Methods

Supplementary Figure 1 Names and locations of 60 protected areas stratified across the African, American and Asia-Pacific tropics.



Representativeness of study sites

Our 60 tropical protected areas spanned 36 different nations. To provide an indication of the degree to which our sites were 'typical', we compared the relative frequency of reserves within 'high-protection' (IUCN Categories I-IV), 'multiple-use' (IUCN Categories V-VI), and unclassified categories between our sample and all 16,038 protected areas within the same nations from the World Database on Protected Areas (www.wdpa.org). We excluded China from this comparison because its reserve-classification scheme differs from that of other nations in having virtually no high-protection reserves; the ratio of multiple-use to high-protection reserves in China was 628.3, whereas ratios for all the other 35 nations were < 3.4. We found no significant difference in the frequencies of reserves in the three different categories between our sample and expected values derived from all 16,038 reserves in the same nations ($G_{adj} = 4.056$, d.f. = 2, P = 0.13; *G*-test for goodness-of-fit, with Williams' correction for sample size) (Supplementary Fig. 2). Other kinds of data, such as the budgets and staffing for protected areas, were unavailable for most sites, precluding more in-depth comparisons of this nature.

Supplementary Figure 2 Number of high-protection (IUCN Categories I-IV), multiple-use (Categories V-VI) and unclassified protected areas in our study compared to expected values derived from all 16,038 protected areas in the same tropical nations.



Reserve isolation

We also assessed the relative geographical isolation of the protected areas in our study, as measured by their distance to the nearest city. We did so because reserve isolation might influence the human pressures that a reserve experiences, and we wished to know whether our reserves were more or less isolated from nearby human populations than is typical of other reserves in the same nations.

For each of our 60 protected areas, we overlaid its boundary map onto a mapped surface of travel-time accessibility¹. This surface estimates, for any point on Earth, the mean travel time in minutes required to reach the nearest city of > 50,000 residents, using conventional local

means such as automobiles, boats and hiking. The surface has a spatial resolution of 0.0083 decimal degrees (925 m at the equator), and we averaged the measurements for every pixel within each reserve to estimate its average isolation.

We then randomly selected 60 reserves for comparison. We stratified the randomly selected reserves across the same 36 nations in which our protected areas occur (choosing for each nation an equal number of random reserves as that found in our original sample). The randomly selected reserves were chosen from the World Database on Protected Areas (<u>www.wdpa.org</u>), using a Mersenne Twist random number generator with a random seed value. Marine protected areas were excluded from the random sample by considering only reserves whose centre-most point fell on land.

We found considerable overlap between the isolation of our reserves (mean \pm SD = 741 \pm 761 minutes to the nearest city) and the randomly selected reserves (505 \pm 479 minutes) (Supplementary Fig. 3). The isolation values did not differ significantly on average, either when using a Mann-Whitney *U*-test (*P* = 0.071) or a two-way ANOVA that contrasted log-transformed isolation values between our sample and the random sites and also among the three major tropical regions (Africa, Americas, Asia-Pacific). This latter analysis revealed no significant difference between our reserves and the random sites (*F*_{1,114} = 3.19, *P* = 0.077), but some difference among the three major regions (*F*_{2,114} = 3.33, *P* = 0.039). In pairwise comparisons, reserves in Africa were more isolated (*P* < 0.05; Tukey's test) than those in the Asia-Pacific, with reserves in the Americas being intermediate and not significantly different from those in the other two regions.

Supplementary Figure 3 Comparison of the relative isolation (travelling time to the nearest city of > 50,000 residents) between the 60 tropical forest protected areas in our study and a random sample of 60 protected areas stratified across the same 36 nations.



Design of interviews

We initially tested whether we could use research publications to assess the knowledge-base at our research sites, using two of the best-studied sites in the tropics, Barro Colorado Island in Panama and La Selva Biological Station in Costa Rica. Despite perusing the entire publication lists for both sites (up to early 2008), we found that recognized experts provided more comprehensive, up-to-date and time-efficient assessments. Moreover, the number of available refereed publications varied enormously among our 60 selected sites, from just 10 to > 3,300 papers. A reliance solely on publications would have imparted an obvious sampling bias when attempting to compare different sites, whereas experts are able to integrate a much wider range of knowledge based on personal observations, communications with other researchers and critically evaluating the relevant technical literature for their site.

Our 10-page interview form, coupled with a telephone or face-to-face interview, allowed us to plumb in detail the accumulated knowledge of our long-term experts. The form (attached below as Appendix 1) includes 120 individual questions, 60 of which have five-part answers. We carefully designed our interview form after consulting the relevant survey-method literature²⁻⁵ and with social-science experts who routinely conduct such surveys. Two of the most important potential biases to avoid are (a) diluting high-confidence responses with low-confidence responses, and (b) interviewing 'clusters' of closely affiliated, like-minded experts^{2,3}. To minimize the first concern, we asked our experts to rank their level of confidence for each question they were asked ('speculative', 'good', 'high'). We discarded all speculative responses prior to analysis. To minimize the second concern, we used both technical publications and communications with an array of different individuals to identify our experts. These experts were predominantly ecologists, zoologists, and botanists with long-term field and empirical datacollection experience in their respective protected area.

Another concern in surveys such as ours is that respondents might provide biased responses either because they fear political or professional retribution^{2,3} or are personally invested in seeing the protected area succeed⁴. To minimize this concern, we offered all respondents complete anonymity, should they wish. We established the following conditions: if an outside party wishes to communicate with an expert for a particular reserve, they should contact the lead author of this study (William Laurance, email: bill.laurance@jcu.edu.au) who will then forward the request to the relevant expert. That expert can then either respond or ignore the request at their discretion. In practice, anonymity was not a concern for most of our experts, all of whom were offered, and most of whom accepted, co-authorship of this study (however, to err on the side of caution, none is explicitly associated with any particularly protected area in this study). We also considered and rejected the notion that these experts might have provided overly positive responses because they wanted to see the reserve succeed. In practice, many respondents (virtually all of whom were independent researchers, not park employees) expressed at least some concerns about the condition of their reserve. Further, our interview protocol was so exhaustive, specific and objective (with both written and verbal components and interviews of 4-5 different researchers per reserve) that it would have been difficult for any individual to obfuscate important changes in the reserve.

A final concern we had was whether 4-5 interviews were sufficient to identify the key trends at our different sites. To test this we conducted a 'saturation analysis'⁵, which is designed to determine how much new information is being provided by each additional interview (Supplementary Fig. 4). First, we arbitrarily selected four of our response variables that varied widely. Second, for each of our 21 reserves for which we had 5 interviews, we pooled the

interview data to generate mean scores for each variable. Third, we compared the mean score across these reserves from 1, 2, 3, and then 4 interviews to those generated by 5 interviews, using linear regression. As shown by the rapid and nonlinear rise in R^2 for each variable, the mean scores for each reserve rapidly converge on the final values after just 2-4 interviews. We conclude from this assessment that our regime of 4-5 interviews per site was sufficient to capture the most important aspects of available expert knowledge.

Supplementary Figure 4 Saturation curves for four representative response variables, compared to values achieved with randomly generated data.



Statistical analyses

For ease of interpretation, we devised a robust and relatively simple statistical approach to assess temporal changes in each guild and potential environmental driver. We illustrate our strategy using the abundance of a single guild, apex predators, as an example. For each reserve, each expert was asked to indicate whether the overall abundance of apex predators had declined by at least 10-25%, remained roughly stable, or increased by at least 10-25%, over the past 20-30 years. These responses were scored as -1, 0, and 1, respectively^A. If an expert had no knowledge

^A We originally collected quantitative data on each guild or environmental driver, using an ordinal scale (-3 = decline of > 50%; -2 = decline of 25-50%; -1 = decline of 10-25%; 0 = no change; 1 = increase of 10-25%; 2 = increase of 25-50%; 3 = increase of > 50%). However, we elected to simplify these data into a three-point scale (+1, 0, -1) because the validity of means and standard deviations derived from ordinal data has been questioned⁶ and because the three-point and ordinal scales yielded virtually identical results. For example, calculated effect sizes for our guilds (using the 27 guilds with adequate sample sizes; Supplementary Table 2) based on the three-point and ordinal scales were strongly, positively and linearly related ($F_{1,25}$ = 744.5, R^2 = 96.8%, P < 0.00001; least-squares regression analysis).

for this particular variable or indicated that their view was speculative, their response was discarded. Among the experts with good or high confidence, we combined scores to generate a mean value (ranging from -1.0 to 1.0) to estimate the long-term trend in abundance of apex predators at their study site.

The means for all 60 sites were then pooled into a single data distribution (Supplementary Fig. 5). We used bootstrapping (random resampling with replacement; 100,000 iterations) to generate confidence intervals for the overall mean of the data distribution. If the confidence intervals for the mean did not overlap zero, we then interpreted the trend as non-random. Because we tested a number of different guilds, we used a stringent Bonferroni correction (P = 0.0056) to reduce the likelihood of Type I statistical errors. Given that our study has important implications for nature conservation, we also identify guilds that would have shown non-random trends ($P \le 0.05$) had we tested them individually.

Supplementary Figure 5 Example of a data distribution for 60 tropical protected areas (arbitrarily divided into increments of 0.4), for plotting changes in the abundance of apex predators. The horizontal black line shows the 95% confidence interval for the mean value, and the *P* indicates the probability of a non-random deviation from zero.



We also assessed effect sizes for changes in guild abundances (Supplementary Table 2) by estimating the mean value for each guild (from bootstrapping), and then dividing this by the standard deviation of that guild. With this procedure, negative values indicate a decline in guild abundance, and positive values an increase. We used a similar procedure to identify changes in our potential environmental driver variables inside (Supplementary Table 3) and outside (Supplementary Table 4) protected areas.

Our reserve-protection index provided a simple assessment of the degree to which practical, on-the-ground enforcement measures—resulting broadly from the number of park guards and their associated infrastructure, vehicles, supporting legal framework, and level of professional motivation—had changed over the past 20-30 years inside the protected area. Each researcher was asked whether the level of actual protection in their reserve had improved, remained constant, or declined over time (scored as +1, 0, and -1, respectively), and the mean value was calculated for each reserve.

We relied on bivariate tests to assess relationships between potential environmental drivers and our reserve-health index. Multivariate analyses were not possible because, for some reserves, data were unavailable for some response variables and drivers. These missing values varied among the reserves, making it impossible to create a complete matrix of drivers and response variables needed for multivariate analyses. We used Spearman rank correlations (with Bonferroni corrections to limit the likelihood of spurious correlations, using a recommended experiment-wise error rate of 0.15 in all cases⁷) to identify potential relationships between the drivers and reserve health, and general linear models to test the efficacy of predictors. We evaluated our general linear models using Akaike's information criterion corrected for finite samples (AIC_c), an information-theoretic index of bias-corrected model weight⁸. We assessed each model's probability using AIC_c weights (wAIC_c); the closer to 1, the stronger the relative evidence for that model. The percent deviance explained (%DE) measures the models' structural goodness-of-fit. The evidence ratio (ER) is the ratio of the wAIC_c for each model over its null (intercept-only model); models with higher ER values have greater support relative to the null.

Validation of interview data

We explored several strategies for independently testing our interview data. For example, we repeatedly attempted to access time-series data on the abundances of selected vertebrate species being compiled for the Living Planet Index (<u>http://en.wikipedia.org/wiki/Living_Planet_Index</u>), an initiative of WWF and the Zoological Society of London. However, the datasets in this index, at least for the 60 protected areas in our study, are currently too sparse and preliminary to provide a sound basis for comparison (B. Collen, pers. comm.). We also explored data on investments in the management of Amazonian protected areas, but found little usable overlap with our study sites (C. A. Peres, pers. comm.). We did find more overlap between our study sites and a pantropical assessment of fire incidence in and around protected areas⁹, but this study provided only a single estimate of fire frequency, not a time series, and so could not be used to test the trend data from our investigation.

We finally elected to do an extensive meta-analysis of available time-series studies, using data from published or in-press research articles, refereed book chapters, and technical research reports. We established four *a priori* criteria to include studies. They had to (1) focus on one of the 60 protected areas in our study, (2) yield clearly interpretable data on one of the guilds or potential driver variables we evaluated, (3) provide a time-series of measurements that overlapped at least partially with our study period (the last 20-30 years), and (4) have been published recently, ideally after 2009. This final criterion was designed to limit the exposure of our experts to the scientific work in question (about 85% of our interviews were conducted between mid 2008 and late 2009), thereby providing a more independent test of our findings. We used several strategies, including the internet, searches of our own extensive technical-literature databases¹⁰, consultation with other relevant experts, and personal knowledge, to identify potentially suitable time-series.

We identified 59 independent datasets that met our four selection criteria and provided a direct basis for comparison with our interviews (Supplementary Table 1). These studies used a variety of repeated-sampling approaches, such as mark-recapture studies, track counts, automatic-camera censuses, plot-based monitoring, and remote sensing, to assess temporal changes in their response variables. The datasets, which span 27 different protected areas, are approximately evenly distributed across the three major tropical regions (21 in Africa, 20 in the Americas, 16 in the Asia-Pacific). Nearly half of these studies (28 of 59) focused on one of six well-studied guilds (primates, large non-predatory vertebrates, top predators) or potential driver variables (forest cover inside reserves, forest cover outside reserves, hunting inside reserves), but the remainder were diverse in nature. Altogether, 15 guilds and 13 driver variables were represented by at least one independent dataset.

To provide a direct basis for comparison with our study, we used a simple three-way system (increase, no significant change, decrease) to classify the trend in each independent dataset, following the conclusions of the original researchers. Using this approach, the null hypothesis is that one third of the 59 independent datasets would agree with the trends in our interview data, based simply on chance. We found, however, that the independent datasets agreed with our findings in 51 of the 59 comparisons (86.4%). This number is strikingly higher than that from random expectation ($G_{adj} = 36.50$, d.f. = 1, P < 0.0001; *G*-test for goodness of fit, adjusted for sample size).

In assessing the eight datasets that disagreed with our findings (Supplementary Table 1), we discerned only one obvious pattern: four described trends that occurred recently, and thus might not have been known to the experts we interviewed, or were regarded as not being representative of longer-term trends. For example, one involved recent chytrid-fungus-related declines of stream-dwelling amphibians at Manu National Park in Peru¹¹ that were detected only in 2009. Two others resulted from recent (2005-2009) efforts to improve protection of Lope Reserve, Gabon, which have led to a recent increase there in the abundance of elephants and other large non-predatory vertebrates¹².

Notably, none of the eight disagreements was fundamental in nature—our experts never reported a trend *opposite* to that shown by the independent test. For example, in Budongo Forest, Uganda, our experts collectively indicated that primate abundance had increased somewhat over the last 2-3 decades, whereas standardized field-monitoring data (35 transects of 2 km in length that were repeatedly censused from 1992-2009) revealed that individual species abundances varied considerably over time, with no clear trend in overall abundance¹³. Similarly, our experts reported that ambient temperature had increased over time at Los Tuxtlas Biosphere Reserve in Mexico, whereas an independent analysis based on long-term records (1925-2006) from 24 nearby meteorological stations revealed just a slight rise in mean temperature (0.016° C per decade) that was not statistically significant¹⁴.

Overall, these validation tests give us considerable confidence in the efficacy of our interview data (see refs. 15-17 for relevant discussions). The available comparisons do not span all of the protected areas, guilds, or potential driver variables we assessed evenly, but this simply illustrates the highly sparse and patchy nature of suitable time-series analyses. Indeed, the 59 datasets we compiled after extensive efforts represent just a tiny fraction (1.6%) of the 3,589 assessments of trends in guilds and potential drivers captured by our interview data (our interviews provided 1,262 assessments of guild trends and 2,327 assessments of trends in environmental drivers, across our network of 60 protected areas). It was precisely this deficit that prompted us to undertake this interview-based investigation, to provide a much more systematic

and far-reaching comparison of the fate of tropical protected areas than has previously been possible.

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Supplementary Table 1. Independent tests of identified trends in guild abundances and potential environmental drivers from expert interviews, using available time-series data from scientific publications and technical reports. For each test, we indicate whether or not the independent data validated the overall trend identified by our expert interviews. 'Time interval' indicates the span of years covered by each empirical dataset. References for each test are listed below.

No.	Protected area	Region	Guild or driver	Trend	Time	Reference
			trend based on	validated?	interval	
			interviews			
1	Budongo	Africa	Primates increased in	No	1992-	1
			abundance		2009	
2	Bwindi	Africa	Harvests of NTFPs	Yes	1991-	2
			declined inside park		2003	
3	Kakamega	Africa	Primates increased in	Yes	1997-	3, 4
			abundance		2010	
4	Kakamega	Africa	Understory birds	Yes	1912-	5
			declined in		2003	
			abundance			
5	Kakamega	Africa	Forest cover declined	Yes	1912-	5
			inside reserve		2003	
6	Kahuzi-Biega	Africa	Primates declined in	Yes	1978-	6
			abundance		2004	
7	Kibale	Africa	Primates declined in	No	1975-	7
			abundance		2006	
8	Kibale	Africa	Ambient temperature	Yes	1975-	8
			increased inside		2006	
			reserve			
9	Kibale	Africa	Rainfall increased	Yes	1900-	8
			inside reserve		2006	
10	Kilum-Ijim	Africa	Large-seeded old-	Yes	1998-	9
			growth trees declined		2006	
			in abundance			
11	Kilum-Ijim	Africa	Harvests of NTFPs	Yes	1998-	9
			increased inside		2006	
			reserve			
12	Lope	Africa	Large non-predatory	No	2005-	10
			vertebrates declined		2009	
13	Lope	Africa	Hunting increased	No	2005-	10
			inside reserve		2009	
14	Nouabale-Ndoki	Africa	Large non-predatory	Yes	2006-	11
			vertebrates declined		2011	
15	Nouable-Ndoki	Africa	Hunting increased	Yes	2006-	11
			inside reserve		2011	

16	Nouable-Ndoki	Africa	Hunting increased outside reserve	Yes	2006- 2011	12
17	Ngungwe	Africa	Human populations increased outside reserve	Yes	1991- 2007	13
18	Okapi	Africa	Large non-predatory vertebrates declined in abundance	Yes	1995- 2006	14
19	Udzungwa	Africa	Primates increased in abundance	No	2004- 2009	15
20	Udzungwa	Africa	Pioneer/generalist trees were stable in abundance	Yes	1986- 2007	16
21	Udzungwa	Africa	Large-seeded old- growth trees were stable in abundance	Yes	1986- 2007	17
22	Udzungwa	Africa	Forest cover remained stable inside the reserve	Yes	1983- 2009	17
23	Udzungwa	Africa	Forest cover declined outside reserve	Yes	1983- 2009	17
24	Barro Colorado Island	Americas	Lianas increased in abundance	Yes	1995- 2007	18
25	Brownsberg	Americas	Illegal mining increased inside reserve	Yes	1971- 2005	19
26	Chamela- Cuixmala	Americas	Top predators declined in abundance	No	1995- 2008	20
27	La Selva	Americas	Terrestrial amphibians declined in abundance	Yes	1970- 2005	21
28	La Selva	Americas	Terrestrial lizards/larger reptiles declined in abundance	Yes	1970- 2005	21
29	La Selva	Americas	Understory insectivorous birds declined in abundance	Yes	1960- 1999	22
30	Los Amigos	Americas	Top predators increased in abundance	Yes	2004- 2008	23
31	Los Amigos	Americas	Large non-predatory vertebrates increased in abundance	Yes	2004- 2008	23

22	T an Aminan	A	Drive stor in success d in	Vaa	2004	22
32	Los Amigos	Americas	abundance	Yes	2004-2008	23
33	Los Amigos	Americas	Omnivorous	Yes	2004-	23
	2001111800	1 111011000	mammals increased		2008	
			in abundance		2000	
3/	Los Amigos	Americas	Game birds increased	Vac	2004	23
54	Los Aningos	Americas	in abundance	1 05	2004-	23
25	т .	· ·		N 7	2008	22
35	Los Amigos	Americas	Larger frugivorous	Yes	2004-	23
			birds increased in		2008	
		-	abundance			
36	Los Amigos	Americas	Hunting declined	Yes	2004-	23
			inside reserve		2008	
37	Los Amigos	Americas	Forest cover declined	Yes	2002-	23
			outside reserve		2010	
38	Los Amigos	Americas	Illegal mining	Yes	2002-	24
	Ũ		increased outside		2010	
			reserve			
39	Los Tuxtlas	Americas	Ambient temperature	No	1925-	25
57	Los Tuxtus	1 mienieus	increased inside	110	2006	20
			reserve		2000	
40	Luquillo	Americas	Exotic plants	Vac	1036	26
40	Luquino	Americas	increased in	1 05	1930-	20
			alered and a		2005	
4.1			abundance	Ът	1000	07
41	Manu	Americas	No change in stream-	NO	1999-	27
			dwelling amphibian		2009	
			abundance			
42	Manu	Americas	No change in	Yes	1999-	27
			terrestrial amphibian		2009	
			abundance			
43	Nouragues	Americas	Illegal mining	Yes	2000-	28
	-		increased inside		2008	
			reserve			
44	Anamalai	Asia-	Primates increased in	Yes	1996-	29
		Pacific	abundance		2010	
45	Khao Yai	Asia-	Top predators	Yes	1999-	30
		Pacific	declined in		2007	
		1 uonno	abundance		2007	
46	Lamhir	Asia-	Large non-predatory	Ves	1984-	31
0		Dacific	vertebrates dealined	105	2007	51
			in abundance		2007	
47	Lombin	Acia	Drimatos daslinadin	Vac	1094	21
4/	Lambir	Asia-	Primates declined in	res	1984-	31
40	T 1'	Pacific	abundance		2007	21
48	Lambir	Asia-	Omnivorous	Yes	1984-	31
		Pacific	mammals declined in		2007	
			abundance			

49	Lambir	Asia- Pacific	Larger frugivorous birds declined in	Yes	1984- 2007	31
		1 uomo	abundance		2007	
50	Lambir	Asia-	Raptorial birds	Yes	1984-	31
		Pacific	declined in		2007	
			abundance			
51	Lambir	Asia-	Hunting increased	Yes	1984-	31
		Pacific	inside reserve		2007	
52	Lore Lindu	Asia-	Forest cover declined	Yes	1972-	32
		Pacific	inside reserve		2007	
53	Mudumalai-	Asia-	Exotic plants	Yes	1997-	33
	Bandipur	Pacific	increased in reserve		2008	
54	Mudumalai-	Asia-	Fires increased inside	Yes	1989-	34
	Bandipur	Pacific	reserve		2005	
55	Northern Sierra	Asia-	Forest cover declined	Yes	1972-	35
	Madre	Pacific	inside reserve		2002	
56	Northern Sierra	Asia-	Forest cover declined	Yes	1972-	35
	Madre	Pacific	outside reserve		2002	
57	Northern Sierra	Asia-	Logging increased	Yes	2003-	36
	Madre	Pacific	inside reserve		2009	
58	Xishuangbanna	Asia-	Forest cover declined	Yes	1976-	37
	_	Pacific	outside reserve		2003	
59	Xishuangbannna	Asia-	Exotic tree	Yes	1976-	37
	_	Pacific	plantations increased		2003	
			around reserve			

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Supplementary Analyses

Supplementary Figure 6 Effects of surrounding disturbances on reserve health (mean \pm SD). Health values declined less in reserves where deforestation, logging or fires were stable or declined, relative to those where these disturbances increased over time. *P* values shown are for Mann-Whitney *U*-tests. Sample sizes are in parentheses.



Supplementary Table 2 Trends in the abundance of 27 animal and plant guilds within 60 tropical protected areas, ranked by effect size (negative values indicate declines in guild abundance, and positive values an increase). *P* values shown in bold are non-random using a stringent Bonferroni correction ($P \le 0.0056$), whereas those in italics are non-random at $P \le 0.05$. The *P* values, estimated mean, and upper and lower 95% confidence limits (CLs) for each guild were estimated by bootstrapping (with 100,000 iterations). Four guilds (aquatic invertebrates, army/driver ants, disease-vectoring invertebrates, dung beetles) were too poorly known to reliably assess overall trends in their abundance.

		Effect			Lower	Upper	No data
Guild	Р	size	Mean	SD	CL	CL	(%)
Ecological specialists	<0.00001	-1.053	-0.425	0.4035	-0.600	-0.250	50.0
Stream amphibians	0.00002	-1.012	-0.3495	0.3452	-0.525	-0.17391	56.7
Freshwater fish	<0.00001	-0.893	-0.4411	0.4938	-0.63441	-0.24775	41.7
Terrestrial amphibians	0.00157	-0.796	-0.2786	0.3497	-0.45455	-0.10256	53.3
Non-venomous snakes	0.00127	-0.761	-0.2968	0.3903	-0.4881	-0.10556	51.7
Bats	0.00190	-0.666	-0.1772	0.266	-0.2973	-0.05714	46.7
Lizards & larger reptiles	0.00382	-0.564	-0.2877	0.5097	-0.49495	-0.08036	40.0
Venomous snakes	0.01511	-0.53	-0.2261	0.4263	-0.42929	-0.02299	48.3
Large non-predatory spp.	0.00022	-0.48	-0.2871	0.5985	-0.44583	-0.12845	5.0
Epiphytes	0.00557	-0.439	-0.151	0.3439	-0.26798	-0.03398	26.7
Lg-seed old-growth trees	0.00086	-0.436	-0.2033	0.4658	-0.33041	-0.07615	8.3
Spp. requiring tree cavities	0.01852	-0.389	-0.1794	0.4616	-0.34804	-0.01068	31.7
Migratory species	0.04674	-0.368	-0.1463	0.3973	-0.31707	0.02451	41.7
Understory insectiv. birds	0.01112	-0.368	-0.1482	0.4023	-0.27516	-0.02128	20.0
Apex predators	0.00469	-0.361	-0.2151	0.5958	-0.37557	-0.05455	6.7
Raptorial birds	0.02587	-0.314	-0.1385	0.4414	-0.27733	0.00043	20.0
Light-loving butterflies	0.16	-0.299	-0.1082	0.3617	-0.3125	0.09615	55.0
Larger frugivorous birds	0.03055	-0.276	-0.1269	0.4598	-0.26042	0.00654	13.3
Primates	0.02777	-0.269	-0.1489	0.553	-0.30121	0.00333	8.3
Rodents	0.13	-0.188	-0.0975	0.5195	-0.26871	0.07364	23.3
Larger game birds	0.13	-0.166	-0.0884	0.5312	-0.24691	0.07014	15.0
Opportunistic omnivores	0.12	-0.164	-0.0996	0.6067	-0.27075	0.07164	10.0
Human diseases	0.00115	0.438	0.2288	0.5227	0.08025	0.37727	11.7
Lianas & vines	0.00116	0.467	0.2016	0.4316	0.07516	0.32801	15.0
Exotic animal species	<0.00001	0.904	0.3475	0.3842	0.24214	0.45283	11.7
Pioneer & generalist trees	<0.00001	1.028	0.4592	0.4465	0.3366	0.5817	15.0
Exotic plant species	<0.00001	1.169	0.4823	0.4126	0.375	0.58951	6.7

Supplementary Table 3 As in Supplementary Table 1 except for potential environmental drivers inside protected areas, and with a different Bonferroni correction ($P \le 0.0071$).

		Effect			Lower	Upper	No data
Driver variable	Р	size	Mean	SD	CI	ĊI	(%)
Reserve health	<0.00001	-0.910	-0.2313	0.2686	-0.3372	-0.1879	0
River & stream flows	0.01052	-0.301	-0.1048	0.3484	-0.1944	-0.0153	1.7
Exotic plantations	0.03395	-0.237	-0.0486	0.2048	-0.1006	0.0033	0
Selective logging	0.13	-0.147	-0.0649	0.4399	-0.1761	0.0464	0
Natural-forest cover	0.25	-0.085	-0.0381	0.4501	-0.1519	0.0758	0
Illegal mining	0.35	-0.047	-0.0116	0.2452	-0.0750	0.0517	1.7
Fires	0.44	-0.024	-0.0076	0.3169	-0.0883	0.0731	0
Rainfall	0.40	0.038	0.0156	0.4085	-0.0994	0.1305	10.0
Hunting	0.11	0.157	0.0982	0.6249	-0.0597	0.2561	0
NTFP harvests	0.02816	0.247	0.1193	0.4828	-0.0031	0.2417	0
Soil erosion	<0.00001	0.517	0.1800	0.3483	0.0893	0.2708	3.3
Reserve-protection effort	0.00005	0.520	0.2500	0.4806	0.1286	0.3714	0
Flooding	<0.00001	0.539	0.1489	0.2762	0.0760	0.2217	5.0
Windstorms	<0.00001	0.561	0.1580	0.2819	0.0759	0.2402	15.0
Roads	<0.00001	0.599	0.1294	0.2160	0.0747	0.1842	0
Stream sedimentation	<0.00001	0.633	0.2497	0.3945	0.1404	0.3591	10.0
Human population density	<0.00001	0.668	0.2286	0.3425	0.1417	0.3156	0
Water pollution	<0.00001	0.709	0.2205	0.3111	0.1396	0.3014	3.3
Ambient temperature	<0.00001	0.745	0.2687	0.3609	0.1633	0.3742	16.7
Livestock grazing	<0.00001	0.765	0.2233	0.2919	0.1497	0.2969	0
Drought severity/intensity	<0.00001	0.851	0.3200	0.3759	0.2218	0.4181	5.0
Air pollution	<0.00001	0.892	0.2946	0.3303	0.2068	0.3824	6.7
Automobile traffic	<0.00001	0.906	0.2806	0.3095	0.2022	0.3589	0

Supplementary Table 4 As in Supplementary Table 1 except for potential environmental drivers outside of protected areas (within a 3 km-wide zone around the protected area), and with a different Bonferroni correction ($P \le 0.0071$).

		Effect			Lower	Upper	No data
	Р	size	Mean	SD	CI	CI	(%)
Natural-forest cover	<0.00001	-1.470	-0.5907	0.4019	-0.6925	-0.489	1.7
River & stream flows	0.03883	-0.248	-0.1005	0.4052	-0.2115	0.0106	8.3
Rainfall	0.27	-0.088	-0.0337	0.3819	-0.1431	0.0756	11.7
Fires	0.00433	0.348	0.1412	0.4054	0.0350	0.2474	3.3
Hunting	0.00153	0.398	0.2257	0.5674	0.0778	0.3736	3.3
Livestock grazing	0.00094	0.432	0.1919	0.4442	0.0747	0.3092	5.0
Windstorms	<0.00001	0.593	0.1432	0.2417	0.0677	0.2188	21.7
Flooding	<0.00001	0.605	0.2492	0.4115	0.1358	0.3626	10.0
Illegal mining	<0.00001	0.626	0.2687	0.4295	0.1541	0.3833	6.7
NTFP harvests	<0.00001	0.720	0.3152	0.4378	0.1927	0.4377	11.7
Selective logging	<0.00001	0.729	0.3613	0.4956	0.2325	0.4901	3.3
Exotic plantations	<0.00001	0.749	0.3416	0.4561	0.2199	0.4633	6.7
Ambient temperature	<0.00001	0.818	0.3221	0.3940	0.2067	0.4375	18.3
Air pollution	<0.00001	0.966	0.3716	0.3846	0.2682	0.4750	10.0
Drought severity/intensity	<0.00001	0.978	0.3747	0.3830	0.2674	0.4820	15.0
Water pollution	<0.00001	1.218	0.4936	0.4054	0.3898	0.5975	5.0
Stream sedimentation	<0.00001	1.234	0.5417	0.4390	0.4219	0.6616	18.3
Soil erosion	<0.00001	1.356	0.5638	0.4158	0.4576	0.6699	10.0
Roads	<0.00001	1.671	0.6601	0.3950	0.5607	0.7594	1.7
Automobile traffic	<0.00001	1.845	0.7012	0.3801	0.6078	0.7945	3.3
Human population density	<0.00001	2.294	0.7943	0.3462	0.7097	0.8789	1.7

Supplementary Table 5 Assessing effects of potential environmental drivers on the reservehealth index, using Spearman rank correlations and general linear models (GLMs). For the correlations, *P* values in bold have a Bonferroni-corrected value of $P \le 0.0071$. For the GLMs, the strongest models are those with weights of the Akaike's information criterion corrected for sample size (wAIC_c) that are closest to 1. The percent deviance explained (%DE) measures the models' structural goodness-of-fit, whereas models with higher ER values have greater support relative to the null (intercept-only) model. Models with blanks could not be fitted with plausible error structures.

	Correl	ations	General	Linear N	Aodels	
Potential driver	Rs	Р	wAIC _c	ER	%DE	n
Natural forest cover-outside	0.487	0.0001	0.989	85.9	16.9	59
Natural forest cover-inside	0.432	0.0006	0.998	502.5	21.7	60
Livestock grazing-inside	0.178	0.174	0.786	3.7	7.7	60
Automobile traffic-inside	0.15	0.251	0.393	0.6	2.2	60
Air pollution-inside	0.052	0.706	0.842	5.2	13.3	56
Stream sedimentation-outside	0.052	0.722	0.189	0.2	10.3	49
Ambient temperature-inside	0.046	0.749	0.887	7.5	21.2	50
Road expansion-outside	0.036	0.784	0.309	0.4	1	59
Droughts-inside	0.011	0.937	0.529	1.1	7.3	57
Illegal mining-outside	0.003	0.980	0.703	1.7	7.5	56
Road expansion-inside	-0.017	0.897	0.252	0.3	0.1	60
Automobile traffic-outside	-0.029	0.829	0.224	0.3	0.6	58
Windstorms-inside	-0.049	0.735				51
Rainfall-outside	-0.054	0.700	0.576	1.3	12.2	53
Windstorms-outside	-0.064	0.667				47
Rainfall-inside	-0.071	0.609	0.825	4.6	15.1	54
Ambient temperature-outside	-0.086	0.555	0.438	0.7	14.6	49
Soil erosion-outside	-0.089	0.520	0.205	0.3	4.5	54
Illegal mining-inside	-0.107	0.418				59
Water pollution-inside	-0.111	0.405	0.724	2.6	8.9	58
Water pollution-outside	-0.129	0.335	0.772	3.4	9.7	57
Stream sedimentation-inside	-0.141	0.310	0.579	1.3	11.2	54
Exotic-tree plantations-outside	-0.143	0.288	0.138	0.2	0.7	56
Livestock grazing-outside	-0.155	0.246	0.701	2.3	8.5	57
Floods-outside	-0.158	0.249				54
Stream/river flows-outside	-0.164	0.227	0.183	0.2	2.9	55
Human populations-inside	-0.171	0.190	0.4	0.7	2.3	60
Air pollution-outside	-0.181	0.185	0.92	11.3	16.8	54
Stream/river flows-inside	-0.19	0.150	0.757	3.1	8.3	59

-0.202	0.122	0.654	1.9	5.7	59
-0.205	0.119	0.777	3.5	8.7	58
-0.213	0.109	0.677	2.1	8.2	58
-0.216	0.097	0.622	1.6	5.2	60
-0.223	0.113	0.977	40.3	24	51
-0.239	0.081	0.928	12.5	18.2	53
-0.253	0.058				57
-0.279	0.0323	0.955	21.2	14.1	58
-0.288	0.0254	0.94	15.7	12.1	60
-0.353	0.0057	0.971	33.8	14.3	60
-0.373	0.0036	0.862	6.2	10.5	58
-0.397	0.0017	0.973	36.1	14.5	60
-0.452	0.0003	0.998	498.1	21.7	60
	-0.202 -0.205 -0.213 -0.216 -0.223 -0.239 -0.253 -0.279 -0.288 -0.353 -0.373 -0.397 -0.452	-0.202 0.122 -0.205 0.119 -0.213 0.109 -0.216 0.097 -0.223 0.113 -0.239 0.081 -0.253 0.058 -0.279 0.0323 -0.288 0.0254 -0.373 0.0036 -0.397 0.0017 -0.452 0.0003	-0.202 0.122 0.654 -0.205 0.119 0.777 -0.213 0.109 0.677 -0.216 0.097 0.622 -0.223 0.113 0.977 -0.239 0.081 0.928 -0.253 0.058 -0.279 0.0323 0.955 -0.288 0.0254 0.94 -0.353 0.0057 0.971 -0.373 0.0036 0.862 -0.397 0.0017 0.973 -0.452 0.0003 0.998	-0.202 0.122 0.654 1.9 -0.205 0.119 0.777 3.5 -0.213 0.109 0.677 2.1 -0.216 0.097 0.622 1.6 -0.223 0.113 0.977 40.3 -0.239 0.081 0.928 12.5 -0.253 0.058 -0.279 0.0323 0.955 21.2 -0.288 0.0254 0.94 15.7 -0.353 0.0057 0.971 33.8 -0.373 0.0036 0.862 6.2 -0.397 0.0017 0.973 36.1 -0.452 0.0003 0.998 498.1	-0.202 0.122 0.654 1.9 5.7 -0.205 0.119 0.777 3.5 8.7 -0.213 0.109 0.677 2.1 8.2 -0.216 0.097 0.622 1.6 5.2 -0.223 0.113 0.977 40.3 24 -0.239 0.081 0.928 12.5 18.2 -0.253 0.058 -0.279 0.0323 0.955 21.2 14.1 -0.288 0.0254 0.94 15.7 12.1 -0.353 0.0057 0.971 33.8 14.3 -0.373 0.0036 0.862 6.2 10.5 -0.397 0.0017 0.973 36.1 14.5 -0.452 0.0003 0.998 498.1 21.7

Supplementary Table 6 Pearson correlations between potential environmental drivers inside versus outside of protected areas, and partial Pearson correlations showing the relationship between these two variables once the effects of reserve area were removed statistically. *P* values in bold have a Bonferroni-corrected value of $P \le 0.0071$.

Driver	R	Р	n	Partial R
Livestock grazing	-0.1722	0.20	57	-0.1643
Exotic-tree plantations	-0.0274	0.84	56	-0.0069
Selective logging	0.2300	0.0825	58	0.2123
Soil erosion	0.2401	0.0803	54	0.2418
Road expansion	0.2749	0.0351	59	0.2814
Population growth	0.2896	0.0261	59	0.3002
Natural forest cover	0.3232	0.0125	59	0.3340
Automobile traffic	0.3445	0.0081	58	0.3529
Fires	0.3623	0.0052	58	0.3518
NTFP harvests	0.3707	0.0063	53	0.3707
Illegal mining	0.4224	0.0012	56	0.4351
River & stream flows	0.4355	0.0009	55	0.4321
Hunting	0.4381	0.0006	58	0.4314
Stream sedimentation	0.4615	0.001	48	0.4608
Water pollution	0.4978	0.0001	57	0.5145
Air pollution	0.5874	<0.0001	54	0.5851
Drought severity/intensity	0.6374	<0.0001	50	0.6374
Flooding	0.6833	<0.0001	54	0.6995
Windstorm disturbance	0.7667	<0.0001	47	0.7474
Rainfall	0.7979	<0.0001	52	0.8060
Ambient temperature	0.8547	<0.0001	48	0.8496

Appendix 1 A non-interactive version of the 10-page interview form used in this study. The present study focuses on changes in the abundance of guilds, as well as the potential drivers of environmental change in our network of protected areas. Data on changes in species richness and composition of guilds are not included in the present analysis, because our experts generally had lower confidence in these trends.

EXPERT QUESTIONNAIRE ON ENVIRONMENTAL CHANGES AT TROPICAL RESEARCH SITES

Objectives

This is the first-ever effort to systematically assess environmental changes across a large and representative cross-section of the world's tropical protected areas and research sites. This survey is being based on a detailed assessment of expert opinion, using a standardized questionnaire.

The goals of the study are to determine the degree to which environmental changes and their drivers vary across different sites, and the degree to which they are similar. This study is also designed to assess whether tropical scientists are experiencing a "shifting baseline" because their study areas and their biota are changing in subtle or insidious ways.

The data being collected are qualitative and comparative in nature, and thus will not compromise in any way the ability of any investigator to publish his or her research findings about a particular research site.

This study is being led by Dr William Laurance of the Smithsonian Tropical Research Institute in Panama, with the assistance of Margareta Kalka and Julio Rendeiro. All individuals who provide detailed responses to this questionnaire as well as intellectual input on the manuscript will be offered coauthorship on at least one publication resulting from this work. Individuals who are especially helpful will be higher in the authorship list.

A critical assumption of expert questionnaires such as this is that the data being collected are reliable. Therefore, please do not respond to any question unless you have at least moderately good, direct or indirect knowledge of the issue at hand.

Expert information

- (1) Full name
- (2) Education level
- (3) Field of expertise
- (4) Gender —---
- (5) Nationality
- (6) Work address
- (7) Email
- (8) Phone
- (9) First year of research at site
- (10) Is your knowledge of the site _____
- (11) Please rate your overall knowledge of the site _____
- (12) How long has it been since you visited the site? months

Protected Area Information

(13) Complete name of Protected Area (PA)

(14) Longitude dd Latitude dd of PA

(15) Size of PA ha

(16) Name of Research Station within PA

Expert Questionnaire on Environmental Changes at Tropical Research Sites

- (17) Does the Focal Research Area (FRA) encompass the PA? ----If answered Yes, please skip to Question 23 If answered No, continue to Question 18
- (18) Please describe the specific locality of the FRA within the PA (i.e. ne, nw, sw, se, center)
- (19) What is the closest distance from the FRA to the border of the PA? km
- (20) Size of FRA ha
- (21) Elevation Range of FRA m
- (22) Please identify your geographical FRA within the PA
- (23) Does the 3 km area bordering the FRA lie mostly within a protected area? ----
- (24) Is the fragmentation of the FRA -
- (25) Within a 3km radius, is the FRA ---
- (26) Please describe area surrounding the PA (land use, disturbance, human settlement, etc)
- (27) How is protection enforced within the PA?
- (28) What is the protection status of the FRA?
- (29) How has the level of protection changed during your time associated with the FRA -

(30) Please comment

Part 1: Changes in Animal and Plant Communities

FEEL FREE TO SKIP QUESTIONS FOR WHICH YOU HAVE LITTLE OR NO KNOWLEDGE.

FOR EACH QUESTION TO WHICH YOU RESPOND, PLEASE PROVIDE DETAILS OF CHANGE, AND FEEL FREE TO ELABORATE ABOUT THE KNOWN OR POSSIBLE DRIVERS OF THE CHANGE.

Over the past 2-3 decades, have any of the following groups changed in (1) Overall Abundance (A) or (2) Species Richness (SR) (native species only) at your FRA (within the PA)?

MAMMALS

(31) Top mammalian predators	(e.g. jaguars, pumas, tigers,	giant otters
Abundance	Species Richness	

Abundance	Species Richness	Knowledge Level
Please specify any abov	e mentioned changes	
Possible drivers of chan	ges	
o Large nen predate	nu anagina (a a farrat alanhanta tanir	-
32) Large, non-predato	ry species (e.g. forest elephants, tapir	s)
Abundance	Species Richness	Knowledge Level
Please specify any abov	e mentioned changes	
Possible drivers of chan	ges	
33) Primates		
Abundance	Species Richness	Knowledge Level

Please specify any above mentioned changes Possible drivers of changes

Expert Questionnaire on Envi	ronmental Changes at Bropical Re	esearch Sites	
(34) Omnivorous/opportunis (e.g. bearded pigs, peccaries	ti <mark>c mammals</mark> , opossums, coati mundis, all >1 ł	(a in weight)	
Abundance	Species Richness	Knowledge Level	
Please specify any above mer Possible drivers of changes	ntioned changes		
(35) Rodents (< 1 kg in weight	0		
Abundance	Species Richness	Knowledge Level	
Please specify any above mer	ntioned changes		
Possible drivers of changes	-		
(36) Bats	Species Pickness	Knowledge Lovel	
	Species Richness		
Diama and the second second	diana dia kaominina		
Please specify any above mer	nuonea changes		
Possible drivers of changes			
(37) Understory birds (e.g. m	any forest-interior insectivores)		
Abundance	Species Richness	Knowledge Level	
Please specify any above mer	ationed changes		
Possible drivers of changes	nonea enanges		
, cooling and the changes			
(38) Larger game birds (e.g.	cracids, guans, curassows, pheas	ants)	
Abundance	Species Richness	Knowledge Level	
Please specify any above mer	ntioned changes		
Possible drivers of changes			
(29) Larger frugivorous birds	(e.g. toucans, hornhills)		
Abundance	Species Richness	Knowledge Level	
Please specify any above mer	ntioned changes		
Possible drivers of changes	nonou onungeo		
i commo ant de cristinges			
(40) Raptors (e.g. eagles, hav	/ks, falcons, owls)		
Abundance	Species Richness	Knowledge Level	
Please specify any above mer	ntioned changes		
Possible drivers of changes			
AMPHIBIANS AND RE	PTILES		
(41) Stream-dwelling amphib	ians		
Abundance	Species Richness	Knowledge Level	
Please specify any above mer	ntioned changes		
Possible drivers of changes			

Expert Questionnaire on Environmental Changes at ^Teropical Research Sites

Abundance	Species Richness	Knowledge Level
Plassa snacify any above	mentioned changes	
Possible drivers of change	es	
	ntilee	
(43) Lizards and larger re Abundance	Species Richness	Knowledge Level
Please specify any above	mentioned changes	
Possible drivers of change	es	
(44) Venomous snakes		
Abundance	Species Richness	Knowledge Level
Please specify any above	mentioned changes	
Possible drivers of change	es	
(45) Non-venomous snak	es	
Abundance	Species Richness	
Plance another any shows	montioned changes	
Please specify any above Possible drivers of change	es	
, coonside uniter of onling		
TERRESTRIAL INV	(ERTEBRATES	
Abundance	Species Richness	Knowledge Level
Please specify any above	mentioned changes	
Possible drivers of change	es	
(47) Army ants (driver ant	s)	
Abundance	Species Richness	Knowledge Level
Please specify any above Possible drivers of change	mentioned changes	
, unvers or oriding		
(48) Leaf-cutter ants (Nec	otropics only)	
Abundance	Species Richness	
Please specify any above	mentioned changes	
Possible drivers of change	es	
Abundance	Species Richness	Knowledge Level
	•	
Please specify any above	mentioned changes	
Possible drivers of change	es	

Abundance Species Richness

Knowledge Level

Expert	Questionnaire on	Environmental	Changes at	Tropical	Research Sites
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Please specify any above r	mentioned changes	
Possible drivers of change	s	
, cooldie anvero of onango	5	
(51) Other group		
Abundance	Species Richness	Knowledge Level
Please specify any above n	mentioned changes	
Possible drivers of change	s	
AQUATIC SPECIES		
(52) Stream-fish assembla	ides	
Abundance	Species Richness	Knowledge Level
Please specify any above n	nentioned changes	
Possible drivers of change	s	
(53) Aquatic invertebrates	Creation D'atomation	Knowledge Lovel
Abundance	Species Richness	
Please specify any above n	mentioned changes	
Possible drivers of change	S	
PLANTS		
(54) Large-seeded specie	s, as a subset of climax species	(e.g. many shade-tolerant trees)
A Lorenda and a		
Abundance	Species Richness	Knowledge Level
Abundance	Species Richness	Knowledge Level
Please specify any above m	species Richness mentioned changes	Knowledge Level
Please specify any above m Possible drivers of change	species Richness	Knowledge Level
Please specify any above m Possible drivers of change	species Richness	Knowledge Level
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39) Migratory species (e.g. bird and mammal frugivores or nectarivores, mig Abundance Species Richness Knowle Please specify any above mentioned changes Possible drivers of changes Species Richness Knowle 30) Ecological specialists (e.g. foraging specialists, species with complex m Abundance Species Richness Knowle Please specify any above mentioned changes Possible drivers of changes Model Species Richness Knowle Please specify any above mentioned changes Possible drivers of changes Species Richness Knowle Please specify any above mentioned changes Possible drivers of changes Knowle Species Richness Knowle Please specify any above mentioned changes Possible drivers of changes Knowle Species Richness Knowle Please specify any above mentioned changes Possible drivers of changes Species Richness Knowle Species Richness Knowle Species Richness Knowle Please specify any above mentioned changes Species Richness Knowle Please specify any above mentioned changes Species Richness Knowle Please specify any above mentioned changes Species Richness Knowle <t< th=""><th>atory fish) dge Level ——–</th></t<>	atory fish) dge Level ——–
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Please specify any above mentioned changes Possible drivers of changes	dae Level
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Prease specify any above menuoned changes	
YOSSIDIE ONVERS OF CHANGES	
eessie arrene er enangee	
) Human diseases (e.g. malaria, leishmaniasis, dengue fever, Chagas)	
Abundance Species Richness Knowle	dge Level

Please specify any above mentioned changes	
And a specify any above memories on any as	

Over the past 2-3 decades, have any of the following changes occurred

- (a) within the focal research area (FRA),
- (b) in the 3km area bordering the FRA, and
- (c) in the general area outside the protected area (PA)

(65) For the area outside the PA, please approximate distance (km) from border of PA ----

(66) Natural forest cover

Within FRA	Within 3km of FRA	Within area outside PA	Knowledge level	Likely impact on research		
Details and possible drivers						

Expert Questionnaire on Environmental Changes at Tropical Research Sites

(67) Hunting				
Within FRA	Within 3km of FRA	Within area outside PA	Knowledge level	Likely impact on research
Details and possible dr	ivers			
(68) Selective loggin	ng			
Within FRA	Within 3km of FRA	Within area outside PA	Knowledge level	Likely impact on research
Details and possible dr	ivers			
(69) Fires				
Within FRA	Within 3km of FRA	Within area outside PA	Knowledge level	Likely impact on research
Details and possible dr	ivers			
(70) Air pollution				
Within FRA	Within 3km of FRA	Within area outside PA	Knowledge level	Likely impact on research
Details and possible dr	ivers			
(71) Water pollution	2			
Within FRA	Within 3km of FRA	Within area outside PA	Knowledge level	Likely impact on research
Details and possible dr	ivers			
(72) Pastoralism/live	estock grazing			
Within FRA	Within 3km of FRA	Within area outside PA	Knowledge level	Likely impact on research
Details and possible dr	ivers			
(73) Illegal mining				
Within FRA	Within 3km of FRA	Within area outside PA	Knowledge level	Likely impact on research
Details and possible dr	ivers			
(74) Automobile trat	ffic			
Within FRA	Within 3km of FRA	Within area outside PA	Knowledge level	Likely impact on research
Details and possible dr	ivers			
(75) Harvest of natu	ral products (e.g. fuel	wood, tree bark, leaves, fungi, e	etc.)	
Within FRA	Within 3km of FRA	Within area outside PA	Knowledge level	Likely impact on research
Details and possible dr	ivers			
(76) Exotic tree plar	tations			
Within FRA	Within 3km of FRA	Within area outside PA	Knowledge level	Likely impact on research
Details and possible dr	ivers			
(77) River/stream flo	WS (e.g. from upstream d	ams or water harvesting)		
Within FRA	Within 3km of FRA	Within area outside PA	Knowledge level	Likely impact on research
Details and possible dr	ivers			
(78) Flooding freque	ency or intensity			
Within FRA	Within 3km of FRA	Within area outside PA	Knowledge level	Likely impact on research
Details and possible dr	ivers			

Expert Questionna	ire on Environmental	Changes at Bropical Re	esearch Sites	
Within FRA	Within 3km of FRA	Within area outside PA	Knowledge level	Likely impact on research
Details and possible of	drivers			
(80) Soil erosion				
Within FRA	Within 3km of FRA	Within area outside PA	Knowledge level	Likely impact on research
Details and possible of	drivers			
w Mindetorm di	turbanaa			
Within FRA	Within 3km of FRA	Within area outside PA	Knowledge level	Likely impact on research
Details and possible of	drivers			
(82) Drought Within FRA	Within 3km of FRA	Within area outside PA	Knowledge level	Likely impact on research
Details and possible of	arivers			
(83) Rainfall				1. Martin Samuel and an and a
	Within 3km of FRA	Within area outside PA	Knowledge level	Likely impact on research
Details and possible of	drivers			
(84) Temperature				
Within FRA	Within 3km of FRA	Within area outside PA	Knowledge level	Likely impact on research
Details and possible of	drivers			
(85) Forest dynami	ics. i.e. tree mortalit	v and recruitment (acce	elerated/decelerated)	
Within FRA	Within 3km of FRA	Within area outside PA	Knowledge level	Likely impact on research
Details and possible of	drivers			
(86) Seed dispersa	1			
Within FRA	Within 3km of FRA	Within area outside PA	Knowledge level	Likely impact on research
Details and possible of	drivers			
	-4:			
Within FRA	Within 3km of FRA	Within area outside PA	Knowledge level	Likely impact on research
Details and possible (drivers	1		
Details and possible (1114613			
(88) Road construc	Within 3km of ERA	Within area outside PA	Knowledge level	Likely impact on research
Details and possible of	drivers			
Within FRA	Within 3km of FRA	Within area outside PA	Knowledge level	Likely impact on research
Details and possible of	drivers			
04	en e			
(90) Other Within FRA	Within 3km of FRA	Within area outside PA	Knowledge level	Likely impact on research
	drivore			
Details and possible of	livers			

Part 3: Additional Questions

Expert Questionnaire on Environmental Changes at Propical Research Sites What do you think will be the biggest future threats to your site, and could you identify possible solutions?

- (91) First biggest threat Possible solution
- (92) Second biggest threat Possible solution
- (93) Third biggest threat Possible solution

(94) Can you recommend other experts on this site? -----

(95) Expert 1			
Name	Expertise	Email	
(96) Expert 2			
Name	Expertise	Email	
(97) Expert 3			
Name	Expertise	Email	
(98) Expert 4			
Name	Expertise	Email	
(99) Expert 5			
Name	Expertise	Email	
(100) Expert 6			
Name	Expertise	Email	
(101) Expert 7			
Name	Expertise	Email	
(102) Expert 8			
Name	Expertise	Email	

(103) Do you have knowledge of long-term changes of other tropical research sites, and if so, would you be willing to be interviewed about them for our survey? -

(104) Site1		
Name	Country	
(105) Site 2		
Name	Country	
(106) Site 3		
Name	Country	

(107) Would you be interested in remaining further involved with this study and in co-authorship of a resulting publication? -

(108) Comment

Please provide publications describing environmental changes at this site. (109) Publication 1 Author name Article title Journal title Year (110) Publication 2

Journal title Year Author name Article title

Expert Questionnaire on Environmental Changes at Illoppical Research Sites (111) Publication 3

(iii) i abileation v				
Author name	Article title	Journal title	Year	

(112) Comment

Thank you very much for your time and we greatly appreciate your participation in this study.