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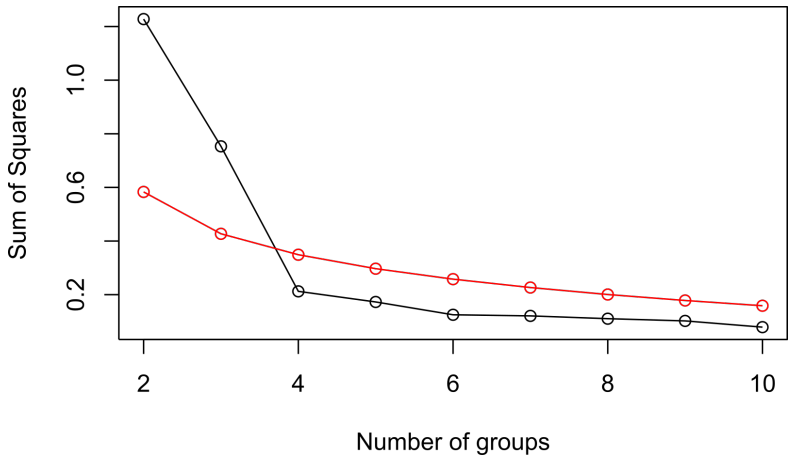
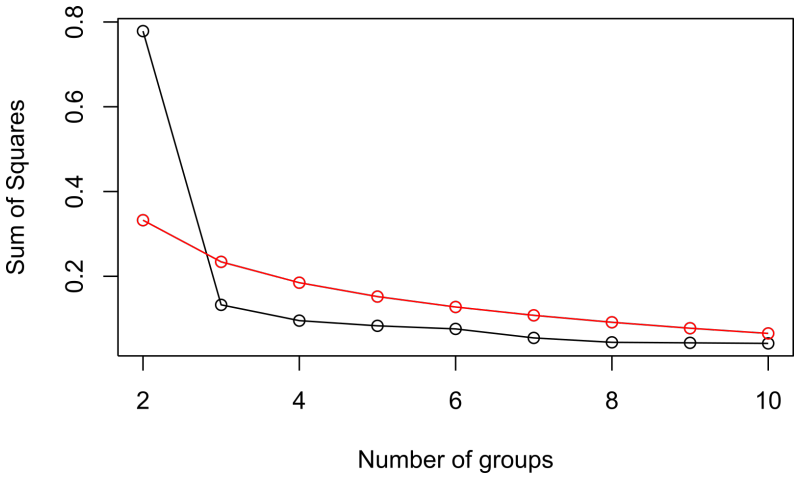
Supplementary Information

Insights into past land-use and vegetation change in the Llanos de Moxos (Bolivia) using fungal non-pollen palynomorphs.

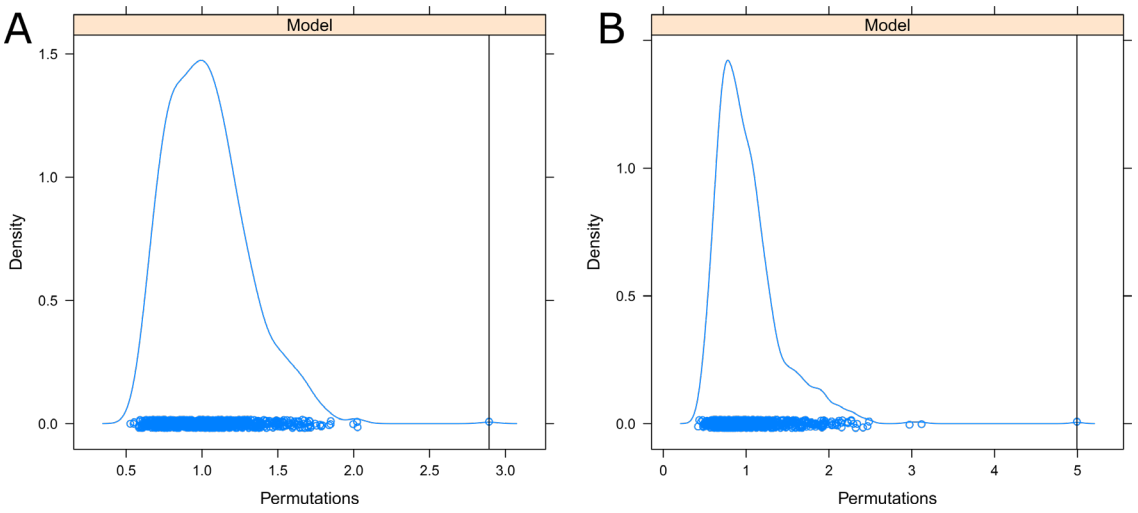
Nicholas J.D. Loughlin, Francis E. Mayle, Noelia B. Nuñez Otaño, Jennifer M.K. O'Keefe, Neil A. Duncan, John H. Walker, Bronwen S. Whitney



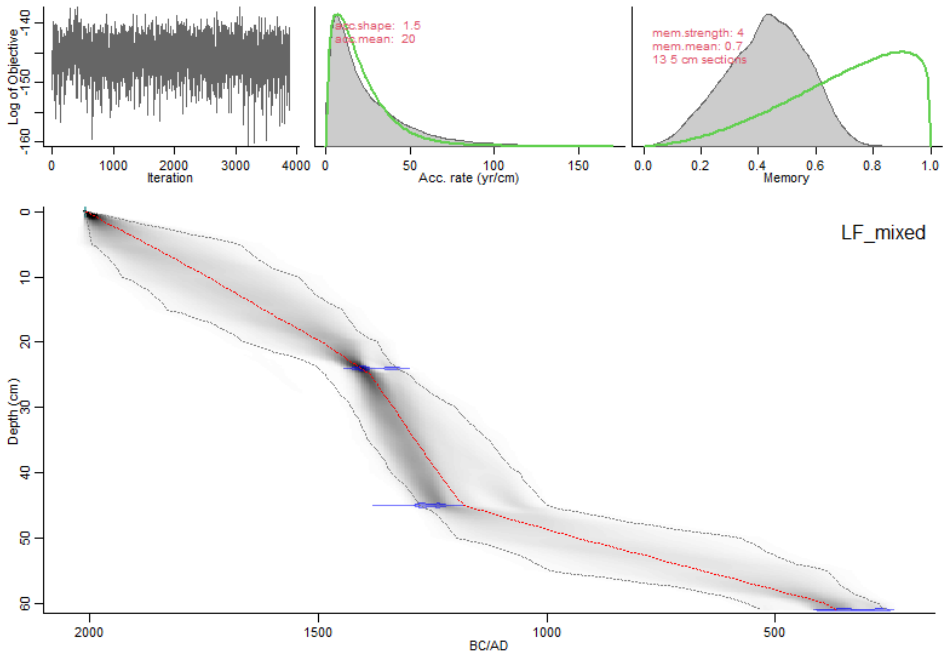
SI Fig 1 – Broken stick model to establish three statistically significant pollen zones. Pollen zones were established using pollen percentage data and calculating a dissimilarity indices using the Bray-Curtis method followed by constrained hierarchical clustering (CONISS). This dendrogram was then tested against a broken stick model to obtain a statistically significant number of zones.



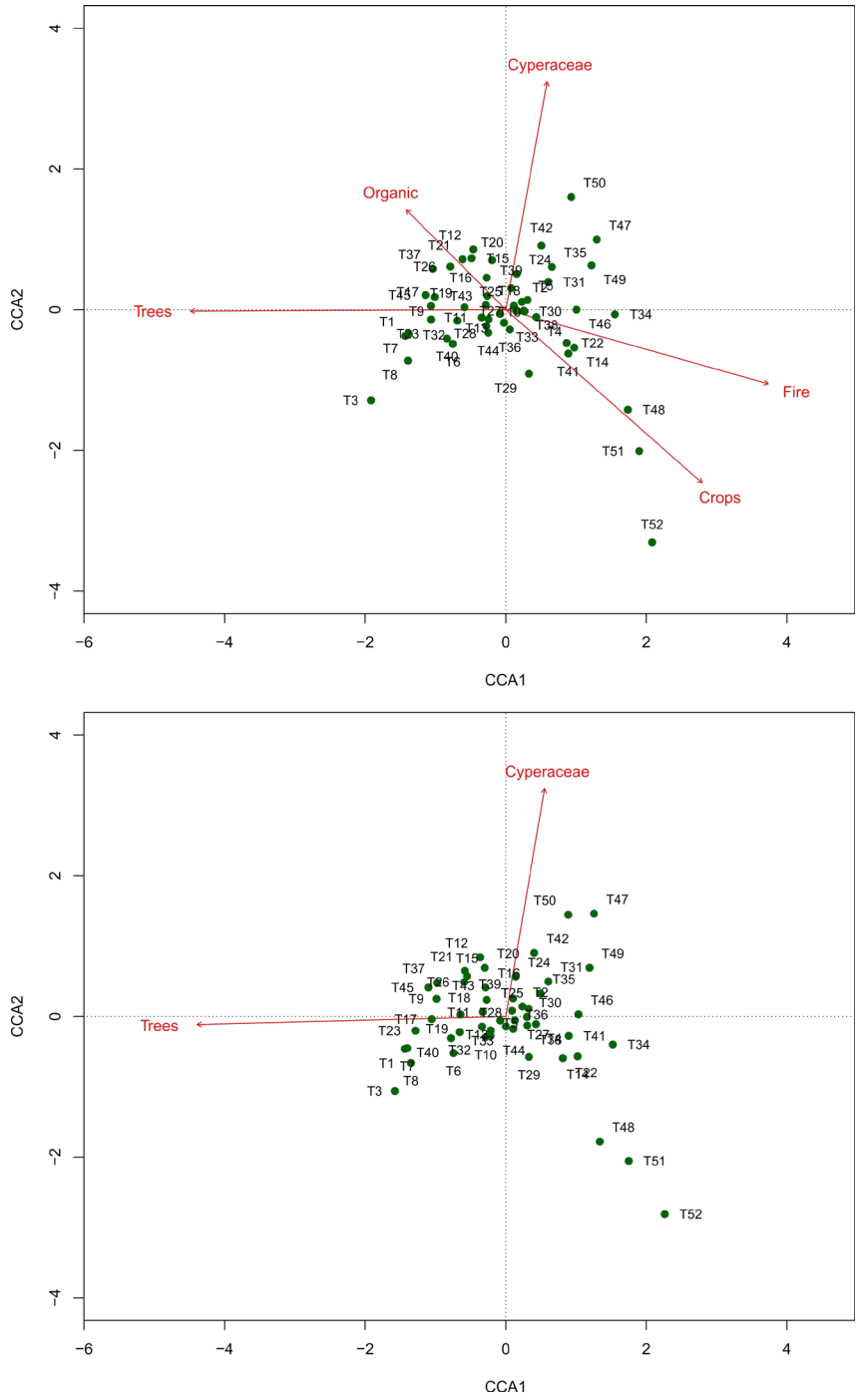
SI Fig 2 – Broken stick model to establish two statistically significant fungal NPP zones. Fungal NPP zones were established using square-root transformed fungal NPP percentage data and calculating a dissimilarity indices using the Bray-Curtis method followed by constrained hierarchical clustering (CONISS). This dendrogram was then tested against a broken stick model to obtain a statistically significant number of zones.



SI Fig 3 – Permutation tests for (A) a full model (2.829) and (B) a reduced model (5.099) to produce an F statistic. Analysis of variance (ANOVA) produced a P < .001 for both the full and reduced model indicating that 99.9% of the permuted values had an F statistic lower than that of the null model (1.036).



SI Fig 4 – Laguna Frontera age-depth model. Model plotted in Bacon (Blaauw and Christen, 2011) using a mixed IntCal20 (Reimer et al., 2020) / SHCal20 (Hogg et al., 2020) atmospheric curve. The change to a greater proportion of forest taxa identified in Whitney et al. (2014) occurs at 23.5 cm which provides a mean age of c. 1420 CE (min-max 1337-1511 CE).



SI Fig 5 – Canonical Correspondence Analysis (CCA) for fungal NPP taxa. Full CCA and Reduced (only statistically significant environmental variables) CCA with all Fungal NPP types displayed as codes (see SI Table 1).

SI Table 1 – Fungal NPP codes for identifications and ecology. ID relates to Plate 1 images in the manuscript. Genus level lifestyles and substrate are taken from *Table S1 – Traits of genera* in Põlme et al (2020). Where only family level identification is achieved the most common genus lifestyles and substrates are provided. NPP codes were extracted from the Non-Pollen Palynomorph Image Database (http://nonpollenpalynomorphs.tsu.ru). 'cf.' was applied in cases where fungal spores in this study are similar to but not exactly the same as database descriptions. Descriptions and a new lab codes (NUN) are provided for fungal NPPs without an NPP code.

ID	NPP Code	Taxa	Genus Level Lifestyle	Substrate
T1	KNG-62	cf. *Megalohypha aqua-dulces*	Wood saprotroph	Wood
T2	BAA-5; UKA16	cf. *Coprinus sensu lato*	Dung and litter saprotroph	Leaf/Fruit/Seed/ Dung
T3	HdV-113	cf. *Preussia-Sporormiella*	Dung and litter saprotroph	Leaf/Fruit/Seed/ Dung
T4	NUN-001	*Arthrinium*-type	Plant pathogen and foliar endophyte	Leaf/Fruit/Seed
T5	NUN-002	*Indet. Conidia*		
T6	NUN-003	*Paradendryphiopsis*-type	*Unspecified*	*Unspecified*
T7	NUN-004	cf. *Cacumisporium sigmoidum*	Wood saprotroph	Wood
T8	Type 810	*Trematosphaeria* cf. *alpestris*	Wood saprotroph	Wood
T9	HdV-359	*Bactrodesmium*-type	Wood saprotroph	Wood
T10	HdV-1052	*Xylariaceae* form 1	Wood and litter saprotroph	Wood/Leaf/Fruit/ Seed
T11	HdV-1052	*Xylariaceae* form 2	Wood and litter saprotroph	Wood/Leaf/Fruit/ Seed
T12	HdV-1018 A-B	*Spegazzinia* cf. *tessarthra*	Wood saprotroph	Wood
T13	HdV-359	*Bactrodesmium*-type	Wood saprotroph	Wood
T14	HdV-201	cf. *Xylomyces aquaticus*	Wood saprotroph	Wood
T15	EMA-38	cf. *Excipularia fusispora*		
T16	cf. HdV-51	*Sporidesmium*-type	Lichen and fungal parasite	Fungi and Algae
T17	cf. UG-1090	*Sporodesmium* cf. *submersum*	Lichen and fungal parasite	Fungi and Algae
T18	cf. EMA-2	*Taeniolella*-type	Lichen and fungal parasite	Fungi and Algae
T19	UG 1112	*Phaeosphaeria*-type	Wood saprotroph	Wood
T20	UG 1112	*Phaeosphaeria* sp.	Wood saprotroph	Wood
T21	cf. UG-1128	*Kretzschmaria* cf. *clavus*	Wood saprotroph and plant pathogen	Wood
T22	HdV-733	*Periconia* sp.	Plant pathogen and foliar endophyte	Leaf/Fruit/Seed
T23	NUN-005	*Brachydesmiella* sp.	*Unspecified*	*Unspecified*
T24	HdV 200	Bulbil		
T25	UKA-20	*Pithomyces*-type	Plant pathogen	Leaf/Fruit/Seed

T26	cf. TM-6; UAB-41B	*Delitschia didyma*	Litter saprotroph	Leaf/Fruit/Seed
T27	HdV-7A	*Chaetomium sp.*	Litter saprotroph and foliar endophyte	Wood/Leaf/Fruit/ Seed
T28	HdV-501	*Zopfiella lundquistii*	Dung saprotroph	Dung
T29	EMA-24	*Rosellinia* sp.	Plant pathogen and wood saprotroph	Wood
T30	HdV-261	*Arnium*-type	Dung saprotroph	Dung
T31	HdV-1029B	*Curvularia* cf. *lunata*	Plant pathogen and litter saprotroph	Wood/Leaf/Fruit/ Seed/Root/Algae
T32	HdV-1043	*Botryosphaeria* cf. *theobromae*	Plant pathogen and litter saprotroph	Leaf/Fruit/Seed
T33	cf. UB-7; UB-31	*Nigrospora* sp.	Litter saprotroph	Leaf/Fruit/Seed
T34	cf. HdV-4	*Anthostomella*-type	Foliar endophyte and litter saprotroph	Leaf/Fruit/Seed
T35	HdV-89	*Tetraploa* cf. *aristata*	Litter and wood saprotroph	Wood/Leaf/Fruit/ Seed
T36	HdV-1013	*Cercophora* sp.	Dung saprotroph	Dung
T37	NUN-006	*Asterina*-type	Epiphyte and litter saprotroph	Leaf/Fruit/Seed
T38	HdV-55	*Sordaria*-type form 1	Dung saprotroph	Dung
T39	HdV-55	*Sordaria*-type form 2	Dung saprotroph	Dung
T40	NUN-007	*Didymosphaeria*-type form 1	Plant pathogen and litter saprotroph	Leaf/Fruit/Seed
T41	NUN-008	*Didymosphaeria*-type form 2	Plant pathogen and litter saprotroph	Leaf/Fruit/Seed
T42	HdV-1052	Indet. Ascospore/Basidiospore		
T43	UG-1252	Indet. Ascospore		
T44	HdV-264	Indet. fungal spore 1		
T45	HdV-264	Indet. fungal spore 2		
T46	NUN-009	*Neurospora* cf. *pannonica*	Unspecified saprotroph	
T47	HdV-55C	*Neurospora* cf. *crassa*	Unspecified saprotroph	
T48	NUN-010	*Neurospora* cf. *cerealis*	Unspecified saprotroph	
T49	NUN-011	*Drechslera-Bipolaris*-type	Plant pathogen and litter saprotroph	Leaf/Fruit/Seed
T50	TM-F	*Trichocladium* cf. *asperum*	Unspecified saprotroph	
T51	NUN-012	*Monodictys*-type	Lichen and foliar parasite	Fungi and Algae
T52	NUN-013	*Vizella* sp.	Plant pathogen and litter saprotroph	Leaf/Fruit/Seed

NPP Descriptions - Here we describe fungal NPPs of uncertain affinity that do not match any existing NPP codes. New types are assigned the prefix NUN (Northumbria University Newcastle).

***Arthrinium*-type (NUN-001)**: Conidia solitary, frequently flattened and with a hyaline rim or germ slit, brown or dark brown, smooth as a rule, 0-septate, schizolytic. Measurement (T4) 17 x 22 µm.

Indet. Conidia (NUN-002): Conidia pyriform up to XX x XX microns, mid to dark brown, truncated at the base, smooth. Measurement (T5) 9 x 18 µm.

***Paradendryphiopsis*-type (NUN-003)**: Conidia 2-septate, pale brown, thin walled, more or less ellipsoidal, schizolytic. Measurement (T6) 8 x 19 µm.

cf. *Cacumisporium sigmoidum* (NUN-004): Conidia septate, end cells paler than the central ones, smooth, ellispsoidal, truncate at the base, with an acute apex. Measurement (T7) 16 x 42 µm.

***Brachydesmiella* sp. (NUN-005)**: Phragmo-conidia, Brown central cell, smaller (sub) hyaline polar cells, schizolytic. Measurement (T23) 13 x 32 µm.

***Asterina*-type (NUN-006)**: Ascospore bicelled, oblong, brown, constricted at the septum, rounded ends, smooth. Measurement (T37) 14 x 24 µm.

***Didymosphaeria*-type form 1/form 2 (NUN-007 / NUN-008)**: Ascospores 1-septate, cylindric-ellipsoidal, thick median septum, smooth. Ascospores in this family vary in size and ornamentation but are mostly 1 septate, brown and usually irregular in shape. Measurement (T40) 10 x 24 µm and (T41) 6 x 15 µm.

***Neurospora cf. pannonica* (NUN-009)**: Ascospores broadly ellipsoidal to subglobose, occasionally globose with longitudinal ribs. Single germ pore at each end. Measurements (T46) 25 x 30 µm.

***Neurospora cf. cerealis* (NUN-010)**: Ascospores broadly ellipsoidal, slightly apiculate at one end. Measurement (T48) 22 x 32 µm; walls with small circular pits up to 3 µm in diameter, one germ pore at each end.

***Drechslera-Bipolaris*-type (NUN-011)**: These genera belong to a species complex along with *Curvularia* and *Exserhilum*. *Bipolaris* has phragmo conidia, distoseptate, brown, single, shizolytic and same as *Dreschlera* differing in the war they germinate. Measurement (T49) 12 x 42 µm.

***Monodictys*-type (NUN-012)**: Dictyo-conidia, subspherical, globose, irregular, constricted at septa. Measurement (T51) 23 x 27 µm.

***Vizella* sp. (NUN-013)**: Ascospores brown, fusiform to ellipsoidal, one to two-celled, with a light transverse band at the upper cell, sometimes with a small hyaline to brown basal cell. Measurement (T52) 5 x 15 µm.