification	Genera	Family	Group	Total	PNM-30	SN-30	SN-80
P. cor	*Physospermum cornubiense*	*Physospermum*	Apiaceae	Rare	33	0	25	8
C. sp	*Carex* sp	*Carex*	Cyperaceae	Rare	31	0	0	31
H. sp	*Hedera* sp	*Hedera*	Araliaceae	Rare	30	0	30	0
C. mul	*Cytisus multiflorus*	*Cytisus*	Fabaceae	Rare	29	0	5	24
C. dis	*Carex distachya*	*Carex*	Cyperaceae	Rare	27	0	6	21
P. avi	*Prunus avium*	*Prunus*	Rosaceae	Rare	24	24	0	0
P. aqu	*Pteridium aquilinum*	*Pteridium*	Dennstaedtiaceae	Rare	24	15	9	0
R. sp	*Rosa* sp	*Rosa*	Rosaceae	Rare	24	11	3	10
E. aus	*Erica australis*	*Erica*	Ericaceae	Rare	23	23	0	0
A. pau	*Aristolochia paucinervis*	*Aristolochia*	Aristolochiaceae	Rare	17	0	17	0
H. hib	*Hedera hibernica*	*Hedera*	Araliaceae	Rare	17	14	3	0
C. sp	*Cytisus* sp	*Cytisus*	Fabaceae	Rare	16	0	16	0
D. hys	*Dianthus hyssopifolius*	*Dianthus*	Caryophyllaceae	Rare	15	0	14	1
G. luc	*Geranium lucidum*	*Geranium*	Geraniaceae	Rare	15	15	0	0
M. pra	*Melampyrum pratense*	*Melampyrum*	Orobanchaceae	Rare	15	0	11	4
G. san	*Geranium sanguineum*	*Geranium*	Geraniaceae	Rare	14	0	13	1
S. arv	*Stachys arvensis*	*Stachys*	Lamiaceae	Rare	12	12	0	0
G. luc	*Galium lucidum*	*Galium*	Rubiaceae	Rare	10	0	5	5
A. cas	*Agrostis castellana*	*Agrostis*	Poaceae	Rare	9	0	9	0
V. riv	*Viola riviniana*	*Viola*	Violaceae	Rare	9	9	0	0
V. ten	*Vicia tenuifolia*	*Vicia*	Fabaceae	Rare	8	0	0	8
C. sat	*Castanea sativa*	*Castanea*	Fagaceae	Rare	7	7	0	0
S. hol	*Stellaria holostea*	*Stellaria*	Caryophyllaceae	Rare	6	0	6	0
A. mil	*Achillea millefolium*	*Achillea*	Asteraceae	Rare	5	5	0	0

Abb	Identification	Genera	Family	Group	Total	PNM-30	SN-30	SN-80
B. ste	*Bromus sterilis*	*Bromus*	Poaceae	Rare	5	5	0	0
L. nig	*Lathyrus niger*	*Lathyrus*	Fabaceae	Rare	5	0	5	0
O. vul	*Origanum vulgare*	*Origanum*	Lamiaceae	Rare	5	0	1	4
C. lae	*Cruciata laevipes*	*Cruciata*	Rubiaceae	Rare	4	4	0	0
M. mel	*Melittis melissophyllum*	*Melittis*	Lamiaceae	Rare	4	0	4	0
NI	Not identified (NI)	NI		Rare	4	3	1	0
P. spi	*Prunus spinosa*	*Prunus*	Rosaceae	Rare	4	0	3	1
Rub	*Rubiaceae*	*Rubiaceae*	Rubiaceae	Rare	4	0	4	0
V. sat	*Vicia sativa*	*Vicia*	Fabaceae	Rare	4	4	0	0
V. sp	*Vicia* sp	*Vicia*	Fabaceae	Rare	4	0	4	0
C. gla	*Cruciata glabra*	*Cruciata*	Rubiaceae	Rare	3	0	0	3
D. gni	*Daphne gnidium*	*Daphne*	Thymelaeaceae	Rare	3	0	2	1
P. gal	*Peucedanum gallicum*	*Peucedanum*	Apiaceae	Rare	3	3	0	0
A. sp	*Asphodelus* sp	*Asphodelus*	Asphodelaceae	Rare	2	0	2	0
D. pur	*Digitalis purpurea*	*Digitalis*	Plantaginaceae	Rare	2	2	0	0
G. rot	*Galium rotundifolium*	*Galium*	Rubiaceae	Rare	2	1	0	1
J. mon	*Jasione montana*	*Jasione*	Campanulaceae	Rare	2	0	1	1
V. cha	*Veronica chamaedrys*	*Veronica*	Plantaginaceae	Rare	2	2	0	0
V. ang	*Vicia angustifolia*	*Vicia*	Fabaceae	Rare	2	1	1	0
Api	Apiaceae	*Apiaceae*	Apiaceae	Rare	1	0	0	1
C. rap	*Campanula rapunculus*	*Campanula*	Campanulaceae	Rare	1	0	1	0
C. pul	*Crepis pulchra*	*Crepis*	Asteraceae	Rare	1	0	0	1
G. syl	*Geum sylvaticum*	*Geum*	Rosaceae	Rare	1	1	0	0
H. mon	*Hypericum montanum*	*Hypericum*	Hypericaceae	Rare	1	0	0	1
L. sp	*Lactuca* sp	*Lactuca*	Asteraceae	Rare	1	1	0	0
L. vim	*Lactuca viminea*	*Lactuca*	Asteraceae	Rare	1	0	0	1

Abb	Identification	Genera	Family	Group	Total	PNM-30	SN-30	SN-80
L. lin	*Lathyrus linifolius*	*Lathyrus*	Fabaceae	Rare	1	0	0	1
L. mar	*Lilium martagon*	*Lilium*	Liliaceae	Rare	1	0	1	0
L. cor	*Lotus corniculatus*	*Lotus*	Fabaceae	Rare	1	0	0	1
Poa	Poaceae	*Poaceae*	Poaceae	Rare	1	1	0	0
P. aca	*Primula acaulis*	*Primula*	Primulaceae	Rare	1	0	1	0
P. cor	*Pyrus cordata*	*Pyrus*	Rosaceae	Rare	1	0	1	0
P. sp	*Pyrus* sp	*Pyrus*	Rosaceae	Rare	1	0	1	0
Q. ile	*Quercus ilex*	*Quercus*	Fagaceae	Rare	1	0	0	1
S. hir	*Sedum hirsutum*	*Sedum*	Crassulaceae	Rare	1	0	1	0
S. cou	*Silene coutinhoi*	*Silene*	Caryophyllaceae	Rare	1	1	0	0
S. sp	*Silene* sp	*Silene*	Caryophyllaceae	Rare	1	0	0	1
S. med	*Stellaria media*	*Stellaria*	Caryophyllaceae	Rare	1	1	0	0
T. com	*Tamus comunis*	*Tamus*	Dioscoreaceae	Rare	1	0	1	0
T. cor	*Tanacetum corymbosum*	*Tanacetum*	Asteraceae	Rare	1	1	0	0
T. sco	*Teucrium scorodonia*	*Teucrium*	Lamiaceae	Rare	1	0	0	1
T. vil	*Thapsia villosa*	*Thapsia*	Apiaceae	Rare	1	1	0	0
T. hum	*Thesium humifusum*	*Thesium*	Santalaceae	Rare	1	0	1	0
T. med	*Trifolium medium*	*Trifolium*	Fabaceae	Rare	1	0	1	0

Table S2. Outputs from GAMLSS models (family BCPE) including the estimates, standard errors (SE), t-values and p-values for the parameters of the response distribution: mean (μ), dispersion (σ), skewness (ν), and kurtosis (τ) of volume per tree, biomass, and carbon storage. The link function used for each parameter is indicated in parentheses.

Volume		**Estimate**	**SE**	**t-value**	**p-value**
μ (identity link)	PNM-30	0.093	0.004	23.565	<0.001
μ (identity link)	SN-30 (vs PNM-30)	-0.064	0.004	-16.405	<0.001
μ (identity link)	SN-80 (vs PNM-30)	-0.002	0.004	-0.450	0.653
σ (log link)	(Intercept)	-0.150	0.016	-9.474	<0.001
nu (identity link)	(Intercept)	0.402	0.020	19.894	<0.001
tau (log link)	(Intercept)	0.838	0.049	16.988	<0.001
Biomass		**Estimate**	**SE**	**t-value**	**p-value**
μ (identity link)	PNM-30	55.646	2.359	23.588	<0.001
μ (identity link)	SN-30 (vs PNM-30)	-38.489	2.347	-16.398	<0.001
μ (identity link)	SN-80 (vs PNM-30)	-1.226	2.697	-0.455	0.649
σ (log link)	(Intercept)	-0.150	0.016	-9.474	<0.001
nu (identity link)	(Intercept)	0.402	0.020	19.892	<0.001
tau (log link)	(Intercept)	0.838	0.049	16.993	<0.001
Carbon		**Estimate**	**SE**	**t-value**	**p-value**
μ (identity link)	PNM-30	27.828	1.180	23.592	<0.001
μ (identity link)	SN-30 (vs PNM-30)	-19.245	1.174	-16.398	<0.001
μ (identity link)	SN-80 (vs PNM-30)	-0.614	1.349	-0.455	0.649
σ (log link)	(Intercept)	-0.150	0.016	-9.475	<0.001
nu (identity link)	(Intercept)	0.402	0.020	19.892	<0.001
tau (log link)	(Intercept)	0.838	0.049	16.993	<0.001