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SUPPLEMENTARY INFORMATION

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Climate–land-use interactions shape tropical mountain biodiversity and ecosystem functions

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SUPPLEMENTARY INFORMATION

This file contains Supplementary Tables, Supplementary Figures, Supplementary Notes and Supplementary References.

SUPPLEMENTARY TABLES

Supplementary Table 1 | Tests on the potentially confounding influence of geology and soil properties on variation in biodiversity and ecosystem function variables.

Supplementary Table 2 | ANOVA testing on differences in the effect of LUI on ESF in different elevation zones.

Supplementary Table 3 | Analyses of single LUI components versus the composite LUI index for explaining ESF.

Supplementary Table 4 | Analyses with subsets of data with reduced correlation among predictor variables.

Supplementary Table 5 | Model weights for a data set only incorporating study sites from the two lower elevation zones with agriculture (N = 30).

SUPPLEMENTARY FIGURES

Supplementary Figure 1 | Levels of soil-mediated ESF in different elevation zones and habitat types.

Supplementary Figure 2 | Levels of plant-mediated ESF in different elevation zones and habitat types.

Supplementary Figure 3 | Levels of animal-mediated ESF in different elevation zones and habitat types.

SUPPLEMENTARY NOTES

Supplementary Note 1 | Influence of potentially confounding variables which change with elevation.

SUPPLEMENTARY REFERENCES

Supplementary Table 1 | Tests on the potentially confounding influence of geology and soil properties on variation in biodiversity and ecosystem function variables.

		Geologic data				Soil element composition			
				Climate x LUI interaction term				Climate x LUI interaction	
Type	Variable	ΔAIC	R^2	Models including geologic data	Original model (without geologic data)	ΔAIC	R^2	Models including soil element composition	Original model (without soil data)
Biodiversity	Plants	10.38	0.64	yes	yes	2.47	0.55	yes	yes
	Animals	7.82	0.87	yes	yes	2.57	0.84	yes	yes
	Microbes	10.21	0.21	no	no	0.51	0.08	no	no
Soil-mediated ESF	SOC	7.34	0.87	yes	yes	-0.40	0.83	yes	yes
	Soil pH	3.27	0.53	no	yes	1.51	0.56	yes	yes
	Soil C/N ratio	1.31	0.55	yes	yes	-8.27	0.40	yes	yes
	Soil N/P ratio	5.56	0.68	no	no	-4.12	0.62	no	no
	AWC	9.99	0.75	no	no	1.58	0.71	yes	no
	$\delta^{15}N$	11.44	0.78	no	yes	-1.84	0.76	yes	yes
	Leaf decomposition	7.24	0.65	yes	yes	-3.48	0.57	yes	yes
	N_2O emission	0.77	0.43	no	yes	2.46	0.29	yes	yes
	CH_4 emission	7.72	0.7	yes	yes	0.29	0.61	yes	yes
	CO_2 emission	17.58	0.48	no	no	2.38	0.45	no	no
Plant-mediated ESF	Vegetation biomass	8.76	0.84	yes	yes	2.60	0.79	yes	yes
	Fine root biomass	13.24	0.43	no	yes	1.81	0.37	no	yes
	Leaf area index	1.33	0.88	yes	yes	0.37	0.83	yes	yes
	NPP (NDVI)	11.24	0.87	no	yes	2.57	0.87	yes	yes
	Plant C/N ratio	10.23	0.70	yes	yes	0.90	0.64	yes	yes
	Plant N/P ratio	17.92	0.76	yes	yes	2.55	0.74	yes	yes
	Wood density	16.51	0.71	yes	yes	2.46	0.68	yes	yes
	Specific leaf area	14.75	0.58	no	no	2.35	0.52	no	no
	Flower density	7.31	0.39	no	yes	2.66	0.34	yes	yes
	Fruit density	20.27	0.59	no	yes	1.61	0.58	no	yes
	Woody plant regrowth	7.02	0.70	yes	yes	-0.59	0.61	yes	yes
Animal-mediated ESF	#Pollinators	16.52	0.53	yes	yes	0.16	0.49	yes	yes
	Frugivory	9.76	0.21	no	no	-1.28	0.11	no	no
	Insect biomass	18.71	0.40	no	no	2.16	0.37	no	no
	Herbivory	9.50	0.44	no	yes	-2.04	0.47	yes	yes
	Ant foraging	9.51	0.85	yes	yes	2.19	0.81	yes	yes
	Bat foraging	20.00	0.41	no	yes	2.46	0.45	yes	yes
	Parasitism	16.21	0.21	no	yes	-12.56	0.80	yes	yes
	Mammal biomass	5.33	0.29	no	no	2.25	0.09	no	no
	Dung decomposition	16.93	0.34	no	no	2.31	0.29	no	no

Apart from MAT and MAP other environmental variables change with elevation, including geology. We here checked whether the type of bedrocks[1] or the element composition of the top soil were important predictors of biodiversity and ESF. The columns shown under 'climate x LUI interaction term' indicate for each response variable if the climate x LUI interaction was included in the best selected model. In the column ΔAIC, green indicates that the original model (based on climate and LUI as predictor variables) was better supported by the data; red indicates that models that additionally included geologic or soil information were better supported. We found that models in which we included geologic data (in addition to climate and LUI variables) were less supported by the data than the original models which only included climate and/or LUI variables (for all response variables ΔAIC > 0). Also models including data on the soil element composition (summarized by a principal component analyses on total S, Na, K, Ca, Mg, Mn, Fe and Al in top soil, up to 50 cm depth) performed less well than the original models in the majority of cases. Important, for the response variables which were better explained by models including soil element composition data (ΔAIC < 0, indicated by red), including soil element composition as an additional explanatory variable did not lead to any changes in the support of a climate x LUI interaction effects.

Supplementary Table 2 | ANOVA testing on differences in the effect of LUI on ESF in different elevation zones.

		ANOVA with (quantitative) LUI			ANOVA with binary land use variable		
Type	**Response Variable**	**Elevation zone**	**LUI**	**Interaction**	**Elevation zone**	**Land use**	**Interaction**
Soil-mediated ESF	SOC	<0.0001	<0.0001	0.040	<0.0001	<0.0001	<0.0001
	Soil pH	<0.0001	0.070	0.020	<0.0001	0.300	0.100
	Soil C/N ratio	0.100	<0.0001	0.020	0.000	0.003	0.220
	Soil N/P ratio	<0.0001	<0.0001	0.500	<0.0001	0.000	0.010
	AWC	<0.0001	<0.0001	0.410	<0.0001	0.210	0.440
	$\delta^{15}N$	0.160	<0.0001	0.090	<0.0001	<0.0001	<0.0001
	Leaf decomposition	0.090	0.910	0.070	0.070	0.340	0.140
	N_2O emission	0.000	0.500	0.200	0.000	0.350	0.370
	CH_4 emission	<0.0001	<0.0001	0.010	<0.0001	0.460	<0.0001
	CO_2 emission	0.000	0.002	0.640	0.000	0.020	0.410
Plant-mediated ESF	Vegetation biomass	0.000	<0.0001	0.010	<0.0001	<0.0001	<0.0001
	Fine root biomass	<0.0001	<0.0001	0.790	<0.0001	0.000	0.130
	Leaf area index	<0.0001	<0.0001	0.000	<0.0001	<0.0001	<0.0001
	NPP (NDVI)	<0.0001	<0.0001	0.047	<0.0001	0.540	0.001
	Plant C/N ratio	0.004	0.010	0.001	0.002	0.020	0.001
	Plant N/P ratio	<0.0001	<0.0001	0.001	<0.0001	0.180	<0.0001
	Wood density	0.020	<0.0001	0.020	0.020	<0.0001	<0.0001
	Specific leaf area	0.130	<0.0001	0.640	0.001	0.000	0.050
	Flower density	0.990	<0.0001	0.130	0.100	0.070	0.030
	Fruit density	0.003	0.010	0.060	0.000	0.020	0.030
	Woody plant regrowth	0.090	<0.0001	0.030	0.000	0.003	0.002
Animal-mediated ESF	#Pollinators	0.002	<0.0001	0.140	<0.0001	0.610	0.130
	Frugivory	0.560	0.070	0.470	0.210	0.020	0.560
	Insect biomass	0.930	0.540	0.590	0.750	0.540	0.300
	Herbivory	0.008	0.006	0.000	0.210	0.170	<0.0001
	Ant foraging	<0.0001	<0.0001	0.150	<0.0001	0.120	0.060
	Bat foraging	0.760	<0.0001	0.860	0.080	0.046	0.420
	Parasitism	0.080	0.770	0.040	0.300	0.340	NA
	Mammal biomass	0.780	0.710	0.860	0.790	0.640	0.920
	Dung decomposition	<0.0001	0.003	0.030	<0.0001	0.620	0.007

Instead of tests of climate-land use interactions, we tested whether there are differences in the effect of land use (with the quantitative LUI and a binary land use variable: natural versus anthropogenic) in different elevation zones of Mt. Kilimanjaro. The table shows P values for the effect of elevation zone, LUI/land use and the interaction term elevation zone x LUI/land use. A significant interaction term indicates that the effect of LUI/land use varies in different elevation zones of Mt. Kilimanjaro. NA, not available.

Supplementary Table 3 | Analyses of single LUI components versus the composite LUI index for explaining ESF.

			Model weights				
Type	**Response Variable**	**Best land use variable***	**Null**	**Climate**	**LUI**	**Additive**	**Interact.**
Soil-mediated ESF	SOC	Landscape structure	0.00	0.00	0.00	0.00	1.00
	Soil pH	LUI	0.00	0.01	0.00	0.33	0.66
	Soil C/N ratio	Landscape structure	0.00	0.00	0.44	0.38	0.17
	Soil N/P ratio	Landscape structure	0.00	0.01	0.00	0.27	0.72
	AWC	Biomass removal	0.00	0.24	0.00	0.51	0.24
	$\delta^{15}N$	Landscape structure	0.00	0.00	0.13	0.75	0.12
	Leaf decomposition	LUI	0.00	0.00	0.00	0.00	1.00
	N_2O emission	Agricultural inputs	0.00	0.00	0.00	0.82	0.18
	CH_4 emission	Biomass removal	0.00	0.03	0.00	0.49	0.48
	CO_2 emission	LUI	0.00	0.00	0.00	0.84	0.16
Plant-mediated ESF	Vegetation biomass	LUI	0.00	0.00	0.00	0.00	1.00
	Fine root biomass	Landscape structure	0.00	0.00	0.54	0.39	0.08
	Leaf area index	Vegetation structure	0.00	0.00	0.00	0.07	0.93
	NPP (NDVI)	LUI	0.00	0.22	0.00	0.33	0.45
	Plant C/N ratio	LUI	0.00	0.00	0.00	0.00	1.00
	Plant N/P ratio	Vegetation structure	0.00	1.00	0.00	0.00	0.00
	Wood density	LUI	0.00	0.00	0.00	0.00	1.00
	Specific leaf area	Agricultural inputs	0.00	0.00	0.00	0.00	1.00
	Flower density	LUI	0.00	0.01	0.02	0.21	0.76
	Fruit density	Vegetation structure	0.00	0.01	0.00	0.04	0.95
	Woody plant regrowth	LUI	0.00	0.00	0.00	0.07	0.93
Animal-mediated ESF	#Pollinators	Biomass removal	0.00	0.00	0.00	0.10	0.90
	Frugivory	LUI	0.14	0.39	0.26	0.15	0.07
	Insect biomass	Biomass removal	0.00	0.18	0.00	0.44	0.39
	Herbivory	Vegetation structure	0.00	0.01	0.02	0.01	0.96
	Ant foraging	Landscape structure	0.00	0.00	0.00	0.01	0.99
	Bat foraging	Agricultural inputs	0.00	0.00	0.00	0.05	0.95
	Parasitism	LUI	0.15	0.42	0.04	0.12	0.27
	Mammal biomass	Landscape structure	0.11	0.53	0.07	0.25	0.05
	Dung decomposition	LUI	0.00	0.69	0.01	0.23	0.07

We analyzed whether ESF responded more strongly to the single land use components of the LUI (biomass removal, agricultural inputs, dissimilarity in vegetation structure compared to natural habitat, proportion agriculture in the surrounding landscape (landscape structure)) than to the composite LUI index and if the use of single components reduced the support for climate x LUI interaction effects. Across the 30 ESF the LUI performed better in explaining ESF than any single component of the LUI (in twelve ESF variables models including the LUI had lower AIC values than models including single LUI components). Single components of the LUI were better supported by the data than the LUI in seven (landscape structure), four (biomass removal), four (dissimilarity in vegetation structure compared to natural habitat), and three (agricultural inputs) cases (i.e. ESF variables). Climate x LUI

interaction effects were equally supported by models including single LUI components than in models including the LUI. Colors indicate low (white) to high percentage values (dark green).

Supplementary Table 4 | Analyses with subsets of data with reduced correlation among predictor variables.

Type	Response Variable	Null	Climate	LUI	Additive	Interact.
Biodiversity	Microbes	45%	55%	0%	0%	0%
	Plants	0%	0%	0%	0%	100%
	Animals	0%	11%	0%	0%	89%
Soil-mediated ESF	SOC	0%	0%	0%	0%	100%
	Soil pH	0%	0%	0%	47%	53%
	Soil C/N ratio	0%	0%	83%	0%	17%
	Soil N/P ratio	0%	0%	0%	79%	21%
	AWC	0%	95%	0%	0%	5%
	$\delta^{15}N$	0%	0%	0%	82%	18%
	Leaf decomposition	0%	0%	0%	0%	100%
	N_2O emission	0%	21%	0%	11%	68%
	CH_4 emission	0%	55%	0%	0%	45%
	CO_2 emission	0%	0%	0%	100%	0%
Plant-mediated ESF	Vegetation biomass	0%	0%	0%	0%	100%
	Fine root biomass	0%	0%	18%	45%	37%
	Leaf area index	0%	0%	0%	0%	100%
	NPP (NDVI)	0%	10%	0%	28%	62%
	Plant C/N ratio	0%	0%	0%	0%	100%
	Plant N/P ratio	0%	0%	0%	0%	100%
	Wood density	0%	0%	0%	0%	100%
	Specific leaf area	0%	0%	2%	86%	12%
	Flower density	0%	0%	1%	6%	93%
	Fruit density	0%	45%	0%	0%	55%
	Woody plant regrowth	0%	0%	0%	0%	100%
Animal-mediated ESF	#Pollinators	0%	6%	0%	0%	94%
	Frugivory	0%	78%	12%	0%	0%
	Insect biomass	0%	97%	0%	0%	3%
	Herbivory	0%	0%	0%	5%	95%
	Ant foraging	0%	0%	0%	1%	99%
	Bat foraging	0%	0%	27%	0%	73%
	Parasitism	34%	61%	0%	0%	5%
	Mammal biomass	9%	91%	0%	0%	0%
	Dung decomposition	0%	100%	0%	0%	0%

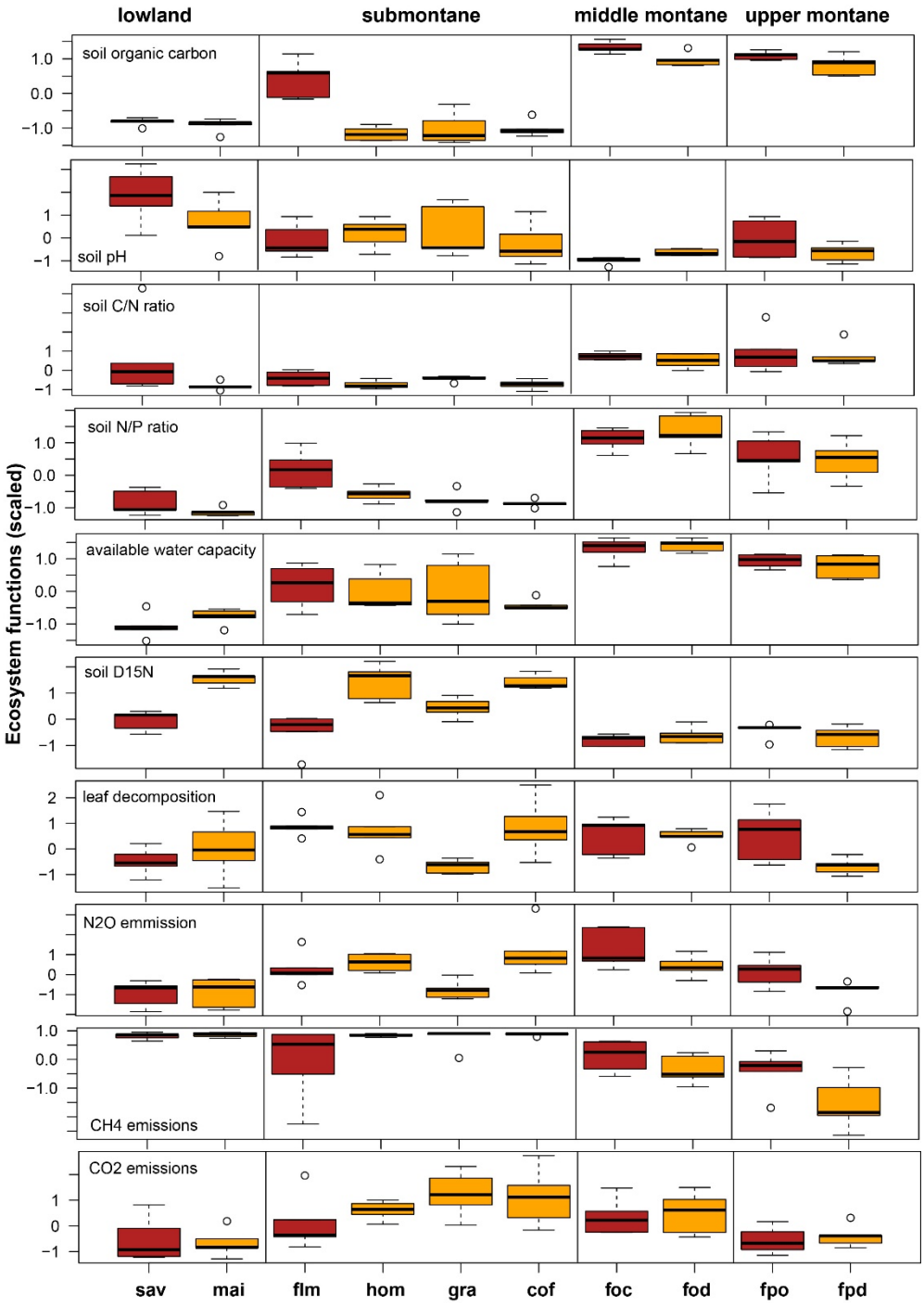
In the original data set MAT and LUI are correlated with Pearson's r = 0.73. Recent publications, however, suggested a threshold of r < 0.7 for variables to be included in parallel as explanatory variables in models. In order to check whether our results are influenced by correlation between explanatory variables we used a jackknifing approach to construct random subsets of the data (by randomly removing data from up to 10 study sites) in which MAT and LUI were correlated with Pearson's r < 0.7. We then identified the model (Null, null model; Climate, climate(-only) model, LUI (-only) model; Additive, Climate + LUI; Interaction: Climate × LUI) which was best supported by the data

(with highest model weights). Shown are the proportion of 500 jackknifing runs per response variable in which the respective model received the highest model weights. Results of these analyses generally reflect the patterns found for the full dataset, underscoring the high support for climate-LUI interaction models. Colors indicate low (white) to high percentage values (dark green).

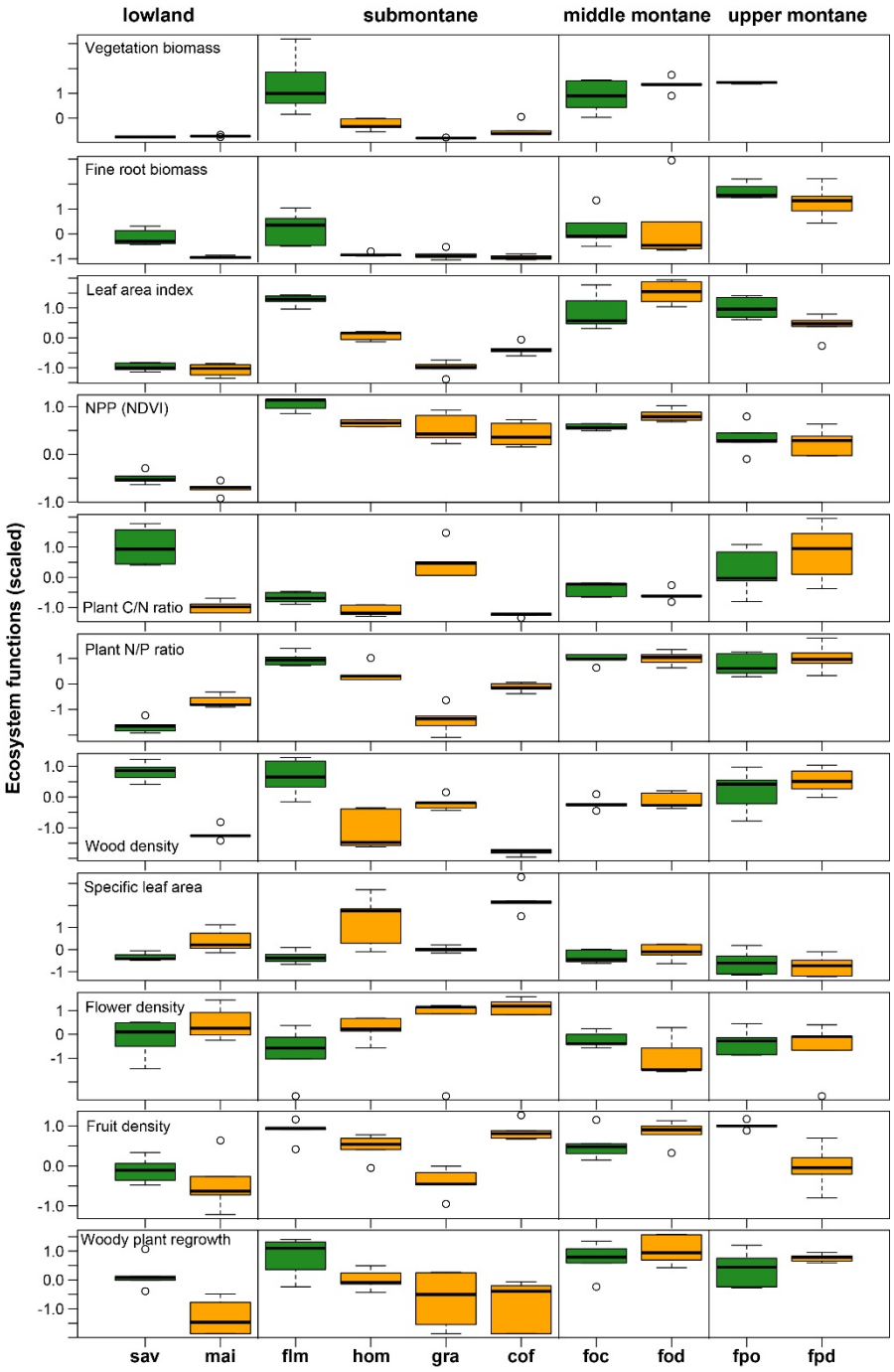
Supplementary Table 5 | Model weights for a data set only incorporating study sites from the two lower elevation zones with agriculture (N = 30).

Type	Response Variable	Null	Climate	LUI	Additive	Interact.
Biodiversity	Microbes	0.14	0.54	0.06	0.13	0.13
	Plants	0.15	0.04	0.36	0.12	0.33
	Animals	0.08	0.41	0.03	0.27	0.21
Soil-mediated ESF	SOC	0.00	0.00	0.00	0.10	0.90
	Soil pH	0.00	0.11	0.00	0.77	0.12
	Soil C/N ratio	0.11	0.04	0.30	0.17	0.38
	Soil N/P ratio	0.00	0.00	0.00	0.13	0.88
	AWC	0.00	0.70	0.00	0.27	0.03
	$\delta^{15}N$	0.00	0.00	0.37	0.59	0.04
	Leaf decomposition	0.09	0.07	0.03	0.03	0.80
	N_2O emission	0.04	0.43	0.02	0.49	0.03
	CH_4 emission	0.00	0.00	0.00	0.02	0.98
	CO_2 emission	0.00	0.01	0.02	0.85	0.11
Plant-mediated ESF	Vegetation biomass	0.00	0.00	0.00	0.01	1.00
	Fine root biomass	0.00	0.00	0.42	0.36	0.22
	Leaf area index	0.00	0.00	0.00	0.00	1.00
	NPP (NDVI)	0.00	0.44	0.00	0.53	0.03
	Plant C/N ratio	0.03	0.02	0.04	0.06	0.85
	Plant N/P ratio	0.00	0.07	0.00	0.02	0.91
	Wood density	0.00	0.00	0.69	0.24	0.07
	Specific leaf area	0.01	0.00	0.51	0.46	0.02
	Flower density	0.00	0.01	0.73	0.20	0.03
	Fruit density	0.09	0.67	0.03	0.18	0.03
	Woody plant regrowth	0.00	0.00	0.69	0.29	0.01
Animal-mediated ESF	#Pollinators	0.02	0.56	0.02	0.31	0.10
	Frugivory	0.47	0.29	0.15	0.08	0.01
	Insect biomass	0.47	0.30	0.14	0.09	0.01
	Herbivory	0.00	0.00	0.04	0.02	0.93
	Ant foraging	0.21	0.55	0.08	0.15	0.02
	Bat foraging	0.00	0.06	0.47	0.30	0.12
	Parasitism	0.15	0.42	0.04	0.12	0.27
	Mammal biomass	0.49	0.22	0.16	0.06	0.07
	Dung decomposition	0.29	0.35	0.15	0.12	0.09

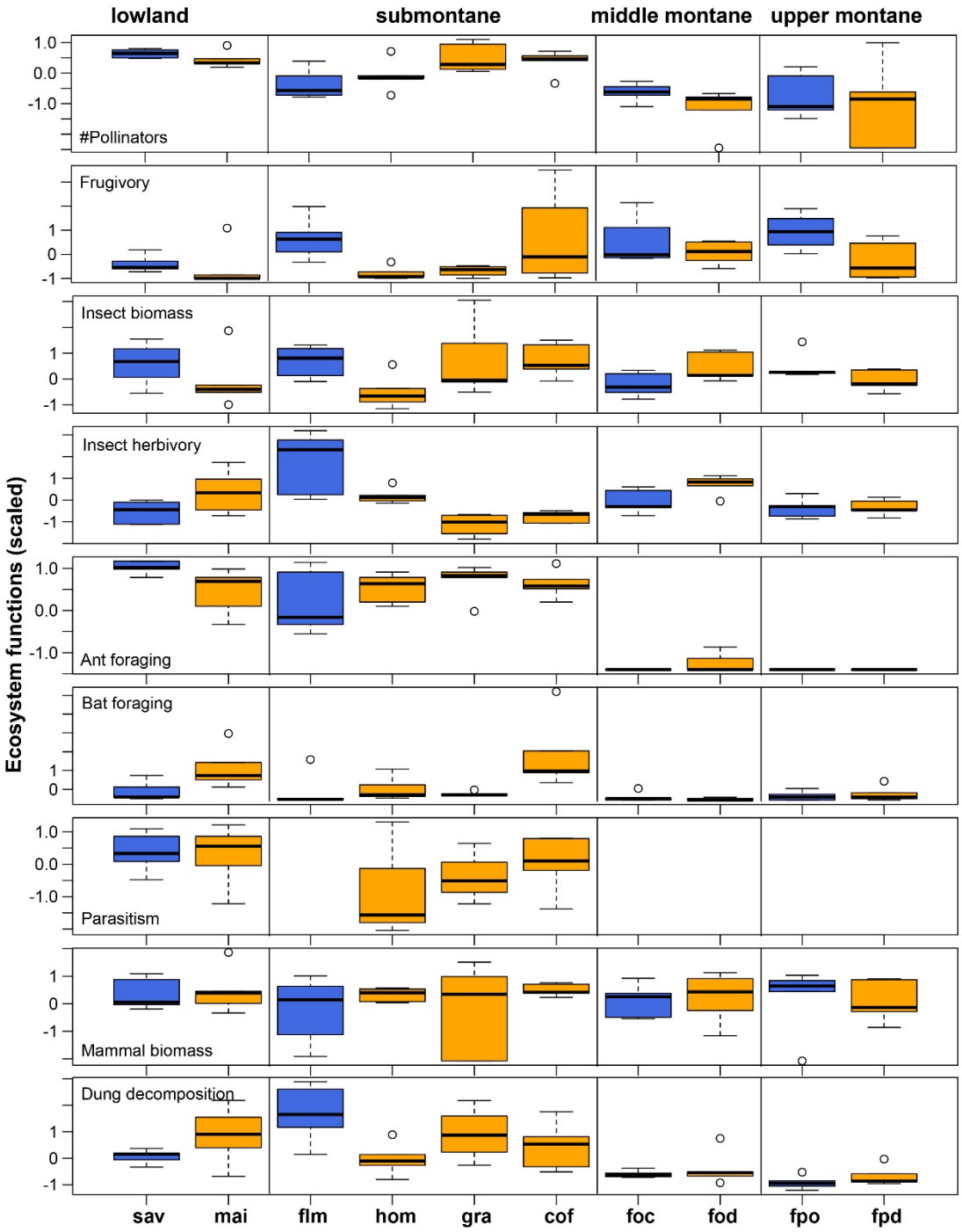
We built a subset of the data (N = 30 study sites) by excluding data from study sites of the montane, subalpine and alpine zone. The data subset incorporated study sites from elevation zones where agriculture formed the land use gradients. LUI and MAT are only slightly correlated with Pearson's r = 0.18. Shown are model weights for all five formal models (Null, null model; Climate, climate(-only) model, LUI (-only) model; Additive, Climate + LUI; Interaction: Climate × LUI). While the climate-land use interaction effect was less supported for the data subset than for the full data set including all 60 study sites, it was still prominent.



Supplementary Figure 1 | Levels of soil-mediated ESF in different elevation zones and habitat types. Boxplots show median (bold line), quartiles (boxes) and extreme values (whiskers, dots) of ESF in natural (brown) and anthropogenic habitats (orange) in different elevation levels (lowland, submontane/lower montane, middle montane, upper montane). In the submontane/lower montane elevation level anthropogenic habitats were sorted by increases in mean levels of LUI (LUI in hom < gra < cof). sav, Savannah; mai, Maize field; flm, Submontane rainforest; hom, Chagga homegarden; cof, Coffee plantation; gra, Grassland; foc, *Ocotea* forest; fod, logged *Ocotea* forest; fpo, *Podocarpus* forest; fpd, burned *Podocarpus* forest.



Supplementary Figure 2 | Levels of plant-mediated ESF in different elevation zones and habitat types. Boxplots show median (bold line), quartiles (boxes) and extreme values (whiskers, dots) of ESF in natural (green) and anthropogenic habitats (orange) in different elevation levels (lowland, submontane/lower montane, middle montane, upper montane). In the submontane/lower montane elevation level anthropogenic habitats were sorted by increases in mean levels of LUI (LUI in hom < gra < cof). sav, Savannah; mai, Maize field; flm, Sub montane rainforest; hom, Chagga homegarden; cof, Coffee plantation; gra, Grassland; foc, *Ocotea* forest; fod, logged *Ocotea* forest; fpo, *Podocarpus* forest; fpd, burned *Podocarpus* forest.



Supplementary Figure 3 | Levels of animal-mediated ESF in different elevation zones and habitat types. Boxplots show median (bold line), quartiles (boxes) and extreme values (whiskers, dots) of ESF in natural (blue) and anthropogenic habitats (orange) in different elevation levels (lowland, submontane/lower montane, middle montane, upper montane). In the submontane/lower montane elevation level anthropogenic habitats were sorted by increases in mean levels of LUI (LUI in hom < gra < cof). sav, Savannah; mai, Maize field; flm, Sub montane rainforest; hom, Chagga homegarden; cof, Coffee plantation; gra, Grassland; foc, *Ocotea* forest; fod, logged *Ocotea* forest; fpo, *Podocarpus* forest; fpd, burned *Podocarpus* forest.

Supplementary Note 1

Influence of potentially confounding variables which change with elevation

We found that temperature and precipitation are the dominant climatic drivers of biodiversity and ecosystem functions which change with elevation. While mean annual temperature (MAT) is closely correlated to elevation (r = -0.98), mean annual precipitation (MAP) exhibits a unimodal distribution along the elevation gradient (r = 0.33). However, on mountains other environmental variables also systematically change with elevation, for example, atmospheric pressure, solar radiation, land area, and, as Mt. Kilimanjaro is of volcanic origin, geology[2]. It might be argued that these variables are also possible predictors of biodiversity and ecosystem functions and that their disregard in the models leads to confounding interpretations concerning the importance of climatic effects. Based on theoretical arguments and the analysis of data with potentially confounding variables we can provide strong support for the major role of climate in determining biodiversity and ecosystem functions. In contrast, we did not find convincing arguments for a significant effect of other environmental variables that are correlated to elevation, such as atmospheric pressure, geology, land area and solar radiation. In the following sections we present the arguments against major potentially confounding variables separately:

Climate: We included mean annual temperature and mean annual precipitation as predictors of biodiversity and ecosystem functions. These variables received overwhelming support in nearly all response variables. Biological theory and data from latitudinal gradients underscore the importance of climate for biodiversity and ecosystem functions. The influence of temperature on biological rates belongs to the best understood principles of life, giving rise to theories from the Arrhenius equation to the metabolic theory of ecology (summarized e.g. in Brown et al.[3]). Temperature has also been supported as the major driver of species richness in review articles[4], global data sets[5,6] and multi-taxa analyses[7]. Similarly, it is well established that water availability is a key factor limiting ecological rates, growths, and reproduction of organisms and diversity across broad climatic gradients[5,8,9]. So there are good reasons to assume close linkages between these key climate variables and biodiversity and ecosystem functions.

Atmospheric pressure (AP): AP is approximately linearly declining with elevation, i.e. by ca. 11% per km of elevation. Including AP instead of MAT in models would therefore lead to highly similar results. However, concerning diversity gradients we know of no concept for assuming a mechanistic link between species richness and AP[10,11], except for a potential positive influence of AP on of net primary productivity which could then be linked to the more-individuals hypothesis[12]. However, the expected changes from differences in atmospheric pressure on plant production are only moderate, e.g., models of Terashima et al.[13] suggested a 23% decline in photosynthesis rates across an elevation gradient of 3000 m. Changes in net primary

productivity varied ~20x across our study sites and, unlike AP, net primary productivity showed a unimodal distribution with elevation which strongly correlated with the distribution of mean annual precipitation on the mountain. Thus, we see no reason to assume a mechanistic linkage between AP and species richness. Concerning ecosystem functions, if AP would be responsible for the observed changes in ESF we would expect monotonic relationships between AP and ESF. But most ecosystem functions showed unimodal distributions with elevation, refuting AP as a major driver. In addition, analyses with higher temporal resolution showed profound seasonal variation in ecosystem functions *within* study sites[14–17]; a common garden experiment in which plants from the lowlands and higher elevations were grown in experimental gardens at low and high elevation revealed higher biomass growth rates and faster reproduction at high elevations (with reduced atmospheric pressure), which directly opposes predictions for reductions in atmospheric pressure[18]. All the results can be well explained by changes in temperature and precipitation but not by changes in atmospheric pressure[14–18]. In addition, observed changes in response variables with elevation on Mt. Kilimanjaro well reflect changes observed along the latitudinal climatic gradient (e.g., for net primary productivity: Field et al.[19]; for leaf decomposition rates Moorhead et al.[20]; for ant foraging rates: Roslin et al.[21]). The most parsimonious explanations for the parallels in the characteristics of ecosystems along elevational and latitudinal gradients is the parallel change in climate along both gradients.

Geology: Particularly on volcanoes, the geology could be closely linked to changes in elevation and thus make it impossible to identify whether geology or climate is the major driver of biodiversity and ESF. We used the map of Downie, & Wilkinson[1] to derive the geological classification of the bedrocks for all 60 study sites. We re-run all models including this factor ('geology' with 9 bedrock categories) and checked if the models were superior to those based only on climate and land use. Without exception, models including geology were less supported by the data than climate-land use models, typically with considerably differences in model support (ΔAIC across 30 ecosystem functions and 3 biodiversity variables: 0.77-20.27 with a mean ΔAIC of 10.66). In addition we expect that if the geology influences biodiversity and ecosystem functions this effect is modulated by soil properties (which are, however, not only constrained by the rocks but also by climate and other factors). Thus, we collected data on the elemental composition of the top soil (0-50 cm: total S, Na, K, Ca, Mg, Mn, Fe and Al) on all study sites and used a principal component analysis to reduce the dimensionality of the data. Due to the strong correlation of the soil elements, the first principal component axis (PCA1) alone included 76% of the variation and can therefore be regarded as a good variable describing the overall composition of the soil. Geology was indeed a good predictor of the elemental composition of the soil, explaining about 51% of the variation of the PCA1.

However, PCA1 was still a poor predictor of biodiversity and ecosystem functions: For each biodiversity and ecosystem function variable we ran all models (climate only, land use only, climate + land use, climate x land use, null model), this time including also the PCA1 as an explanatory variable. If the soil composition would be an important driver of biodiversity and ecosystem functions we expected that models including the PCA1 would become well supported in the multi-model inference approach. We found that only for eight out of 33 response variables, the PCA1 was included in the best selected model. Not surprisingly, most of these response variables were soil property variables (soil C/N, soil N/P, soil SOC, soil δ15N and leaf decomposition rates). For most of these eight response variables, climate-only or climate-land-use models were nearly equally supported by the data. Importantly, including PCA1 did not lead to any changes in the support for a climate-land use interaction term. So we are confident that soil properties, linked to geologic properties of the volcanic rocks, are relevant predictors of very few ESF only. Moreover, their inclusion did not change any of our major findings on the importance of climate, land use and their interaction effects. In addition to these analyses, most argumentations raised in the section 'atmospheric pressure' fit here equally well. Seasonal changes in ESF, parallels in patterns of ESF along latitudinal and elevational gradients, and experimental work conducted by our group on Mt. Kilimanjaro suggest climate rather than for geology in driving the broad-scale patterns in biodiversity and ecosystem functions.

Land area has been supported as driver of biodiversity and it is often correlated to elevation. In our former study[7] we incorporated land area as a predictor of biodiversity (but not of ecosystem functions at the local scale) but it was much less supported than MAT across the different taxa and taxonomic levels which were tested in our previous study. For total species richness of plants and animals (the level which we analysed in the present study) land area was actually not supported at all. We, therefore, did not incorporate it in the current study.

Solar radiation: Solar radiation typically increases with elevation but this trend is strongly modulated by changes in cloud cover[2]. Even though we have no measurements for solar radiation across all study sites we expected the highest values at the highest elevations (low cloud cover, reduced atmospheric turbidity), moderately high values in the savannah vegetation (low cloud cover but higher atmospheric turbidity) and lowest values in the cloud forests (high cloud cover, moderate atmospheric turbidity). Furthermore, if solar radiation has an influence on biodiversity and ecosystem functions we would expect it to be positive (with the exception of proportional data like C:N or N:P ratios). The patterns of biodiversity and ecosystem functions which we detected at Mt. Kilimanjaro did not fit to these expectations. Biodiversity was high in the lowlands and linearly declined with elevation.

Ecosystem functions mostly peaked in areas where solar radiations is low (in elevations between 1700-2500 m asl). Moreover, as explained under atmospheric pressure, seasonal

changes in ESF variables, the parallels between patterns in biodiversity and ESF along elevation and latitudinal gradients, and manipulative experiments conducted on Mt. Kilimanjaro, support a major influence of climate and refute an influence of solar radiation.

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