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Data on Sustainable palm fruit harvesting as a pathway to conserve Amazon peatland forests

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Supplementary Table 1. List of sampling sites evaluated in this study. Areas are only given for sites where the design of the plots and transects defined a specific sampling area.

River basin	Site	Code	Area (ha)	Total N° palms	% Female	Type	Travel time (hrs)	Harvesting technique	Sampling year
Amazonas	Dos de Mayo	DDM-1	2.9	200	4	Transect	5	Cutting	2019
Amazonas	Dos de Mayo	DDM-2	4.6	213	10	Transect	5	Cutting	2019
Amazonas	Dos de Mayo	DDM-3	2.3	218	8	Transect	6	Cutting	2019
Amazonas	San Jorge	SJOR-1	1.8	200	11	Transect	5	Cutting	2019
Amazonas	San Jorge	SJOR-2	2.7	200	18	Transect	5	Cutting	2019
Corrientes	Cuchara	CRA-01	N.A.	210	55	Transect	30	Cutting	2020
Corrientes	Cuchara	CRA-02	N.A.	204	50	Transect	31	Cutting	2020
Corrientes	Puerto Oriente	POR-01	N.A.	210	37	Transect	26	Cutting	2020
Corrientes	San Carlos	SCA-01	N.A.	210	47	Transect	25	Cutting	2020
Itaya	Limón	LIM-1	3.7	200	14	Transect	9	Cutting	2019
Itaya	Limón	LIM-2	1.9	200	35	Transect	12	Cutting	2019

River basin	Site	Code	Area (ha)	Total N° palms	% Female	Type	Travel time (hrs)	Harvesting technique	Sampling year
Itaya	Limón	LIM-3	1.9	200	25	Transect	11	Cutting	2019
Itaya	Puerto Alegría	PTA-1	2.3	200	52	Transect	3	Climbing	2019
Itaya	Puerto Alegría	PTA-2	3.3	200	52	Transect	4	Climbing	2019
Itaya	Las Brisas	QCH-1	3.7	200	20	Transect	4	Cutting	2019
Itaya	Las Brisas	QCH-2	1.9	200	3	Transect	4	Cutting	2019
Itaya	Las Brisas	QCH-3	1.9	200	20	Transect	4	Cutting	2019
Marañón	Cuninico	CUN-1	3.8	224	10	Transect	24	Cutting	2019
Marañón	Cuninico	CUN-2	2	200	17	Transect	26	Cutting	2019
Marañón	IDP	IDP-1	0.36	66	35	Plot	31	Cutting	2018
Marañón	IDP	IDP-2	0.36	32	38	Plot	33	Cutting	2018
Marañón	N.MIL	N. MIL-1	0.54	85	46	Plot	47	Cutting	2018
Marañón	N.MIL	N. MIL-2	0.54	66	39	Plot	46	Cutting	2018
Marañón	N.MIL	N. MIL-3	0.54	64	23	Plot	47	Cutting	2018

River basin	Site	Code	Area (ha)	Total N° palms	% Female	Type	Travel time (hrs)	Harvesting technique	Sampling year
Marañón	Nuevo Pandora	NPA-01	0.5	89	42	Plot	33	Cutting	2019
Marañón	Nuevo Pandora	NPA-02	0.5	51	37	Plot	33	Cutting	2019
Marañón	Ollanta	OLLN	N.A.	100	31	Transect	25	Cutting	2019
Marañón	P.DIAZ	P. DIAZ-1	0.54	152	37	Plot	37	Cutting	2018
Marañón	P.DIAZ	P. DIAZ-2	0.54	126	43	Plot	38	Cutting	2018
Marañón	P.DIAZ	P. DIAZ-3	0.54	194	43	Plot	38	Cutting	2018
Marañón	P.LIM	P. LIM-1	0.54	83	40	Plot	43	Cutting	2018
Marañón	P.LIM	P. LIM-2	0.54	26	42	Plot	43	Cutting	2018
Marañón	P.LIM	P. LIM-3	0.36	63	43	Plot	42	Cutting	2018
Marañón	P.IND	P.IND-1	0.72	103	26	Plot	37	Cutting	2018
Marañón	P.IND	P.IND-2	0.36	65	48	Plot	36	Cutting	2018
Marañón	Nuevo Pandora	PAND-1	N.A.	200	52	Transect	33	Cutting	2019
Marañón	Nuevo Pandora	PAND-2	N.A.	100	46	Transect	33	Cutting	2019

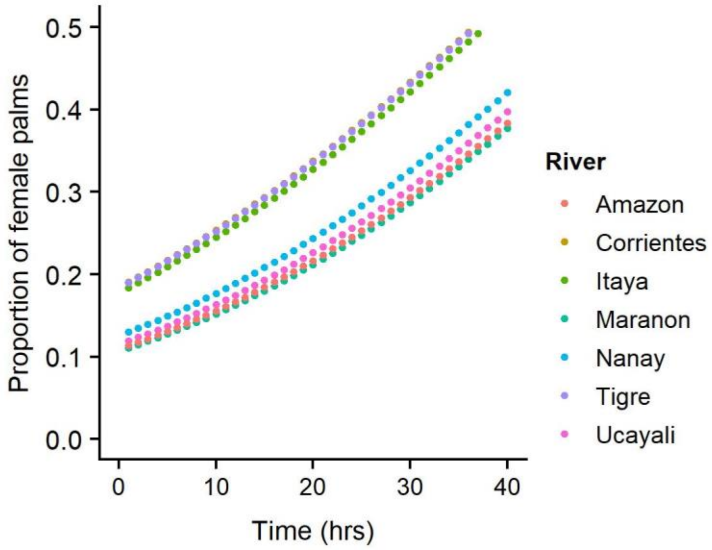
River basin	Site	Code	Area (ha)	Total N° palms	% Female	Type	Travel time (hrs)	Harvesting technique	Sampling year
Marañón	Parinari	PARN	0.69	101	24	Transect	17	Climbing	2017
Marañón	Parinari	PRN-01	0.5	89	25	Plot	17	Climbing	2017
Marañón	S.ANA	S. ANA-1	0.54	124	27	Plot	37	Cutting	2018
Marañón	S.ANA	S. ANA-2	0.36	84	25	Plot	38	Cutting	2018
Marañón	S.ANA	S. ANA-3	0.54	124	38	Plot	38	Cutting	2018
Marañón	Bolivar	SAMI	N.A.	100	33	Transect	28	Climbing	2017
Marañón	Bolivar	SAM-01	0.5	84	46	Plot	28	Climbing	2017
Marañón	San Antonio	SAN-1	4.6	200	11	Transect	24	Cutting	2019
Marañón	San Antonio	SAN-2	4.4	200	19	Transect	24	Cutting	2019
Marañón	Saramuro	SAR-1	3.7	200	11	Transect	23	Cutting	2019
Marañón	Saramuro	SAR-2	3.2	200	22	Transect	24	Cutting	2019
Marañón	Veinte de enero	VEN-01	0.5	54	17	Plot	12	Climbing	2017
Marañón	Veinte de enero	VEN-02	0.5	69	29	Plot	12	Climbing	2017

River basin	Site	Code	Area (ha)	Total N° palms	% Female	Type	Travel time (hrs)	Harvesting technique	Sampling year
Marañón	Veinte de enero	VEN-03	0.5	41	12	Plot	12	Climbing	2017
Marañón	Veinte de enero	VEN-04	0.5	29	31	Plot	13	Climbing	2017
Marañón	Veinte de enero	VEN-05	0.5	37	43	Plot	13	Climbing	2017
Marañón	Veinte de enero	VEN-1b	N.A.	100	44	Transect	12	Climbing	2019
Marañón	Veinte de enero	VEN-2b	N.A.	104	40	Transect	12	Climbing	2019
Marañón	Veinte de enero	VEN-7b	N.A.	100	28	Transect	20	Climbing	2019
Marañón	Veinte de enero	VEN-8b	N.A.	100	49	Transect	14	Climbing	2019
Marañón	Veinte de enero	VEN-9b	N.A.	102	49	Transect	14	Climbing	2019
Nanay	Mishana	MSH-1	3.2	200	19	Transect	13	Climbing	2019
Nanay	Mishana	MSH-2	3.3	200	21	Transect	13	Climbing	2019
Nanay	San Juan	SJR-1	3.7	200	24	Transect	18	Cutting	2019
Nanay	San Juan	SJR-2	3.5	200	32	Transect	18	Cutting	2019
Tigre	Malvinas	AUCA	N.A.	100	26	Transect	20	Cutting	2019

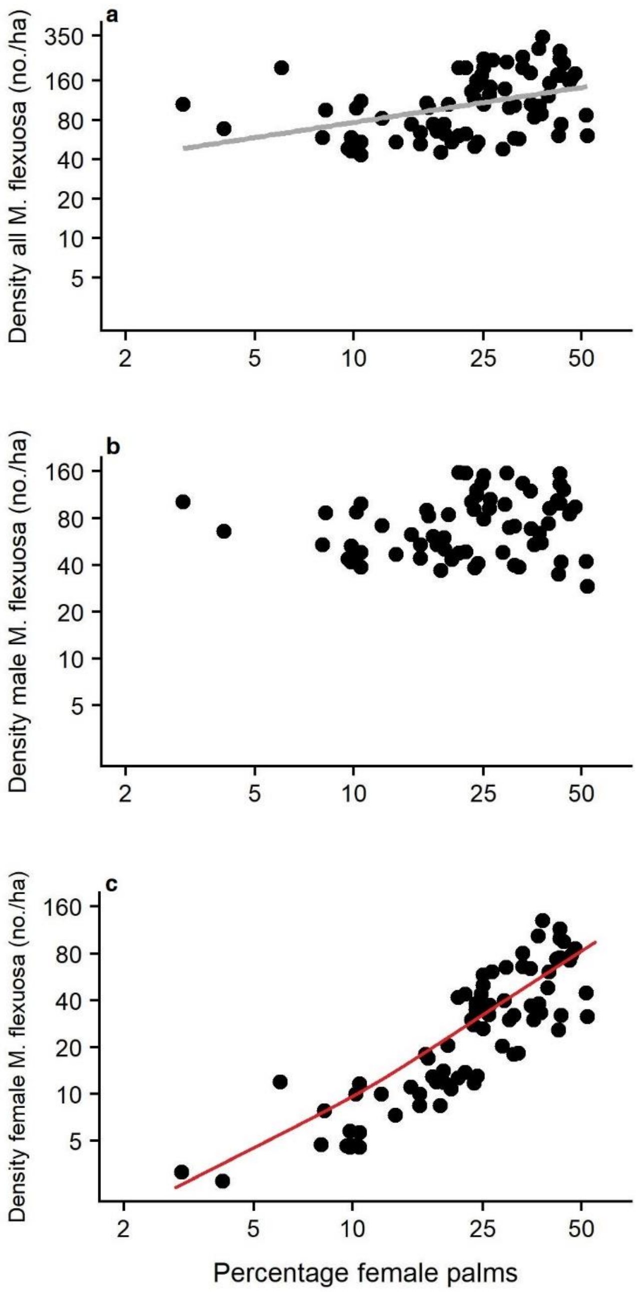
River basin	Site	Code	Area (ha)	Total N° palms	% Female	Type	Travel time (hrs)	Harvesting technique	Sampling year
Tigre	Malvinas	MAL-01	N.A.	210	20	Transect	19	Cutting	2019
Tigre	Cristo Rey	CRB-01	N.A.	210	38	Transect	19	Cutting	2020
Tigre	Florida	FLO-01	N.A.	210	48	Transect	23	Cutting	2020
Tigre	Monte Verde	MOV-01	N.A.	210	39	Transect	17	Cutting	2020
Tigre	Monte Verde	MOV-02	N.A.	210	51	Transect	17	Cutting	2020
Tigre	Nueva York	NYK-1	4.3	208	10	Transect	16	Cutting	2019
Tigre	Nueva York	NYK-2	3.3	200	43	Transect	15	Cutting	2019
Tigre	Piura	PIUR	N.A.	102	29	Transect	18	Cutting	2017
Tigre	Piura	PIU-02	0.5	49	10	Plot	18	Cutting	2017
Tigre	Sanango	SAN-01	N.A.	210	48	Transect	24	Cutting	2020
Ucayali	Capitán Clavero	CLA-01	0.5	33	18	Plot	11	Cutting	2019
Ucayali	Capitán Clavero	CLAV-1	3.7	200	14	Transect	11	Cutting	2019
Ucayali	Capitán Clavero	CLAV-2	3.8	200	14	Transect	11	Cutting	2019

River basin	Site	Code	Area (ha)	Total N° palms	% Female	Type	Travel time (hrs)	Harvesting technique	Sampling year
Ucayali	Jenaro Herrera	CAPT	N.A.	100	25	Transect	14	Cutting	2008 – 2009
Ucayali	Jenaro Herrera	IRIC-1	N.A.	100	33	Transect	14	Cutting	2008 – 2009
Ucayali	Jenaro Herrera	IRIC-2	N.A.	105	24	Transect	14	Cutting	2017
Ucayali	Jenaro Herrera	JEN-14	0.5	42	36	Plot	14	Cutting	2017
Ucayali	Jenaro Herrera	JEN-15	0.5	37	19	Plot	12	Climbing	2017
Ucayali	Jenaro Herrera	JEN-15b	N.A.	110	26	Transect	12	Cutting	2017
Ucayali	Jenaro Herrera	JEN-21	0.5	32	16	Plot	14	Cutting	2019
Ucayali	Jenaro Herrera	REQ-1	N.A.	100	21	Transect	13	Cutting	2008 – 2009
Ucayali	Jenaro Herrera	Req-13b	4.3	200	10	Transect	13	Cutting	2019
Ucayali	Jenaro Herrera	REQ-4	N.A.	100	6	Transect	14	Cutting	2008 – 2009
Ucayali	Jenaro Herrera	REQ-5	N.A.	100	21	Transect	13	Cutting	2008 – 2009
Ucayali	Jenaro Herrera	SAPN	N.A.	100	22	Transect	12	Cutting	2008 – 2009
Ucayali	Puerto Miguel	PMI-01	0.5	66	23	Plot	9	Cutting	2019

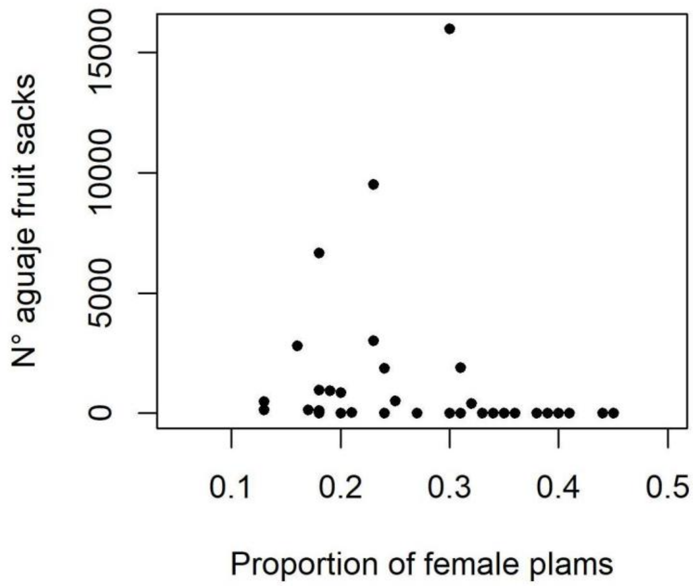
River basin	Site	Code	Area (ha)	Total N° palms	% Female	Type	Travel time (hrs)	Harvesting technique	Sampling year
Ucayali	Puerto Miguel	PMI-02	0.5	50	30	Plot	9	Cutting	2019
Ucayali	Puerto Miguel	PMIG-1	2.7	200	15	Transect	9	Cutting	2019
Ucayali	Puerto Miguel	PMIG-2	4	200	24	Transect	9	Cutting	2019
Ucayali	Pumacahua	PUMA	3.4	200	8	Transect	13	Cutting	2019



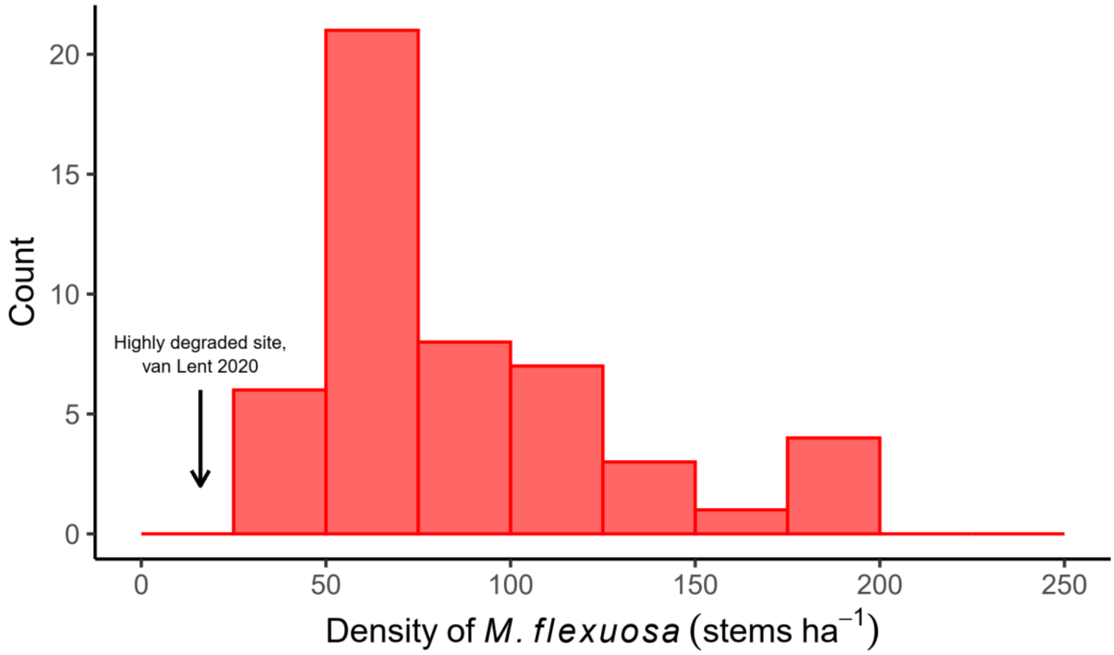
Supplementary Figure 1. Variation among river basins in the relationship between travel time to Iquitos and the proportion of female palms of *M. flexuosa*. These relationships were estimated from the random effect for river basins in the mixed model that predicts variation in the proportion of female palms as a function of distance to Iquitos and harvesting technique (see main text). The variation among river basins is likely due to transport capacity: small rivers with less frequent transport (Tigre, Itaya, Corrientes) have stands in better condition for a given distance from Iquitos than rivers with more frequent transport (Amazon, Marañón and Ucayali).



Supplementary Figure 2. Relationship between the percentage of female palms across all the sampling sites and (**a**) the density of adult palms of *M. flexuosa*, (**b**) the density of male palms and (**c**) the density of female palms. Overall, the density of *M. flexuosa* declines as the proportion of females drops (grey line in panel **a**), but the density of male palms remains constant. These patterns illustrate that strict selective harvesting of female palms occurs within these stands. The red line in panel (**c**) shows the predicted relationship between the proportion of female palms if the density of males remains constant whilst the proportion of female trees declines. The predicted trend closely fits the observed relationship in the data. Note the use of a log scale for the x-axis to linearise these relationships.



Supplementary Figure 3. Relationship between the number of sacks of fruit of *M. flexuosa* supplied to Iquitos in 2012/13 by different communities[1] and the average proportion of female palms in palm swamps associated with each community in the study area. We assumed that communities where we had data on the proportion of female palms, but were not included in (1), did not supply fruit to Iquitos in 2012/13. Overall, among communities, the volume of fruit supplied to Iquitos in 2012/13 is associated with the average proportion of females in nearby palm swamps (Spearman rank correlation; $p<0.001$).



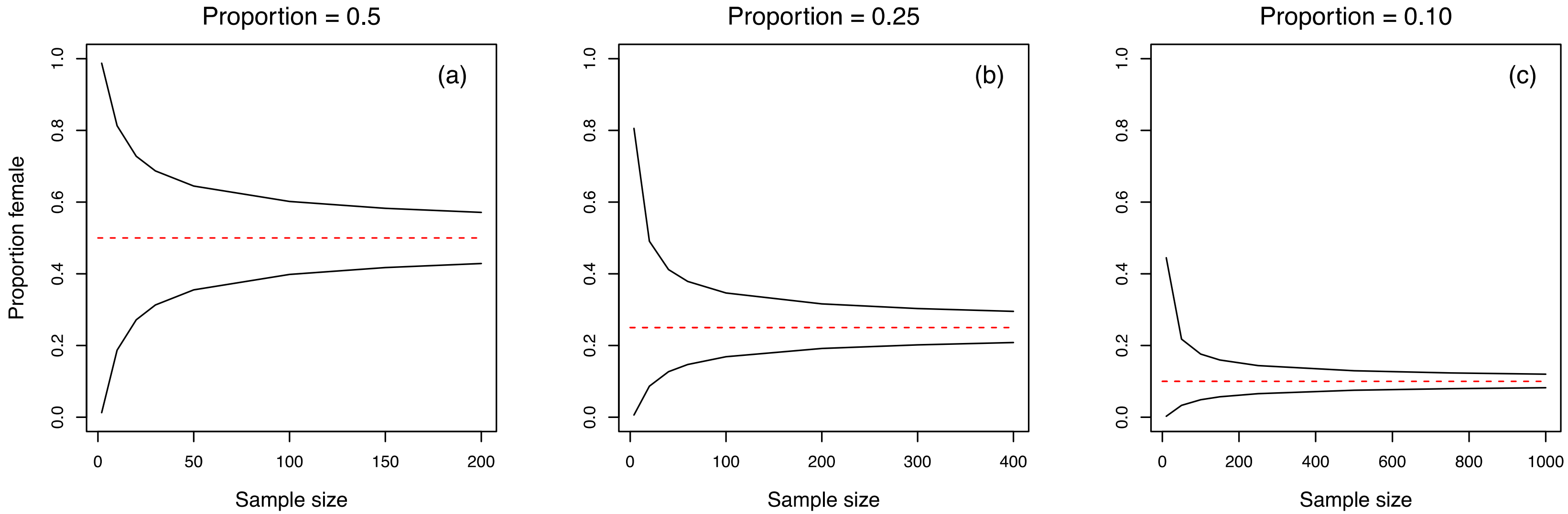
Supplementary Figure 4. Density of *M. flexuosa* palms across all sites in our dataset. Our data include stands with current and historical harvesting and also where there is little or no record of previous extraction activities. The stem density of *M. flexuosa* of all our sites is higher that the stem density of *M. flexuosa* (16 stems ha^{-1}) in the highly degraded stand sampled by (2) that found a net carbon source from the peat of -7.1 ± 1.4 Mg C ha^{-1} a^{-1} due to high levels of heterotrophic respiration.

Source: this study.

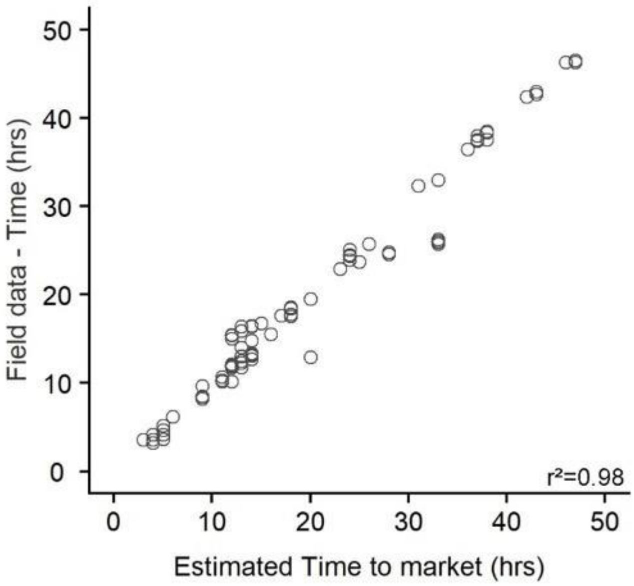
Supplementary Figure 5. Illustration of sex determination in the field and the sale of *M. flexuosa* fruit and products. Floral organs of aguaje: **a** female and **b** male reproductive structures. Commercialisation of aguaje: panel **c** shows how the fruit are collected and transported from the forest to the market: each sack (35-40 kg) constitutes the unit of sale of aguaje, panel **d:** the different methods of consuming and using aguaje as a fruit or in processed products (oil, jam or soap).

Source: this study

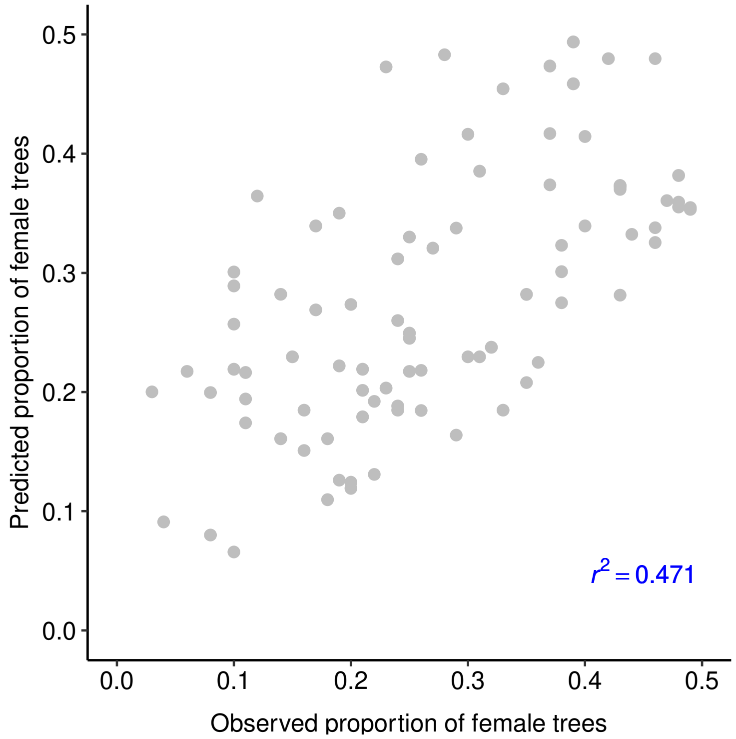
Supplementary Figure 6. Techniques used for harvesting of *M. flexuosa* fruit in the northern Peruvian Amazon. **Panels a, b:** cutting down the palm tree, which is the commonest method of fruit extraction. **Panel c**: climbing the tree using ropes and harness.



Supplementary Figure 7. Uncertainty associated with variation in the sample size for estimating the proportion of *M. flexuosa* palms in forests that have been degraded to differing extents. Confidence limits (black solid lines) illustrate how variation in the number of palm trees affects the confidence in the estimate of the proportion of females in the sample. (a) Variation in the confidence limit with sample size for a population with 50% male and 50% female palms; (b) variation in the confidence limit with sample size for a population with 25% female palms; (c) variation in the confidence limit with sample size for a population with 10% female palms. The dashed red lines represent the proportion of females at 50%, 25% and 10% respectively whilst the black lines represent the upper and lower 95% confidence limits of the estimate. Samples of 200 trees provide a reasonable level of confidence for all degrees of degradation.



Supplementary Figure 8. Relationship between travel time to market recorded in the fieldwork and the estimated time values for the pixels. The strong relationship (r^2=0.98) supports the use of modelled travel times to estimate the proportion of females across the study area.



Supplementary Figure 9. Comparison of predicted and observed values of the proportion of female trees at each sample site, following k-fold cross-validation analysis (k = 5) of the mixed model. The predicted values for each site were generated using parameters for the impact of travel time, harvesting technique, community and river basin on the proportion of female trees estimated using 80 % of the remaining data and the same mixed model structure as in the original analysis. Overall, the significant relationship ($p<0.001$) between predicted and observed values demonstrates that the outcome of the statistical model was not strongly influenced by a small number of data points and can be used to extrapolate across the region of interest.

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