Supplementary materials

SM1 Growth of iNaturalist

iNaturalist in Mexico is experiencing substantial growth that would bias simple trends, given the increases in observers and observations each year, as shown in the table below.

	Butterflies		Bombus		Odonata		Solanacea	
Year	Observers	Records	Observers	Records	Observers	Records	Observers	Records
2008	41	186	2	3	20	58	0	0
2009	49	100	3	3	35	112	0	0
2010	67	605	9	9	48	124	0	0
2011	50	188	3	3	38	95	0	0
2012	104	276	8	10	66	246	39	104
2013	161	379	15	15	108	313	64	135
2014	221	735	30	48	151	852	65	133
2015	291	1049	37	69	199	903	97	327
2016	509	1869	76	163	328	1894	213	602
2017	657	2209	108	212	433	2217	376	1234
2018	811	2764	162	306	607	2670	763	1911
2019	1222	4351	239	457	840	3981	1278	3347
2020	1401	5226	309	650	822	3332	1365	3966
2021	1577	5389	424	913	1075	4737	1993	5656
2022	2080	7214	566	1228	1200	5627	2250	5778
2023	2329	9395	517	1237	1271	5609	2541	6654
2024	2460	12950	501	1217	1279	4005	2713	7022

Table S1. Basic data for the four taxonomic groups for which indices of abundance were obtained.

SM2 Theoretical value of the slope of diversity/observer vs. year

Because insects' numbers are increasingly reported in iNaturalist, the extent to which this increase might have affected the indices used herein was assessed. The mean number of species reported and observers per year, in 2008–2024, was plotted for the butterflies, bumblebees, and dragonflies and damselflies (Figure 3). The iNaturalist data showed a simultaneous increase in the number of species observed and the number of observers. Species/observer ratios are reported. Given that the index is a quotient of two growing functions, what might the theoretical value of its slope be?

This work was based on an assumption that the observed number of species is a function of effort, with an asymptote, as in the Michaelis-Menten formula (Clench 1979), which is often used to model curves of species vs. effort. Using the Michaelis-Menten formula, a model for the number of species observed, given the collecting effort, is s[f] = a*f/(1+b*f), where *f* is the effort, and *a* and *b* are parameters such that *a/b* is the total number of species in the region under consideration. The index used herein is s[f]/f. Its derivative with respect to *f* is $-a*b/(1+b*f)^2$, which is always negative, regardless of the shape of the effort function. However, the precise value depends on parameters *a* and *b* of the accumulation curves, and on the shape of the effort function. Because the total number of observed species, for large effort, is $Tot = a/b$, the slope of the diversity/effort is $-(a^2*Tot^{-1})/[1 + a*f/Tot)^2]$. This equation suggests that, for large values of *Tot*, the slope should be close to zero. Consequently, the saturation effect is assumed to be small, except perhaps for the bumblebees. This problem warrants further consideration.

SM3. Potential vegetation types, according to Rzedowsky (1986).

The potential vegetation classes according to are:

Xerophytic shrubs (Mx)
Pine-oak forest (Bce)
Grasslands and savannas (P)
Tropical dry forest (Btc)
Tropical wet forest (Btp)
Spiny forest (Be)
Cloud forest (Bmm)
Tropical subdeciduous forest (Bts)
Mangrove and other wetlands (Vas)

The percentages of pixels in the raster of *Vegetacion Potencial de Mexico* Rzedowsky (1986), with iNaturalist observations are:

	Mx	Bce	P	Btc	Btp	Be	Bmm	Bts	Vas	NumTot
VPR	38.65	18.76	8.76	14.03	9.23	5.89	1.00	2.57	1.05	3,891
Butterflies	18.70	19.51	16.80	17.46	10.06	5.62	6.23	4.58	1.04	58,048
Odonata	27.44	14.37	15.31	23.10	6.28	4.80	2.09	6.16	0.46	36,775
Solanaceae	36.15	17.74	18.43	14.55	2.68	6.98	1.25	1.25	0.97	39,014
Bombus	17.94	33.23	30.54	4.02	2.78	3.90	5.12	0.11	1.50	6,543
Mean	27.78	20.72	17.97	14.63	6.21	5.44	3.14	2.93	1.00	

Table S2. Percentage of observations of different taxa in the potential vegetation map of Mexico, ordered by mean proportion of observations. The first four vegetation types had at least 14% of the observations, and the last five types contained less than 7%. Only the first four types were used. The first row is the percentage of area in the map, for the given vegetation type.

The iNaturalist observations are clearly not proportional to the amount of vegetation type in the country. Grasslands and savannas had many more observations that would be expected according to area. The regressions of diversity/effort vs. time in the four most visited vegetation types are shown below.

Taxon	Potential Vegetation	Slope X 1000	p	p(ARIMA)	n	Model
Bombus	All	-10.31	2.700E-03	1.040E-03	6,543	ARIMA
Bombus	MX	-16.94	9.000E-03	6.400E-05	1,174	ARIMA
Bombus	POF	-18.28	6.440E-10	1.110E-06	2,174	ARIMA
Bombus	G	-2.52	6.800E-01	4.100E-01	1,998	OLS
Bombus	TDF	-21.39	1.600E-02	8.760E-01	263	OLS
Butterflies	All	-6.11	3.123E-03	2.740E-02	58,048	ARIMA
Butterflies	MX	-8.72	3.510E-02	2.550E-02	10,857	ARIMA
Butterflies	POF	-10.17	1.530E-01	5.420E-03	11,327	ARIMA
Butterflies	G	-5.02	3.280E-01	NoConvergence	9,750	
Butterflies	TDF	-9.34	1.150E-02	5.400E-02	10,133	ARIMA
Odonata	All	-0.89	6.800E-01	5.400E-02	36,775	ARIMA
Odonata	MX	8.06	3.760E-02	NoConvergence	10,090	
Odonata	POF	-6.62	5.120E-02	9.010E-01	5,283	OLS
Odonata	G	1.44	8.430E-01	4.200E-02	5,630	ARIMA
Odonata	TDF	-7.85	4.200E-02	1.430E-01	8,495	OLS
Solanaceae	All	3.13	1.650E-01	7.930E-01	39,014	OLS
Solanaceae	MX	1.97	4.440E-01	7.810E-01	14,105	OLS
Solanaceae	POF	1.1	6.820E-01	7.810E-01	6,920	OLS
Solanaceae	G	-16.25	2.000E-02	8.880E-01	7,189	OLS
Solanaceae	TDF	8.71	1.040E-01	8.880E-01	5,676	OLS

Table S3. Results of GLS regressions of different_species/unit_effort for the four most common potential vegetation types, aggregated by two degree hexagons. Slope × 1,000. The number of observations for the taxon in the potential vegetation class is *n*.

The table below shows the numbers of species, for the most visited vegetation types, in total, and how many reported by the frequent observers

Taxon	VPR	Total Names	Reported Names
Bombus	Mx	16	10
Bombus	POF	20	15
Bombus	G	9	8
Bombus	TDF	14	7
Butterflies	Mx	153	44
Butterflies	POF	220	40
Butterflies	G	86	24
Butterflies	TDF	198	32
Odonata	Mx	185	36
Odonata	POF	187	60
Odonata	G	105	56
Odonata	TDF	184	65
Solanaceae	Mx	176	46
Solanaceae	POF	210	36
Solanaceae	G	111	24
Solanaceae	TDF	153	36

Table S4. Numbers of species in the iNaturalist database, for different taxa in the four most visited potential vegetation types, according to Rzedowsky (third column), and maximum number of species reported by an observer (with more than two observations), for each combination of taxon and vegetation type. Except for *Bombus*, every taxon is undersampled in the vegetation types used.

SM4. Regressions over the entire country

Graphs of the indices of amount of species/effort for four families of butterflies are shown below.

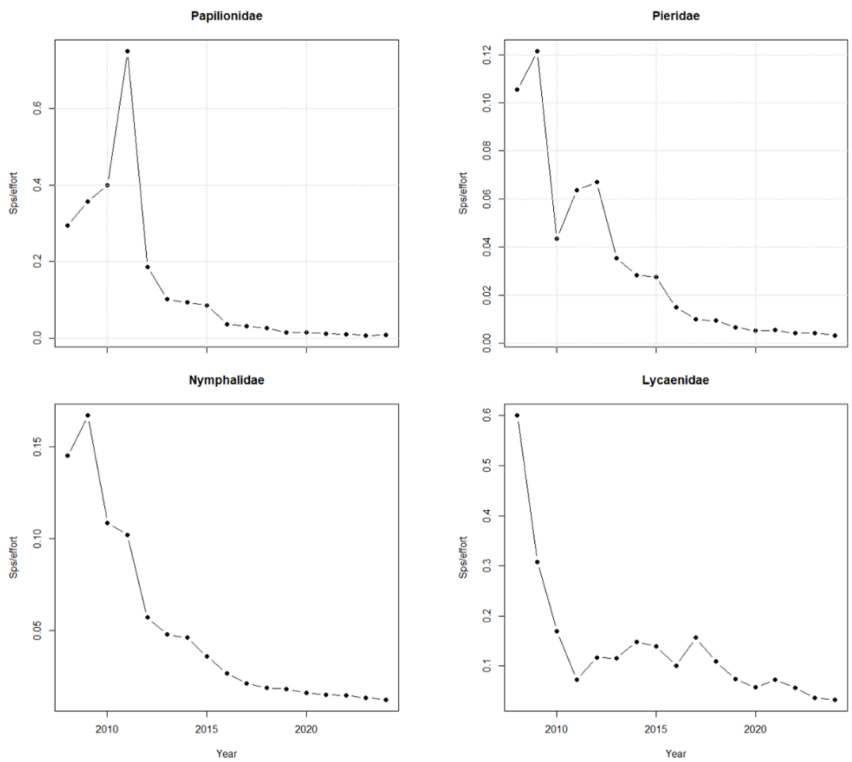

Figure S1. Species/observer vs. year for four families of butterflies. Data are aggregated for all of Mexico. In all cases, the slope is negative.

	Slope	p	n	Model used
Papilionidae	-2.63	0.282	5538	ARIMA
Pieridae	-6.26	0.000000088	29994	OLS
Nymphalidae	-1.0	0	20145	ARIMA
Lycaenidae	-10.0	0.0025	2316	ARIMA

Table S5. Generalized least squares regressions for species/effort vs. year for the four butterfly families, aggregated over all of Mexico. The slopes are multiplied by 1,000. For three of the four families, regression with a first-order autocorrelated structure had better performance than ordinary least squares.

SM5. Predictors of loss of diversity, and regression results

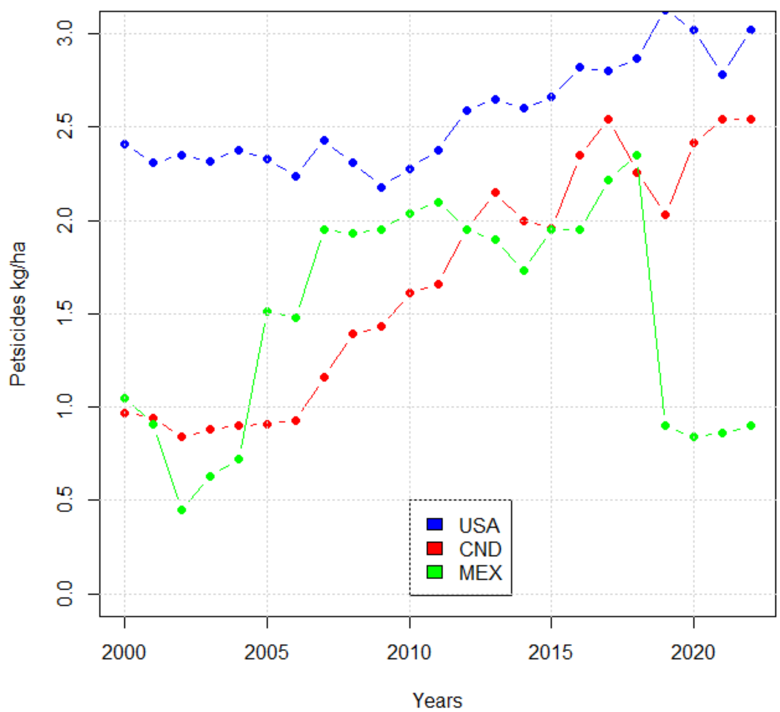

Figure S2. Rates of pesticide use (kg/ha) in the three largest North American countries, as reported in the FAO world statistics database (https://www.fao.org/statistics/en). USA, United States; CND, Canada; MEX, Mexico.

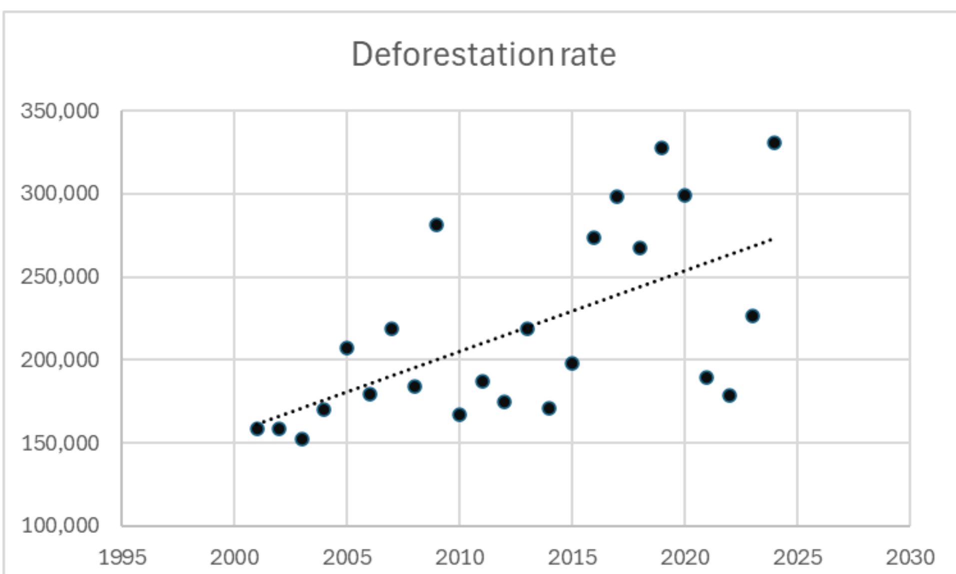

Figure S3. Loss of forest cover in Mexico, in ha (https://www.globalforestwatch.org/).

Although for all insect groups, the regressions on the residuals of the GLS (of index vs. year) against deforestation and pesticide use were negative, the probability under the null hypothesis was never very low. Consequently, the data did not indicate evidence of a relationship between the negative trend in diversity and the predictors. Table S3 shows the results for hexagons of two degrees.

	Value		p-value
(Intercept)	0.0166		0.588
DefRate		-0.0456	0.161
PetsicideUse		-0.0542	0.129

	OdonatesTwo Degree		
	Value		p-value
(Intercept)	0.018		0.848
DefRate		-0.0227	0.814
PetsicideUse		-0.0113	0.914

	Bumblebees Two Degree		
	Value		p-value
(Intercept)	-0.00538		0.743
DefRate		-0.01159	0.493
PetsicideUse		-0.0036	0.843

	SolanaceaeTwoDeg		
	Value		p-value
(Intercept)	-0.0444		0.473
DefRate		0.0157	0.774
PetsicideUse		0.1131	0.183

Table S6. Regressions of residuals vs. standardized predictors (deforestation rate: DefRate) and pesticide use per hectare. No slope had low probability under an H0 of zero slope.

SM6. Informal questionnaire

A Qualtrics ™ questionnaire was sent to researchers in Ecology working in the national university of Mexico, the Instituto de Ecologia in Xalapa, VER, and Ecosur in San Cristobal, CHP.
The questionnaire had the following results:

Do you do field work?	Number of Answers
Less than annually	1
Annually	12
Monthly	13
How long ago did you start going to the field?	
≤5 years	0
≤10 years	1
>10 years	25
Have you noticed changes in insect abundance?	
No	2
Yes, an increase	1
Yes, a decrease	23
How have you noticed?	
Insects impacted on vehicles	19
Clouds of insects around lights	17
Direct monitoring	10
Other	10
How much you do trust your observations?	
Very reliable	14
Reliable	6
Doubtful	6

A total of 27 answers were returned out of 37 requests. Because the questions were not exclusive, the sum of the answers might not total 27.

Clench, H. 1979. How to make regional lists of butterflies: some thoughts. Journal of the Lepidopterist´s Society **33**:216-231.
Rzedowsky, J. 1986. Vegetación de México. Limusa, México D. F.