Supporting Information

Fig S1. Linear regression of the annual mean temperature against year for the time period 1981 to 2015 at the Estacion de Biologia-Chamela in Jalisco, Mexico. Between 1981 and 2015 mean annual temperature rose ~2.4 ^{o}C. (see Methods).

Fig S2. Comparison of mean dry weight biomass of arthropods caught per day over five days of sampling in ten sticky ground traps placed in the same area of the Chamela forest for the same amount of time in July 1987 and 1988 (1) and again in August 2014**.** The total dry weight biomass of captured arthropods is given above each bar.

Fig. S3. Quasi-Poisson regressions of *E. coqui* counts in four of Woolbright's (2,3) study areas in the Luquillo forest. (A) Regression for the Sonadura West *E. coqui* census area near the El Verde field Station. (B) Segmented regressions of estimated *E. coqui* abundances in a study area near the El Verde field station. The figure shows the dramatic increase in *E. coqui* numbers following Hurricane Hugo which struck the Luquillo Forest on September 18, 1989. The rapid return to the pre-perturbation rate of decline suggests the ongoing influence of climate change on birth and death rates. (C) and (D) QuasiPoisson regressions on time for *E. coqui* counts for two of Woolbright's study areas in the Bisley watershed. The regression equations are given for each census and the 95% confidence intervals are shown around the best fit regression lines. Pr(Chi) is the result of a likelihood ratio Chi-square test of whether the independent variable improves the Poisson model beyond an intercept-only model. P <.05 indicates a statistically significant regression.

Fig S4. Nonparametric Theil-Sen regression of the relative decline in mist net catch rate between 1990 and 2005 as a function of the percent of a given species' diet made up of invertebrates for 7 of the most common bird species in Waide's (4) study area near El Verde. The regression was significant at P<.05. Declines in catch rates were calculated relative to the Ruddy Quail Dove, *G. montana*, a granivore that showed no decrease in abundance between 1990 and 2005. RQD=Ruddy Quail Dove (*Geotrygon montana)*, PBF=Puerto Rican Bull Finch (*Loxigilla portoricensis*), PRTh= Red Legged Thrush (*Turdus plumbeus*), PRE=Puerto Rican Emerald Hummingbird (*Chlorostilbon maugaeus*), BWV=Black-whiskered Vireo (*Vireo altiloquus*), PRTa=Puerto Rican Tanager *(Nesospingus speculiferus*), PRT= Puerto Rican Tody (*Todus mexicanus*). Diet data from Reagan and Waide (5).

Fig. S5. Results of the hierarchical partitioning analyses. The bars show percent of the total deviance that each variable explains independent of the other variables. Variables with high percentages are more likely to be causal (6).

Fig. S6. Results of the cross-correlation analyses for the SOI and the abundance time series of the canopy invertebrate and the walking stick populations. See text for interpretation and discussion.

Fig. S7. The decline in total agricultural land in Puerto Rico that was subject to pesticide application between 1969 and 2012. Data from U.S. Department of Agriculture, National Agricultural Statistics Service, Census of Agriculture https://www.agcensus.usda.gov/.

www.pnas.org/cgi/doi/10.1073/pnas.1722477115

Fig. S8. Trends and relationships for the Luquillo forest climate variables.

Fig. S9. The Southern Oscillation Index (SOI) from 1975 to 2018. Positive values (blue bars) correspond to La Nina years with below-normal air pressure at Tahiti and above-normal air pressure at Darwin, combined with ocean temperatures across the eastern tropical Pacific that are colder than average. Negative values (red bars) correspond to El Niño years with above normal air pressure at Tahiti and below-normal air pressure at Darwin, combined with ocean temperatures in the eastern tropical Pacific that are warmer than average. Major droughts in Puerto Rico (red bars along X axis) are associated with El Nino episodes, and major hurricanes (blue bars along X axis) with La Niña. Also shown are the approximate time periods over which the eruptions of El Chichon (September1982) and Mount Pinatubo (June 1991) lowered global temperatures. To add context with respect to ENSO for the various censuses analyzed in this study, the time periods during which they were conducted are shown at the top of the figure.

Table S1. Data from mark-recapture studies of *Anolis* populations conducted in the same sampling area in the Luquillo forest using the Schnabel capture-recapture method (25). Data for 1976 and 1977 from Lister (1).

Table S2. Rates of decline for rainforest anoles from Puerto Rico (1 and this study), Costa Rica (7), and Panama (8).

Table S3. Definition of the most important climate variables, as defined by the Hierarchical Partitioning analysis, that were employed as potential predictors in the univariate and multivariate quasiPoisson regressions.

Table S4. Results of the Vinod Causality analysis using the generalCorr R package (9). SO=Woolbright's Sondadura Old study area. SW = Woolbright's Sonadura West study area. The unanimity index (UI) quantifies the likelihood that either X or Y is causal. The most likely causal path for 5 of the 6 data sets is that mean maximum temperature causes declines in abundance. Given a UI slightly above 15, the causal direction for the *E. coqui* population at the Sonadura Old study area is indeterminate.

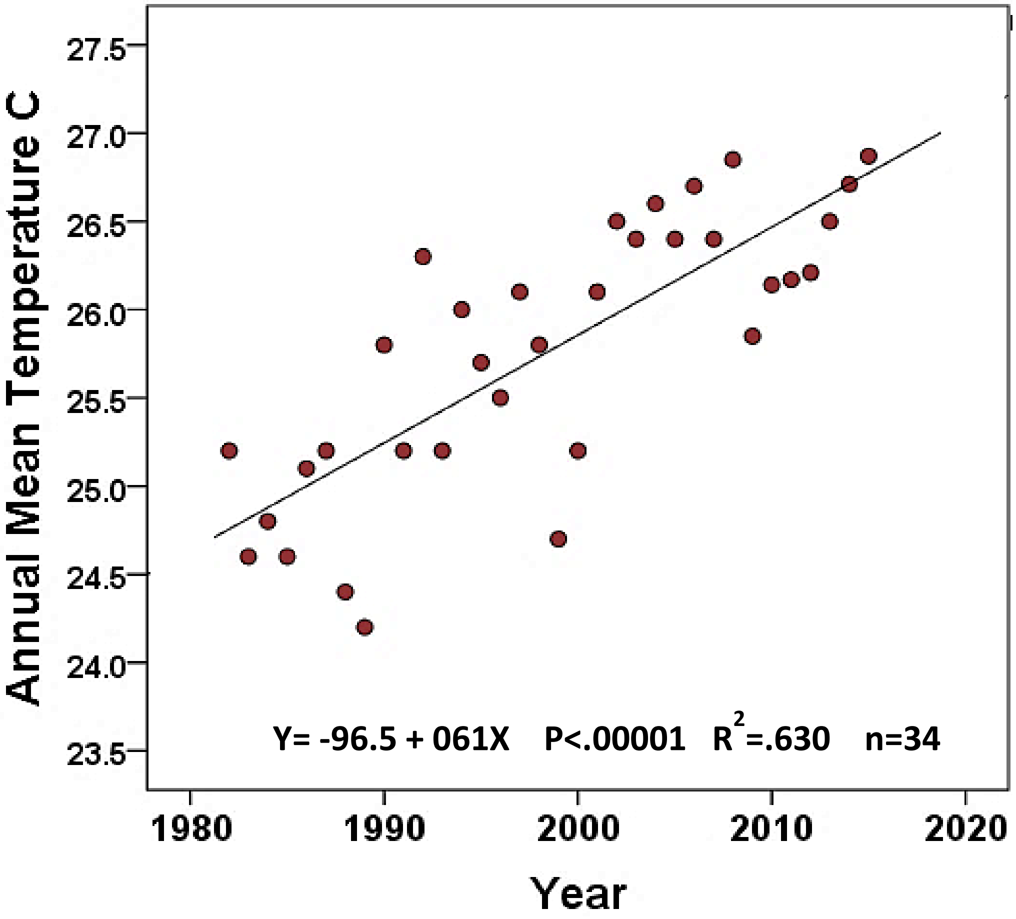
Table S5. Results of the multiple quasiPoisson regression analyses.

Dataset S1 – Luquillo sweep net data 1

Dataset S2 – Luquillo sweep net data 2

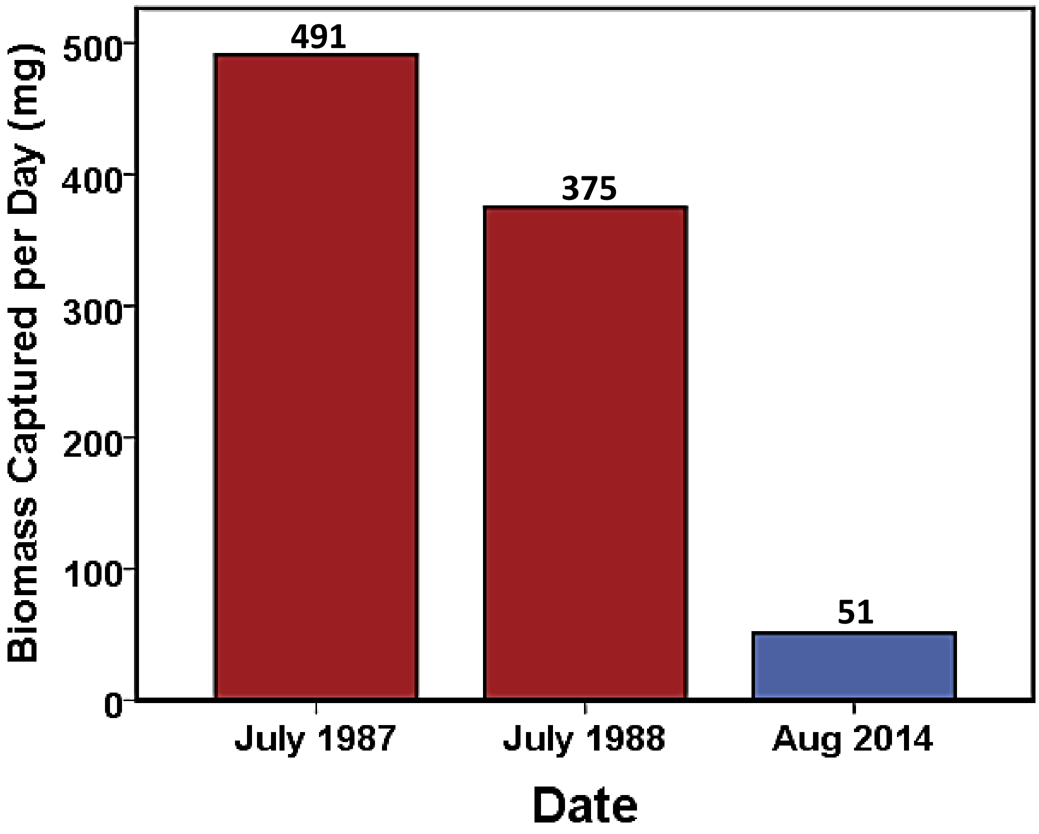
Dataset S3 – Luquillo trap data

Dataset S4 – Chamela traps



Annual Mean Temperature C
27.5
27.0
26.5
26.0
25.5
25.0
24.5
24.0
23.5
Y= -96.5 + 061X P<.00001 R2=.630 n=34
1980
1990
2000
2010
2020
Year

Fig. S1



Biomass Captured per Day (mg)
500
400
300
200
100
0
491
375
51
July 1987
July 1988
Aug 2014
Date

Fig S2.

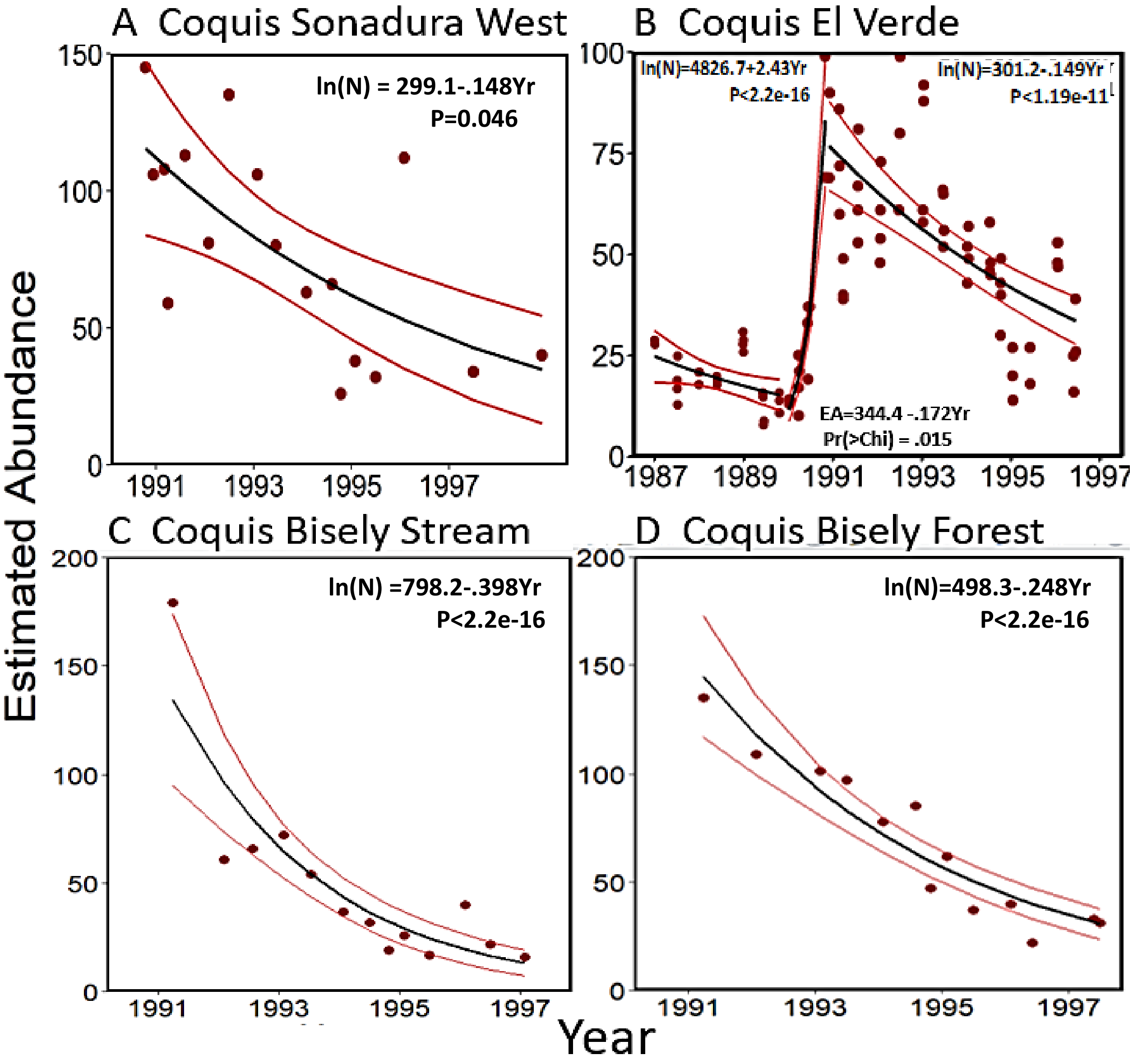

A Coquis Sonadura West
ln(N) = 299.1-.148Yr
P=0.046
150
100
50
0
1991
1993
1995
1997
B Coquis El Verde
ln(N)=4826.7+2.43Yr
P<2.2e-16
ln(N)=301.2-.149Yr
P<1.19e-11
EA=344.4 -.172Yr
Pr(>Chi) = .015
100
75
50
25
0
1987
1989
1991
1993
1995
1997
C Coquis Bisely Stream
ln(N) =798.2-.398Yr
P<2.2e-16
200
150
100
50
0
1991
1993
1995
1997
D Coquis Bisely Forest
ln(N)=498.3-.248Yr
P<2.2e-16
200
150
100
50
0
1991
1993
1995
1997
Estimated Abundance
Year

Fig S3.

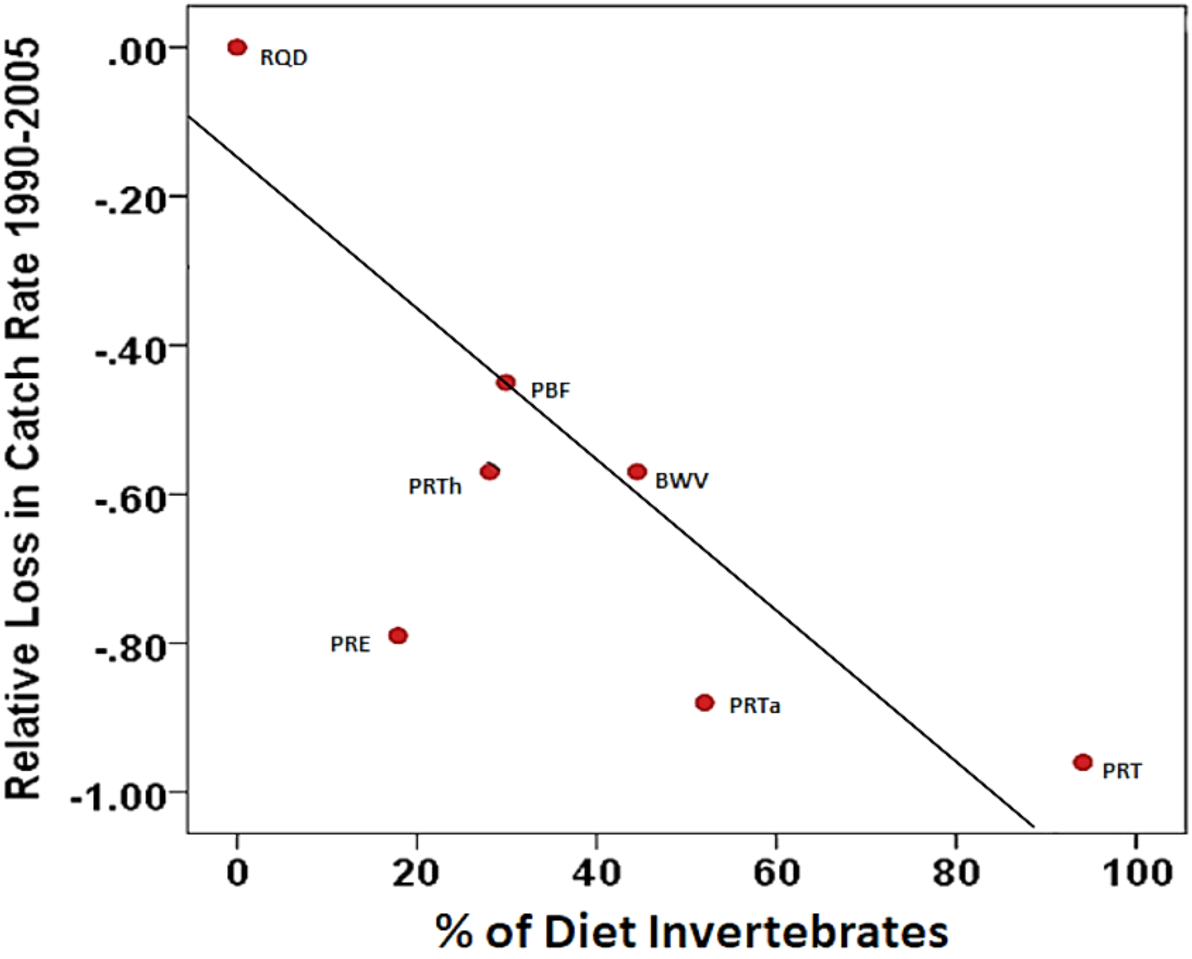

Relative Loss in Catch Rate 1990-2005
.00
-.20
-.40
-.60
-.80
-1.00
0
20
40
60
80
100
% of Diet Invertebrates
RQD
PBF
PRTh
BWV
PRE
PRTa
PRT

Fig. S4.

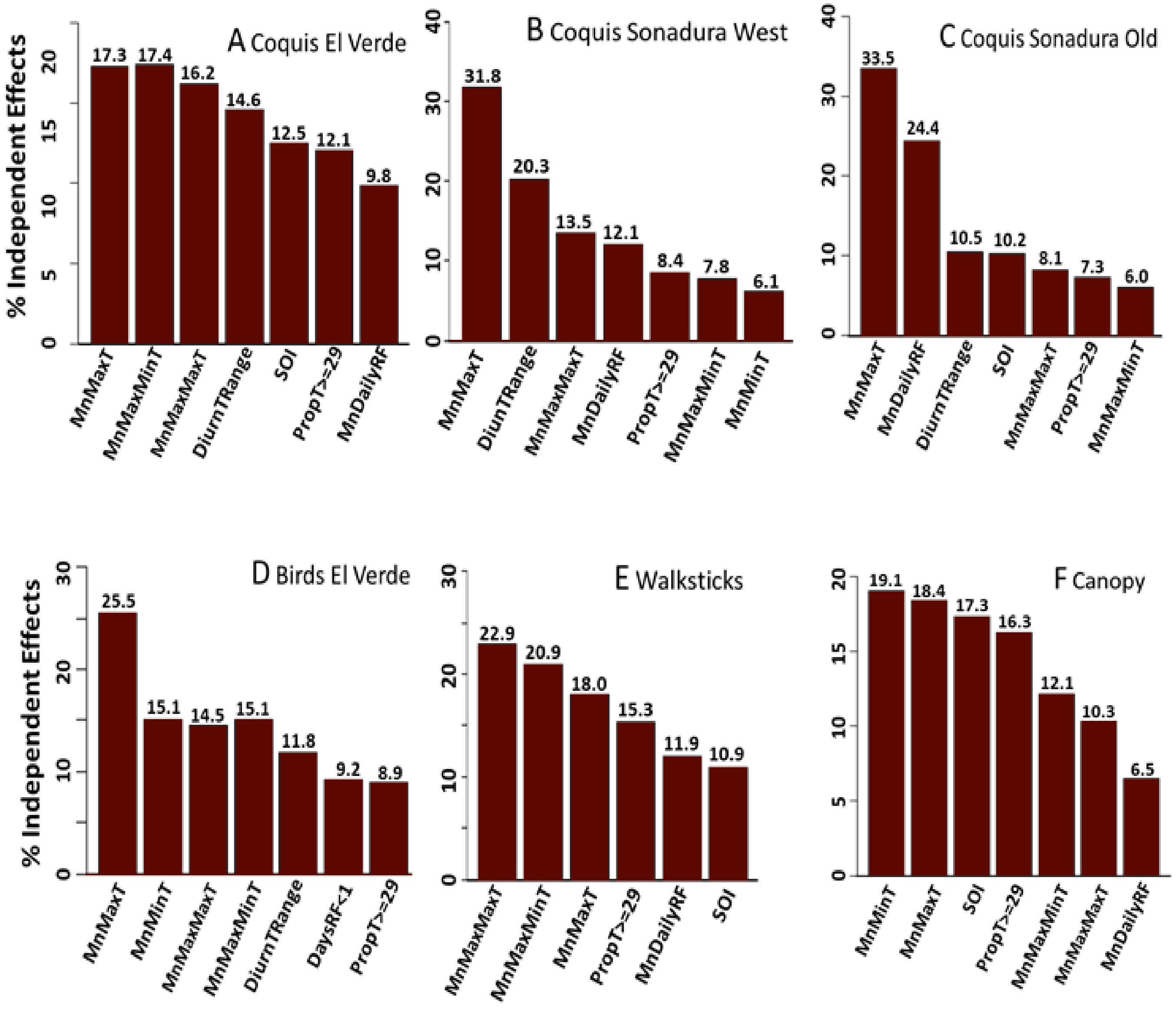

% Independent Effects
A Coquis El Verde
0
5
10
15
20
17.3
17.4
16.2
14.6
12.5
12.1
9.8
MnMaxT
MnMaxMinT
MnMaxMaxT
DiurnTRange
SOI
PropT>=29
MnDailyRF
B Coquis Sonadura West
0
10
20
30
40
31.8
20.3
13.5
12.1
8.4
7.8
6.1
MnMaxT
DiunTRange
MnMaxMaxT
MnDailyRF
PropT>=29
MnMaxMinT
MnMinT
C Coquis Sonadura Old
0
10
20
30
40
33.5
24.4
10.5
10.2
8.1
7.3
6.0
MnMaxT
MnDailyRF
DiurnTRange
SOI
MnMaxMaxT
PropT>=29
MnMaxMinT
% Independent Effects
D Birds El Verde
0
10
20
30
25.5
15.1
14.5
15.1
11.8
9.2
8.9
MnMaxT
MnMinT
MnMaxMaxT
MnMaxMinT
DiurnTRange
DaysRF<1
PropT>=29
E Walksticks
0
10
20
30
22.9
20.9
18.0
15.3
11.9
10.9
MnMaxMaxT
MnMaxMinT
MnMaxT
PropT>=29
MnDailyRF
SOI
F Canopy
0
5
10
15
20
19.1
18.4
17.3
16.3
12.1
10.3
6.5
MnMinT
MnMaxT
SOI
PropT>=29
MnMaxMinT
MnMaxMaxT
MnDailyRF

Fig. S5

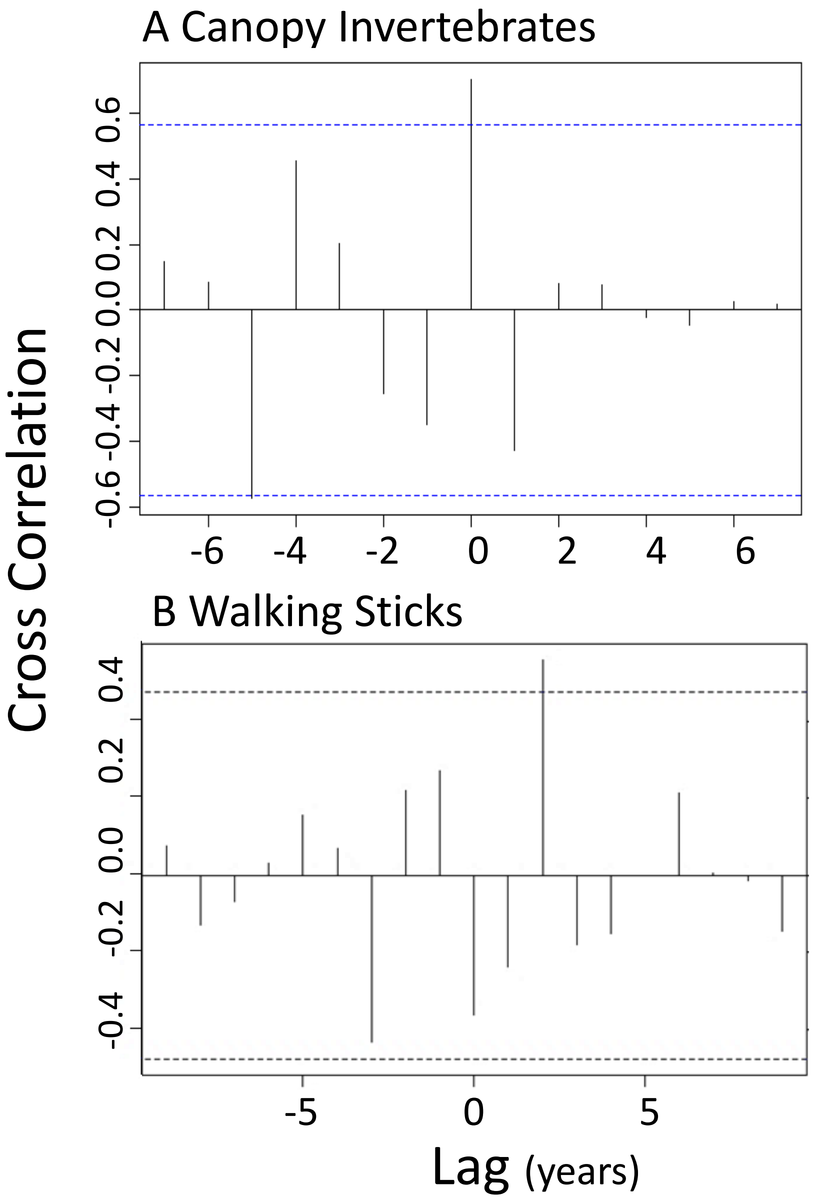

A Canopy Invertebrates
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
-6
-4
-2
0
2
4
6
Cross Correlation
B Walking Sticks
-0.4
-0.2
0.0
0.2
0.4
-5
0
5
Lag (years)

Fig. S6

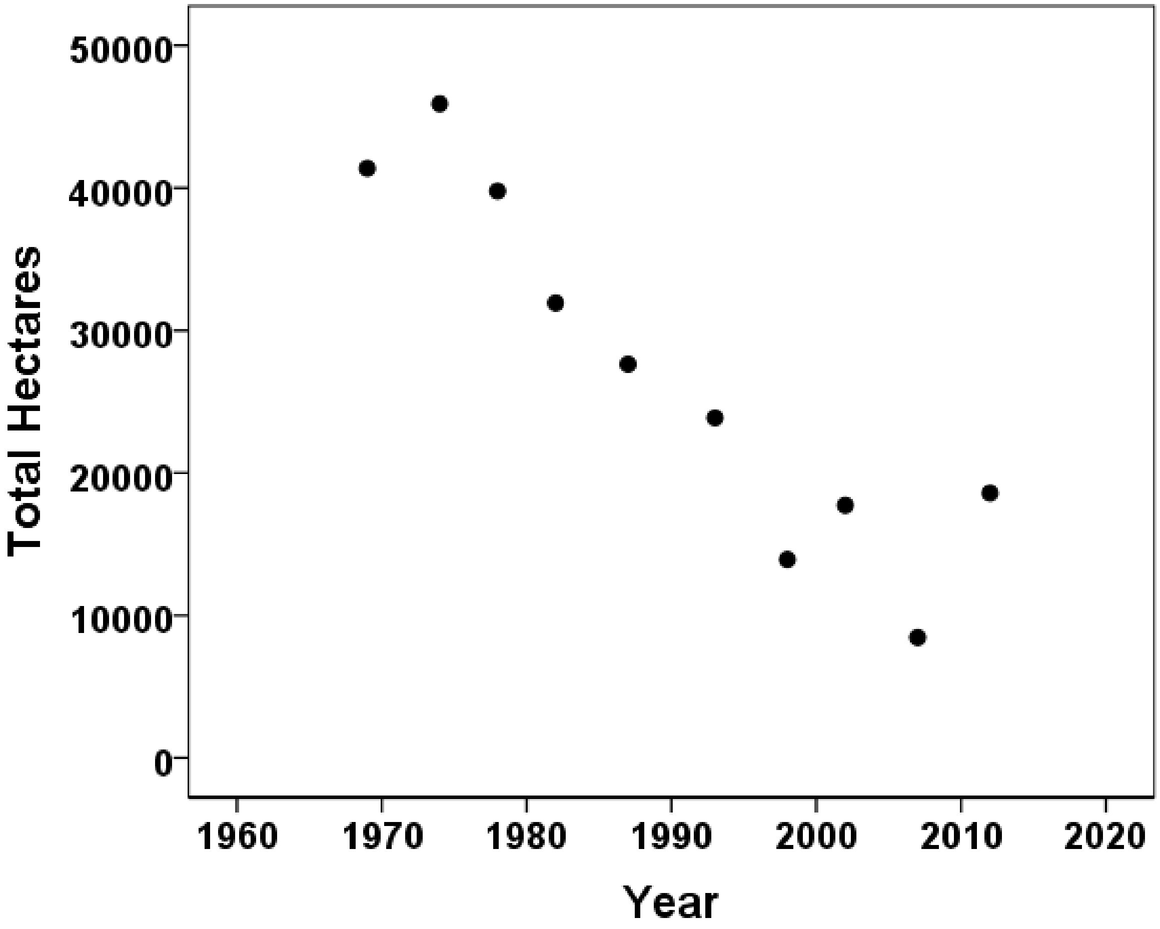

50000
40000
30000
20000
10000
0
Total Hectares
1960
1970
1980
1990
2000
2010
2020
Year

Fig. S7.

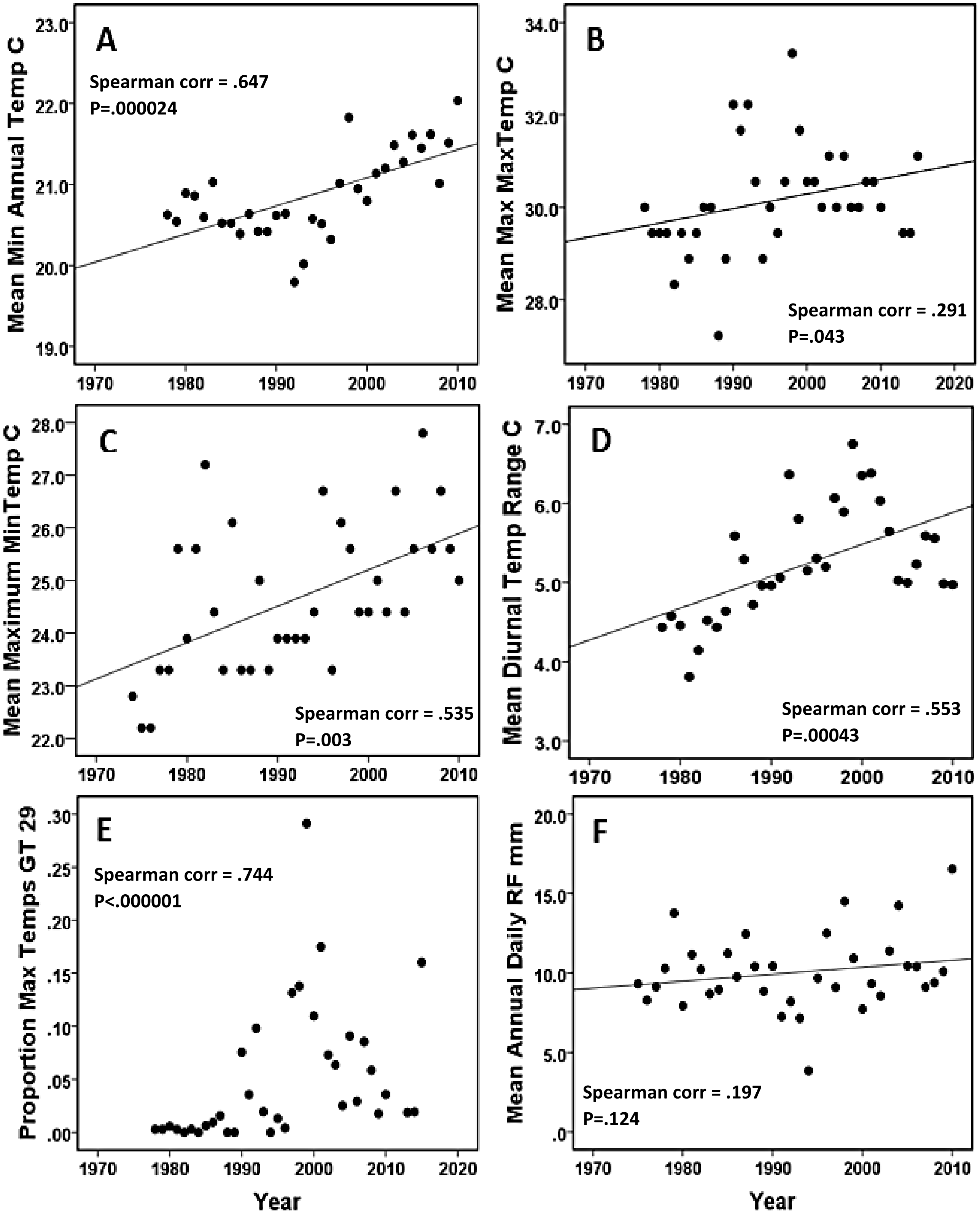

A
Mean Min Annual Temp C
Spearman corr = .647
P=.000024
19.0
20.0
21.0
22.0
23.0
1970
1980
1990
2000
2010
B
Mean Max MaxTemp C
Spearman corr = .291
P=.043
28.0
30.0
32.0
34.0
1970
1980
1990
2000
2010
2020
C
Mean Maximum MinTemp C
Spearman corr = .535
P=.003
22.0
23.0
24.0
25.0
26.0
27.0
28.0
1970
1980
1990
2000
2010
D
Mean Diurnal Temp Range C
Spearman corr = .553
P=.00043
3.0
4.0
5.0
6.0
7.0
1970
1980
1990
2000
2010
E
Proportion Max Temps GT 29
Spearman corr = .744
P<.000001
.00
.05
.10
.15
.20
.25
.30
1970
1980
1990
2000
2010
2020
Year
F
Mean Annual Daily RF mm
Spearman corr = .197
P=.124
.0
5.0
10.0
15.0
20.0
1970
1980
1990
2000
2010
Year

Fig. S8

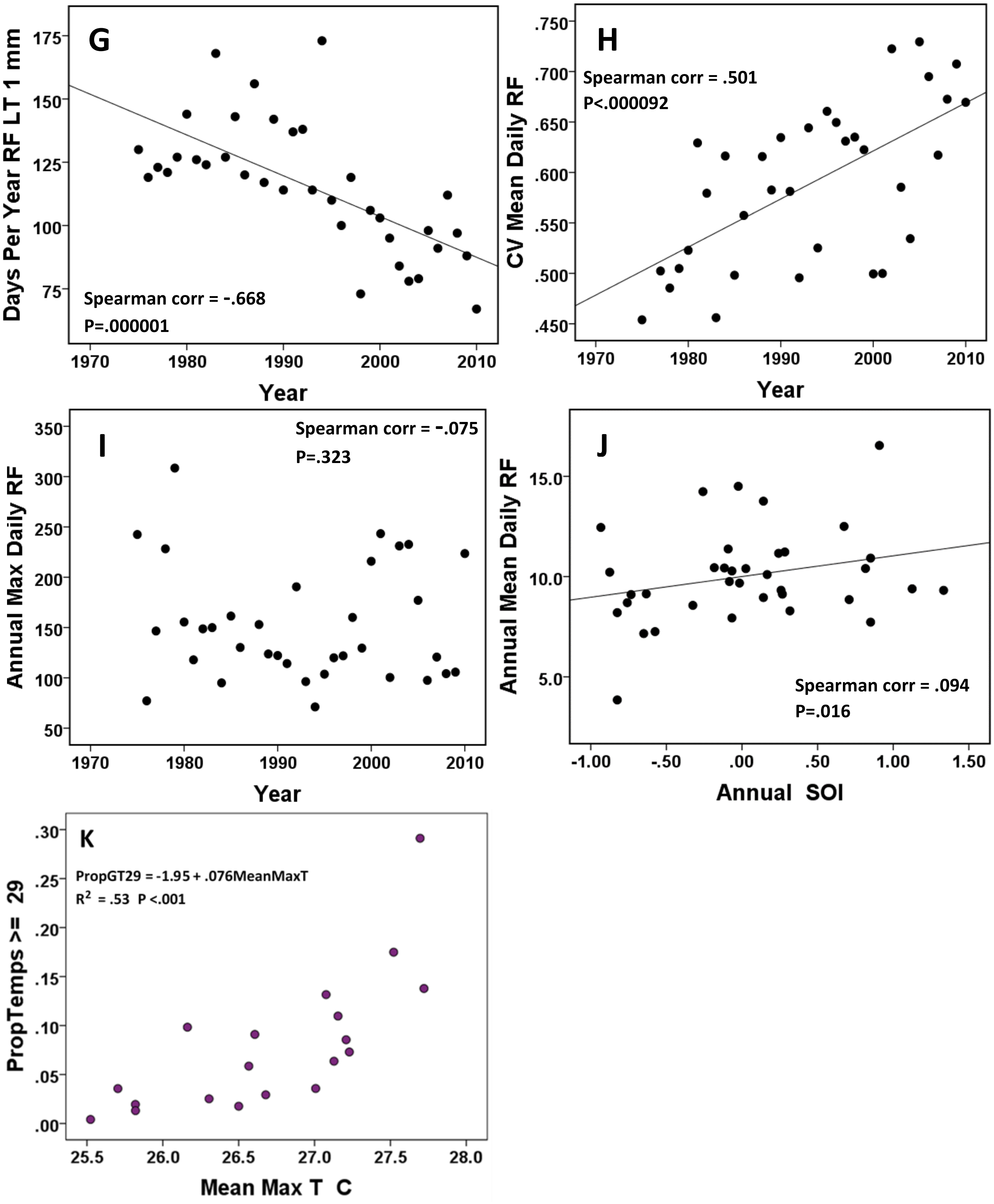


Fig. S8 continued

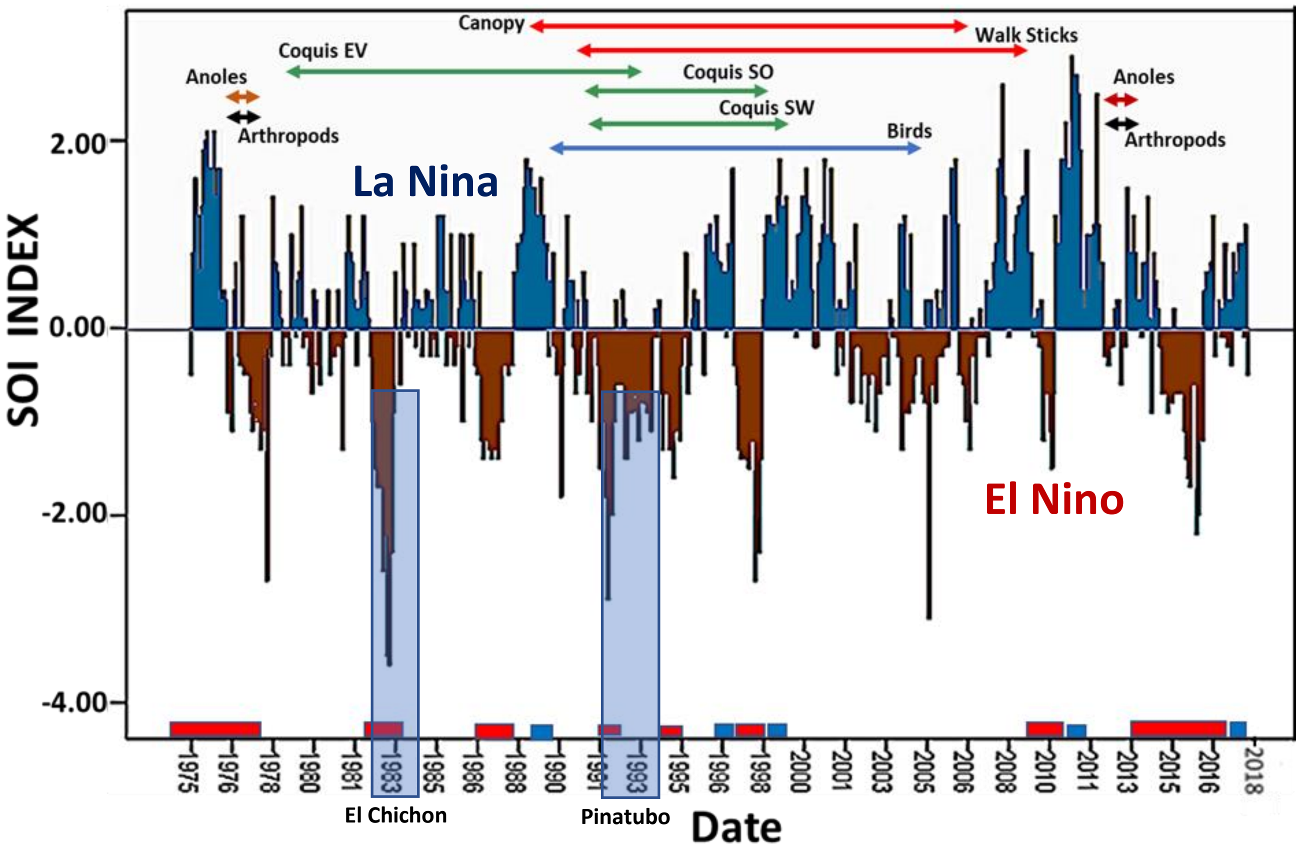
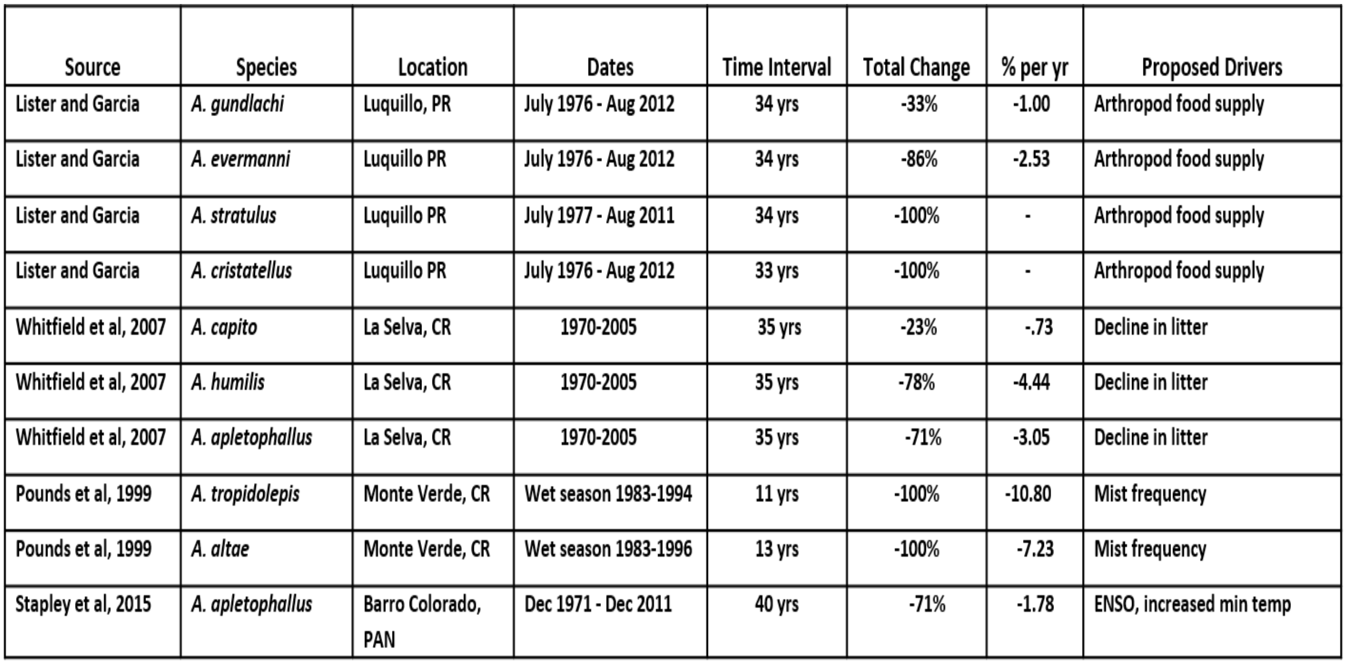

SOI INDEX
2.00
0.00
-2.00
-4.00
Canopy
Walk Sticks
Coquis EV
Coquis SO
Coquis SW
Birds
Anoles
Arthropods
Anoles
Arthropods
La Nina
El Nino
1975
1976
1978
1980
1981
1983
1985
1986
1988
1990
1991
1993
1995
1996
1998
2000
2001
2003
2005
2006
2008
2010
2011
2013
2015
2016
2018
El Chichon
Pinatubo
Date

Fig. S9

Table S1

Date	Species	Sex	Estimated N	95% CI	Estimated Anole Biomass (g per quadrat)
Jul 1976	*A. gundlachi*	Adult male	40	38-42	192
		Adult female	42	34-56	100
		Juveniles	0	-	0
	A. evermanni	Adult male	23	20-26	80
		Adult female	24	20-30	56
		Juveniles	0		0
	A. stratulus	Adult male	4	-	10
		Adult female	4	-	7
		Juveniles	0	-	0
	TOTALS		137		445 g
Jan 1977	*A. gundlachi*	Adult male	36	28-45	189
		Adult female	33	24-50	63
		Juveniles	25		21
	A. evermanni	Adult male	8	6-10	36
		Adult female	10	9-12	19
		Juveniles	18	-	13
	A. stratulus	Adult male	4	-	10
		Adult female	4	-	7
		Juveniles	0	-	0
	TOTALS		138		357 g
					MEAN = 401 g
Aug 2011	*A. gundlachi*	Adult male	19	17-21	152
		Adult female	42	40-44	117
		Juveniles	0	-	0
	A. evermanni	Adult male	0	-	-
		Adult female	2	-	15
		Juveniles	0	-	0
	A. stratulus	Adult male	0	-	0
		Adult female	0	-	0
		Juveniles	0	-	0
	TOTALS				284 g
Jan 2012	*A. gundlachi*	Adult male	15	14-16	131
		Adult female	40	37-43	105
		Juveniles	5	-	4
	A. evermanni	Adult male	1	-	3.8
		Adult female	7	-	27
		Juveniles	0	-	0
	A. stratulus	Adult male	0	-	0
		Adult female	0	-	0
		Juveniles	0	-	0
	TOTALS		68		271 g
					MEAN = 277 g

Table S2



Source	Species	Location	Dates	Time Interval	Total Change	% per yr	Proposed Drivers
Lister and Garcia	*A. gundlachi*	Luquillo, PR	July 1976 - Aug 2012	34 yrs	-33%	-1.00	Arthropod food supply
Lister and Garcia	*A. evermanni*	Luquillo PR	July 1976 - Aug 2012	34 yrs	-86%	-2.53	Arthropod food supply
Lister and Garcia	*A. stratulus*	Luquillo PR	July 1977 - Aug 2011	34 yrs	-100%	-	Arthropod food supply
Lister and Garcia	*A. cristatellus*	Luquillo PR	July 1976 - Aug 2012	33 yrs	-100%	-	Arthropod food supply
Whitfield et al, 2007	*A. capito*	La Selva, CR	1970-2005	35 yrs	-23%	-.73	Decline in litter
Whitfield et al, 2007	*A. humilis*	La Selva, CR	1970-2005	35 yrs	-78%	-4.44	Decline in litter
Whitfield et al, 2007	*A. apletophallus*	La Selva, CR	1970-2005	35 yrs	-71%	-3.05	Decline in litter
Pounds et al, 1999	*A. tropidolepis*	Monte Verde, CR	Wet season 1983-1994	11 yrs	-100%	-10.80	Mist frequency
Pounds et al, 1999	*A. altae*	Monte Verde, CR	Wet season 1983-1996	13 yrs	-100%	-7.23	Mist frequency
Stapley et al, 2015	*A. apletophallus*	Barro Colorado, PAN	Dec 1971 - Dec 2011	40 yrs	-71%	-1.78	ENSO, increased min temp

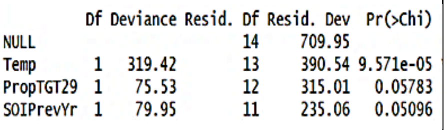
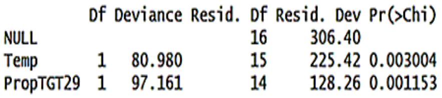
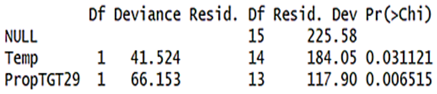
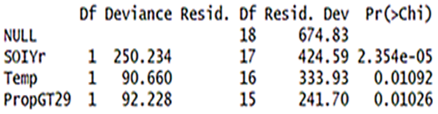
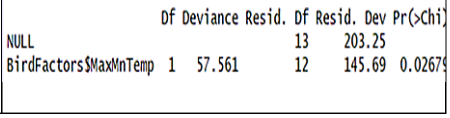
Table S3

Index	Definition	Units	Justification
MnMaxT	Mean of maximum daily temps	^{o}C	Rising temperatures are affecting all life in the Biosphere
MnMinT	Mean of minimum daily temps	^{o}C	Minimum (night time) temperatures are increasing faster than day time temperatures. Higher nocturnal temperatures are known to have a significant negative impact on the abundances and population growth rates of tropical vertebrates.
MnMaxMaxT	Mean of maxima of daily maximum temps	^{o}C	Extreme day time temperatures can have a wide range of nonlinear, negative effects on the fitness and abundances of plants and animals
MnMaxMinT	Mean of the maxima of daily minimum temps	^{o}C	Given the rapid elevation in night time temperatures, extremes of nocturnal temperatures are becoming increasingly important to understanding the biological effects of climate warming.
PropT>=29	Proportion of days per year when daily temperature exceeds 29 ^{o}C	-	A measure of increases in extreme temperatures, and, indirectly, the duration that plants and animals are exposed to these extremes.
DiurnTRange	Mean diurnal temp range	^{o}C	A measure of the quotidian variability in temperatures that animals and plants are exposed to. Affects metabolic demands, energy needs, and sensitivity to climate change. Diurnal temperature range has been decreasing worldwide since the 1950s
MnDailyRF	Annual mean daily rainfall	mm/day	Like temperature, rainfall affects all living things starting with plant productivity. Invertebrates and amphibians are especially sensitive to variations in precipitation and moisture.
DaysRF<1	N days per year when total rainfall is less than 1 mm	days	Consecutive dry days. Correlated with other measure of the dryness of a given habitat including reduced humidity, soil moisture and, over the long term, severity of drought. Known to be increasing over large areas of Central America.
SOI	The Southern Oscillation Index is a measure of the intensity of El Niño and La Niña events in the Pacific Ocean. The SOI is calculated from the normalized monthly mean sea level pressure anomalies at Tahiti and Darwin. The anomalies are calculated as departures from the 1951 to 1980 based period.	-	Fluctuations in the SOI are correlated with weather extremes including hurricanes, drought and heat waves that can have major, long lasting impacts on populations

Table S4

Group	**X**	**Y**	**Covariate**	**UI**	**Causation**
E. coquis El Verde	MeanMaxT	Abundance	MnDailyRF	100	X ➔ Y
E. coquis SW	MeanMaxT	Abundance	MnDailyRF	100	X ➔ Y
E. coquis SO	MeanMaxT*	Abundance	MnDailyRF	15.7	X↔Y
Walking Sticks *L. portoricensis*	MeanMaxT	Abundance	None	100	X ➔ Y
Canopy Insects	MeanMaxT	Abundance	MnDailyRF	100	X ➔ Y
Birds El Verde	MeanMaxT	Abundance	MnDailyRF	100	X ➔ Y

Table S5

Population	Model	Residual Deviance and Significance
E. coquis El Verde	ln(N) = 21.3 - .65MnMaxT - 16.21PropGt29 + .44SOIPrevYr	
E. coquis Sonadura West	ln(N) = 20.7 - .65MnMaxT + 8.02PropGt29	
E. coquis Sonadura Old	ln(N) = 12.4 - .32MnMaxT + 7.17PropGt29	
Walking Sticks *L. portoricensis*	ln(N) = 20.7 - .62MnMaxT - .58SOIYr + 4.0PropGt29	
Birds	ln(N) = 12.13 - .29MnMaxT	

E. coquis El Verde

```
          Df Deviance Resid. Df Resid. Dev  Pr(>Chi)
NULL                         14     709.95
Temp       1   319.42        13     390.54 9.571e-05
PropTGT29  1    75.53        12     315.01   0.05783
SOIPrevYr  1    79.95        11     235.06   0.05096
```

E. coquis Sonadura West

```
          Df Deviance Resid. Df Resid. Dev Pr(>Chi)
NULL                         16     306.40
Temp       1   80.980        15     225.42 0.003004
PropTGT29  1   97.161        14     128.26 0.001153
```

E. coquis Sonadura Old

```
          Df Deviance Resid. Df Resid. Dev Pr(>Chi)
NULL                         15     225.58
Temp       1   41.524        14     184.05 0.031121
PropTGT29  1   66.153        13     117.90 0.006515
```

Walking Sticks *L. portoricensis*

```
        Df Deviance Resid. Df Resid. Dev  Pr(>Chi)
NULL                       18     674.83
SOIYr    1  250.234        17     424.59 2.354e-05
Temp     1   90.660        16     333.93   0.01092
PropGT29 1   92.228        15     241.70   0.01026
```

Birds

```
                         Df Deviance Resid. Df Resid. Dev Pr(>Chi
NULL                                        13     203.25
BirdFactors$MaxMnTemp  1   57.561          12     145.69  0.0267
```

SI References

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