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TI 2018-039/VIII
Tinbergen Institute Discussion Paper

Economics in the Anthropocene: Species Extinction or Steady State Economics

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Economics in the Anthropocene:

Species Extinction or Steady State Economics.

By Joeri Sol[*]

April 11th, 2018

Using IUCN Red List of Threatened Species (2016v2) data, I calculate an expected extinction rate for the coming century that is 759 to 7,582 times the natural background rate. Extinction rates exceed the planetary boundary formulated by Rockström et al. (2009) nearly everywhere (521 out of 538 regions) and do so beyond the zone of uncertainty introduced by Steffen et al. (2015) in 329 regions (or 51.5 percent of land surface). I show that species extinction increases with population density and GDP per capita, and while I cannot claim causal links, my findings suggest that the conservation of nature requires degrowth or at least a transition to a steady state economy.

"*I cannot, therefore, regard the stationary state of capital and wealth with the unaffected aversion so generally manifested towards it by political economists of the old school. I am inclined to believe that it would be, on the whole, a very considerable improvement on our present condition.*"

John S. Mill (1848, Book 4, Chapter 6)

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Crutzen (2002) proposed to adopt the term Anthropocene to describe the geological epoch during which mankind has obtained an influence on global natural processes (e.g., the atmospheric concentration of carbon dioxide, methane, nitric oxide and sulphur dioxide). Although the formalization of the Anthropocene with the International Union of Geological Sciences is still under way, Waters et al. (2016) argue that humanity's stratigraphic signature is already sufficiently distinct to recognize this geological epoch by reviewing evidence of the growth of new materials (e.g. concrete and plastics) and the transformation of land and ocean surface by mineral extraction and trawler fishing. Wackernagel et al. (2002) estimated that consumption rose from using 70% of Earth's regenerative capacity in 1961 to 120% in 1999, and according to WWF (2016) it currently takes the regenerative capacity of 1.6 Earths to provide for the renewable resources that we lay claim on.

The (pending) arrival of the Anthropocene makes it more salient that continued growth of economic activity carries the risk of irreversibly damaging global carrying capacity.[1] Rockström et al. (2009) formulate nine planetary boundaries for economic activity and assign parameter values to eight such ecological limits; currently, we surpass three safe thresholds.[2] Naturally, idea that economic growth can only be a transitory stage is not new to economics (Malthus, 1798; Mill, 1848; Boulding, 1966; Meadows et al., 1972). Daly (1974) already reasoned for the desirability and necessity of steady state economics based on common sense and

[1] This paper follows Daly (2013)'s recommendation to distinguish between economic growth and economic development. A steady state economy does not allow for quantitative growth of physical wealth, but leaves room for development, i.e., qualitative improvements in the amount of service obtained from this wealth.

[2]That is, climate change, biodiversity loss, and the nitrogen cycle. Recently, Steffen et al. (2015) propose to distinguish between two thresholds: *'in zone of uncertainty*' and '*beyond zone of uncertainty*'. The authors place the loss of biodiversity and our influence over the nitrogen and phosphorus cycles in the latter category.

the second law of thermodynamics.[3] The accumulated evidence that we risk seriously harming global carrying capacity with continued economic growth makes this paradigm shift urgent as well.

This paper concentrates on biodiversity loss. Reductions in biodiversity can harm global carrying capacity through reduced ecosystem efficiency and resilience, and for many, through reduced immaterial value.[4] Rockström et al. (2009) propose a planetary boundary of 10 extinctions per million species years (E/MSY) and Steffen et al. (2015) add a "*zone of uncertainty*" of up to 100 E/MSY. Background extinction due to natural selection is thought to lie between 0.1 and 1 E/MSY and the global extinction rate is currently estimated to lie between 100 and 1000 E/MSY (Rockström et al., 2009; Steffen et al., 2015). Using IUCN Red List of Threatened Species (2016v2) data, I calculate a global expected extinction rate for the coming century that is 759 E/MSY.[5]

Subsequently, I explore regional variation in expected species extinction across 538 regions, covering 98% of global land surface. I show that only 17 regions stay below the proposed planetary boundary for biodiversity loss, while in 329 regions

[3] See also Georgescu-Roegen (1971). Steady state economics is not to be confused with the steady state growth paths studied by Solow (1956).

[4] See, for example, Cardinale et al. (2012, p. 60-61) on ecosystems efficiency: *"… as a general rule, reductions in the number of genes, species and functional groups of organisms reduce the efficiency by which whole communities capture biologically essential resources (nutrients, water, light, prey), and convert those resources into biomass."* and see Rockström et al. (2009, p. 474) on ecosystems stability: *"Ecosystems that depend on a few or single species for critical functions are vulnerable to disturbances, such as disease, and at a greater risk of tipping into undesired states."* See discussions in Dirzo et al. (2014) and Costanza et al. (1997) for the importance of biodiversity for ecosystem services and the valuation of ecosystem services, respectively.

[5] Although the practice of turning assessment categories into extinction probabilities is not undebated (e.g. rankings based on extinction rates that combine assessment categories are sensitive to the chosen probabilities), Mooers et al. (2009, p. 3700) describe that: "*The Red List is currently the only basis we know of for consistent, broadly-available estimates of extinction risk, and indeed was originally formulated to be consistent with (at least) notional probabilities of extinction.*" Using an alternative method, based on simulations of species abundance and habitat size relations, Pimm and Raven (2000) estimate expected extinction rates for the coming century that range from well over 3.000 E/MSY to almost 50.000 E/MSY, depending on the conservation scenario.

expected extinction rates surpass the planetary boundary beyond the zone of uncertainty. I regress these regional expected extinction rates on both population density and GDP per capita and obtain positive partial correlation after controlling for the land surface of the region, for 11 (sub)continental dummies, and for the regions being islands or landlocked. Although the partial correlations do not allow for the causal inference of an effect of human activity on species extinction, my findings are consistent with the interpretation that economic growth beyond planetary boundaries harms global carrying capacity.[6]

While I do consider the regional variation in expected extinction rates that I illustrate in this paper informative, I caution the reader to base conservation priorities solely on these rates. In terms of the library metaphor in Weitzman (1998)'s Noah's Ark problem, the expected extinction rates could be considered the survival probability of a library, but not the number of books in the library (i.e., species richness) nor their distinctiveness (i.e., species' isolation on a phylogenetic tree). For maps of species richness and genetic diversity, see Greyner et al. (2006) and Miraldo et al. (2014), respectively.[7] To the best of my knowledge, this paper is first to map expected species extinction relative to expected background extinction.

This paper proceeds as follows: Section I describes the data, Section II contains the analysis, and Section III concludes.

[6] Dirzo et al. (2014) uses an earlier version of the IUCN Redlist data to illustrate that the body mass of extinct fauna is larger than that of threatened fauna, which in turn is much larger than non-threatened fauna; a pattern consistent with a human influence.

[7] See Myers et al. (2000) for the identification of 25 biodiversity hotspot. See Isaac et al. (2007)'s edgeofexistence.org program and for an example that combines extinction risk and evolutionary distinctiveness to set conservation priorities. See Veron et al. (2017) for a discussion of incorporating evolution distinctiveness and phylogenetic diversity into conservation policy.

I. Data

The IUCN Redlist of Threatened Species contains assessments of extinction threat levels for both plant and animal species based on population size, habitat range and estimated extinction risk. This paper uses the 2016-2 version that contains 82,954 assessments, categorized as either least concern (39,053), data deficient (13,489), vulnerable (11,219), endangered (7,602), near threatened (5,323), critically endangered (5,107), extinct (855), lower risk/conservation dependent (238), or extinct in the wild (68). Most of the assessments are carried out by IUCN Species Survival Commission (SSC), and all assessment are reviewed by a member from the Red List Authority on the relevant taxonomic group. Close to 70 percent of the assessments has been (re-)assessed after 2010.

To construct my measure for expected species extinction, I assume that the sufficiency criterion about extinction risks is a valid estimate for the extinction risk for all assessments within the category.[8] For critically endangered species, the extinction risk criterion specifies a probability of extinction of at least 50% during the coming 10 years, and for endangered and vulnerable species 20% and 10% within 20 and 100 years, respectively (IUCN, 2012).[9] I add the expected background extinctions by multiplying the number of non-extinct non-data deficient assessed species with the upper bound estimate for background extinction from Rockström et al. (2009) of 1 E/MSY. Finally, I express this estimate for expected extinctions relative to the background extinction to create

[8] On the hand, one can argue that this assumption leads underestimation of the extinction rate, as it is a sufficiency criterion. On the other hand, it is only one out of five sufficiency criteria, allowing for overestimation of the extinction rate. Other sufficiency conditions specify population size, changes to population size and habitat ranges; for example, a "*population size estimated to number fewer than 50 mature individuals*" gives the assessment critically endangered (IUCN 2012, p.9). See IUCN (2012) for the complete description of the sufficiency criteria.

[9] I further assume that (critically) endangered species that managed to survive (ten) twenty years will continue to do so for the remainder of the century. Assuming that (critically) endangered species that survive (ten) twenty years face an unchanged extinction risk, would more than double the global extinction rate estimate. This alternative assumption also implies that less than one in thousand critically endangered species can be expected to survive the century.

my dependent variable, heightened *Extinction Rate*. Globally, the extinction rate is 759 to 7582 times the background extinction rate, while the proposed planetary boundary is at 10 times background extinction.[10]

To calculate the regional estimates, I only consider the assessments of species that were labelled as (once) native to the respective regions. The dataset includes 538 regions, covering 98% of global land surface. Note that, although I refer to regional estimates, I still base my estimates on global extinction risk. For example, the Giant Panda which is assessed as vulnerable and regionally extinct in Hunan, still contributes to the extinction rate of Hunan, because it is labelled as once native to the region.

Figure 1 presents the distribution of *Extinction Rate* by regions geographically.[11] The 17 regions in the dark green color stay below the planetary boundary for biodiversity loss, representing 2.6 percent of assessed land area. The 192 regions in the zone of uncertainty are depicted in light green and yellow and make up 45.9 percent of assessed land. Due to the positive skew in the regional estimates, illustrated in Figure 2, I chose different bin sizes for the remaining colors, with cut-off levels of 50, 100, 200, 300, and 500 hundred times the background extinction rate, respectively. Apart from the consideration that the extinction rate should be somewhat comparable within color category and the intention to illustrate the variation in extinction rates, these cut-off levels are arbitrary.

< Insert Figure 1, Figure 2 and Table 1 about here>

[10] This estimate of 759 consists of the expected number extinctions due to heightened extinction risk, 5,195.8 (=0.5*5,107+0.2*7,602+0.1*11,219) plus background extinctions 6.852 (=1*(82,954 – 855 – 86 – 13,489)*100/1,000,000) relative to the background extinction. Using the lower bound for background extinction gives an expected rate of 7582 times the background rate and planetary boundary of 100 times the background rate. In the remainder of the paper, I discuss the estimates expressed relative to the upper bound estimate for background extinction.

[11] In case I was unable to determine whether an area was not assessed, or uncertain to which assessed region the area belongs, I left the area blank. The 19 FAO marine regions are not included in the analysis and left undiscussed except for footnote 15 and Appendix Figure C.

Table 1 presents the number of observations, mean, standard deviation, and correlations for *Extinction Rate* and the two main independent variables of interest. In the regression analysis, I use the natural logarithm of *Extinction Rate* due to the earlier mentioned skew. For population density (measured in inhabitants per square kilometer) and GDP per capita (per year, measured in 2011 PPP international dollars where available and in US dollar otherwise), I used the most recent estimates from the World Bank for most countries, complemented with regional estimates from various sources.[12] Both population density and GDP per capita exhibit a large positive skew as well, hence I use *Ln Population Density* and *Ln GDP per Capita* as independent variables in the regression analysis. The number of observations for the population density variable drops to 528 (due to the omission 10 uninhabited islands after the log transformation). I found estimates of the *GDP per Capita* for 489 regions.

The difference between the regional mean (189) and global extinction rate (759) may seem surprising at first, however this difference is expected when (critically) endangered species have smaller habitats; i.e. species of least concern occur in several regional estimates, but only once in the global estimate. For this reason, all regressions control for the regions' land surface. Inspection of Figure 1 and 2 also reveals that part of the variation may be attributed to regions being coastal, landlocked or islands. Landlocked regions have lower extinction rates and islands have higher extinction rates. Similarly, Figure 1 illustrates notable (sub)continental variation, perhaps related to the type of ecosystems or regional

[12] The regional estimates for the population density, GDP per capita, and land area of states, islands, and provinces in Argentina, Australia, Brazil, Canada, Chile, China, India, Indonesia, Japan, Malaysia, New Zealand, Russia, South Africa, and the United States were obtained from Wikipedia. The relevant pages refer to the respective census bureaus, and except for the population density estimates for Russia (2004) and the regional GDP per capita estimates for Argentina (2008), Japan (2007) and Russia (2009), all estimates are from 2010 or more recent.

interdependencies. In the regression analysis, I add 14 dummies to control for these types regional variation.[13] Next, I turn to the regression analysis to estimate partial correlations.

II. Analysis

I start by regressing my extinction rate measure on population density in (1), and subsequently on population density and GDP per capita in (2) due to the different number of observations for both variables:

$$Ln\ Extinction\ Rate_i = \beta_0 + \beta_1 Ln\ Population\ Density_i + \sum_{j=2}^{16} \beta_j\ Control_{ji} + \varepsilon_i, \quad (1)$$

$$Ln\ Extinction\ Rate_i = \beta_0 + \beta_1 Ln\ Population\ Density_i + \beta_2 Ln\ GDP\ per\ Capita_i + \sum_{j=3}^{16} \beta_j\ Control_{ji} + \varepsilon_i, \quad (2)$$

where *i* refers to the region and *j* to the earlier discussed controls.[14] Under the null hypothesis, supposing that absolute scarcity is irrelevant, one may expect $\beta_1 \leq 0$ and $\beta_2 \leq 0$; that is, regional population density and GDP per capita is either unrelated to extinction rates or negatively related (e.g. when more prosperous regions have more means for conservation or export their polluting activities, see

[13] Except for the Canary Islands, Hawaii, Madeira and the Selvages, I followed the IUCN division of (sub)continental areas. I have relabelled the Canary Islands, Madeira and the Selvages as North African regions and placed Hawaii in Oceania, instead of Europe and North America, respectively. In the regression analysis I introduce dummy variables for *Antarctica* (7 regions), *Caribbean* (30 regions), *East Asia* (44 regions), *Europe* (45 regions), *Mesoamerica* (42 regions), *North Africa* (9 regions), *North America* (64 regions), *North Asia* (26 regions), *Oceania* (48 regions), *South and Southeast Asia* (55 regions), *Sub Saharan Africa* (65 regions), *West and Central Asia* (27 regions), where the 76 regions in South America serve as the base category. In addition, I add dummy variables for regions being landlocked (171 regions) and island (145 regions), where the 222 coastal regions serve as the base category. See Appendix Figure A for the distribution of the extinction rate within (sub)continental regions.

[14] The different number of controls is due to the omission of Antarctica in (2), as I did not find estimates for Antarctic regions' GDP per capita.

also Arrow et al. (1995)). The alternative hypothesis, $\beta_1 > 0$ and $\beta_2 > 0$, is consistent with absolute scarcity being relevant; that is, more densely populated regions and regions with more economic activity harm carrying capacity at some point. Table 2 presents the estimates of equation (1) and (2) using ordinary least squares in columns (1) and (2). In column (3), I cluster standard errors on this (sub)continental level.

< Insert Table 2 here >

Column (1) and (2) of Table 2 show that a doubling of population density is associated with an increase in the extinction rate of 11.2 percent, and of 15.6 percent after controlling for GDP per capita in the smaller sample, respectively. These estimates are statistically significant at the 1 percent level. GDP per capita is also positively related to the extinction rate (*p-value* = 0.035), where a doubling is associated with an increase of 8.3 percent.[15] Although partial correlations do not allow for causal inference of an effect of human activity on species extinction, to put these estimates in perspective, the expected global population increase from 7.3 billion to the UN estimate of 11.2 billion by the end of the century would raise the extinction rate with 8.3 percent (United Nations, 2015). For the current

[15] The results are robust to clustering standard errors on the (sub)continental level, see column (3). Both models (1) and (2) are significant improvements over the models that only include controls, as illustrated with the F-statistics and Likelihood Ratio tests reported in the bottom row of Table 2. Appendix Table A presents the OLS regressions of *Ln Extinction Rate* on the controls only, which give R^2 values of .490 and .507, for the samples used in column (1) and (2), respectively. If anything, I expect my estimates to suffer from downward attenuation bias due regional spillovers. On top, Appendix Figure C presents a scatterplot of *Ln Extinction Rate* and *Ln Population Density* for (sub)continental and FAO marine regions, suggesting that the positive relation is also present at the (sub)continental and oceanic level.

number of assessed species, this is equivalent to 432 additional expected extinctions, about half the number of recorded during the past millennium.[16]

As mentioned, my data does not allow for causal inference, yet it is difficult to think of explanations other than current levels of human activity doing harm to regional carrying capacity. One such alternative explanation could be that the assessment process rather than absolute scarcity explains the earlier shown relations. If endangered species are more difficult to assess for researchers in more sparsely populated regions or researchers in richer regions have more means to make such assessments, extinction rates may vary with assessment effort. However, controlling for the (log) number of species assessed and the (log) number of data deficient species does not change the results qualitatively.

III. Concluding remarks

Several authors warn that we may find ourselves at the start of sixth wave of species mass extinction (e.g. Leakey, 1995; Wake and Vredenburg, 2008; Barnosky et al., 2011). According to the IUCN assessments, we may need to record more than five times the number of extinctions during the coming century than we did in the past millennium.[17] Continued growth of population and GDP per capita is likely to increase the number extinctions even further. For the sake of posterity, I sincerely hope that we can turn this tide of species extinction and keep these estimates from having predictive power.

So far, this paper has ignored the information on the type of threats provided with the IUCN assessments. The largest threat categories (biological resource use, agri-

[16] The global extinction rate would be raised from 759 to 822, or an additional 63 times the background extinction of 6.9 species. Species are considered extinct if they have not been observed over the last 50 years. For some of the included extinctions, the last observations date back from the 11th century (e.g., the Madagascan Dwarf Hippopotamus).

[17] Also note that, the past thousand years we have already experienced more extinctions than we would have expected from background extinction only; based on the IUCN sample we would expect to have recorded 8.3 to 83 extinctions during the last millennium instead of 855.

and aquaculture, and claims on land for residential and commercial development) could be remedied against by protecting sufficiently large habitats. Fortunately, the urgency of reducing the threat to biodiversity seems increasingly recognized in policy circles, e.g. the United Nations declared this decade as the United Nations Decade on Biodiversity (UN, 2011). Unfortunately, many nations still fail to meet the 2020 Aichi Biodiversity Targets for legally protected areas, set at 17 and 10 percent of land area and territorial waters, respectively (UNEP, 2010). Data from The World Bank for reveals that 88 out of 217 countries met the target for protection on land in 2014, and 54 countries did so for marine areas. The low coverage of protected areas in some of the most threatened regions is perhaps most alarming.[18] If not the need for conservation, what is driving these differences in protection? Future research aimed at better understanding how to best manage protected areas and how to encourage countries that currently fall short of the Aichi targets seems warranted.

Serious action to preserve biodiversity, considered a moral obligation by many, likely requires institutional changes that go beyond the protection of biodiversity hotspots. For example, the conservation of coral reefs puts a constraint on the consumption of fossil fuel, as Frieler (2013) predicts that it takes limiting global warming to 1.5 degrees Celsius to preserve more than 10 percent of global reefs. Calculations by McGlade and Ekins (2015) illustrate that most known reserves of fossil fuels should remain unused to achieve this objective, yet economic growth oftentimes remains a celebrated means to reduce poverty and improve human welfare. We should realize, however, that continued growth comes at a collective cost, whereas reducing poverty through redistribution of income has less apparent ecological cost. Economic policy in the Anthropocene should aim to improve carrying capacity rather than zealously chase economic growth.

[18] See Appendix Table B.

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List of Figures and Tables

Figure 1: Geographical distribution of *Extinction Rate*.

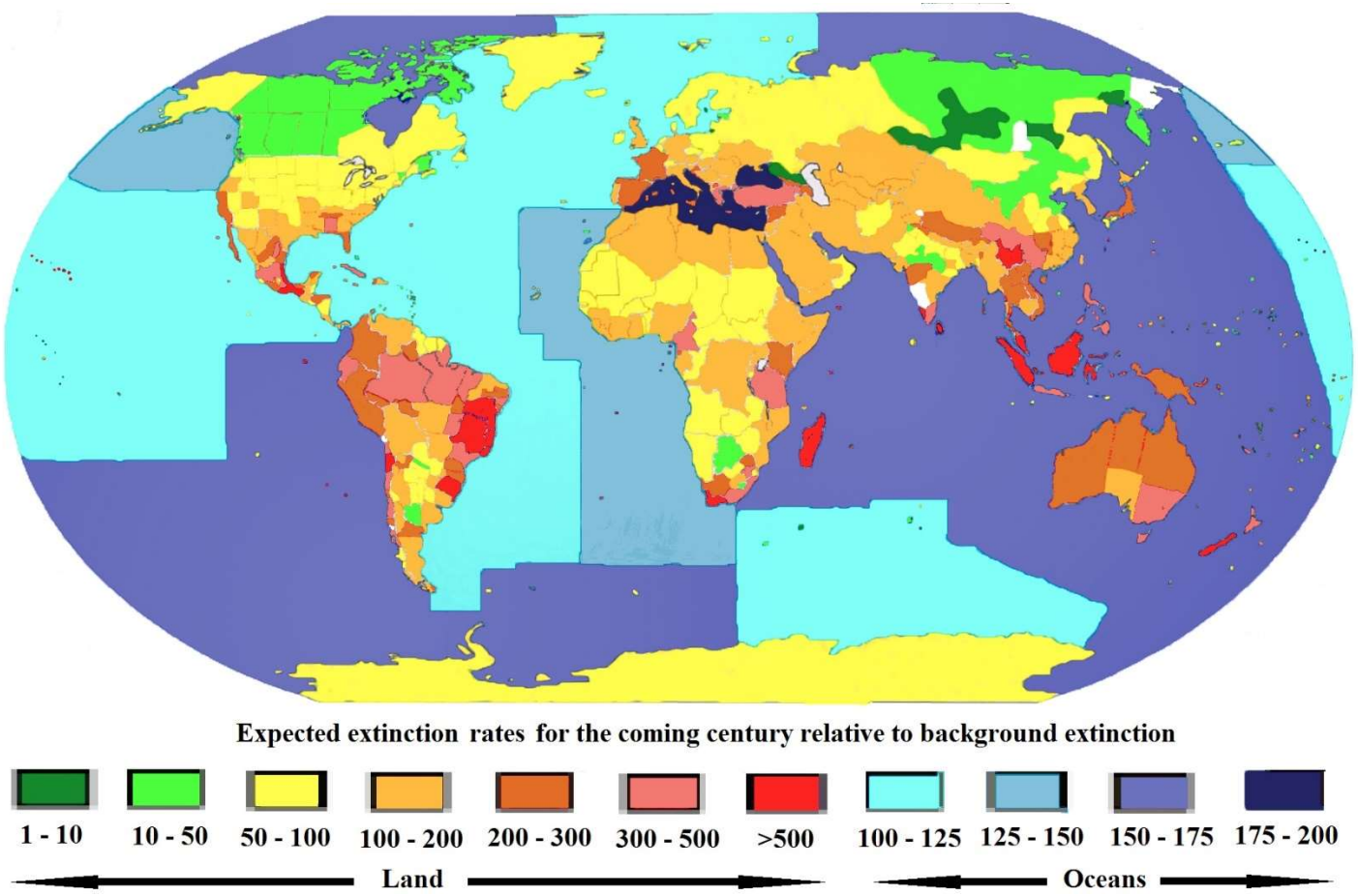


Figure 2: Distribution of *Extinction Rate* by region type.

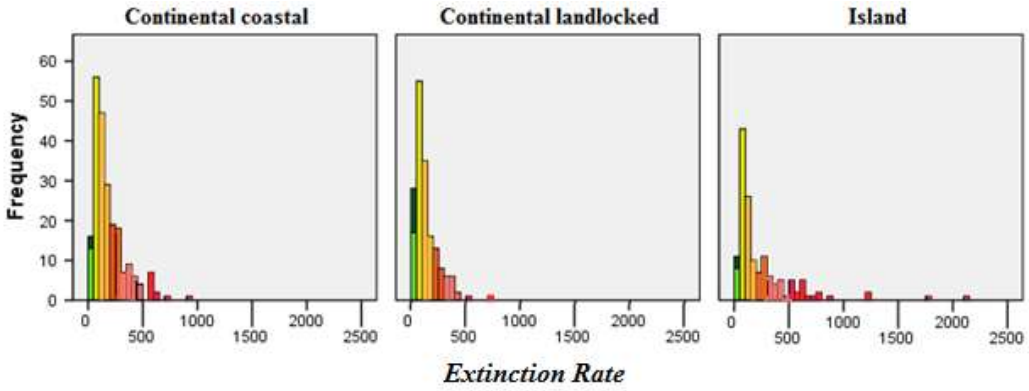


Table 1: Descriptive statistics and correlations:

	N	Mean	SD	(2)	(3)	(4)
(1) Extinction rate	538	189.2	198.3	.44***	-.23	-.12*
(2) Extinctions	538	1.48	6.88		-.02	.10*
(3) Population density	538	214.0	766.6			.07
(4) GDP per capita	489	21.3	21.7			

***, **, * indicate correlations significantly different from zero at the 1%, 5%, and 10%.

Table 2: OLS regression results of *Ln Extinction Rate* on *Ln Population Density* and *Ln GDP per Capita*.

	(1)	(2)	(3)
Ln Population Density	.112***	.156***	.167***
	(.025)	(.027)	(.030)
	[.201]	[.257]	[.275]
Ln GDP per Capita		.083**	.101**
		(.039)	(.040)
		[.094]	[.113]
Controls included	YES	YES	YES
Standard errors clustered	NO	NO	YES
N	528	489	489
R^2	.510	.542	.513
F-statistic[a]	20.86***	18.03***	20.44***

***, **, * indicate coefficients significantly different from zero at the 1%, 5%, and 10%, standard errors are shown in parentheses and standardized coefficients in brackets.

a. Comparison to a model that contains only the control variables.

Appendix

Figure A: Histograms of *Extinction Rate* by (sub)continental regions.

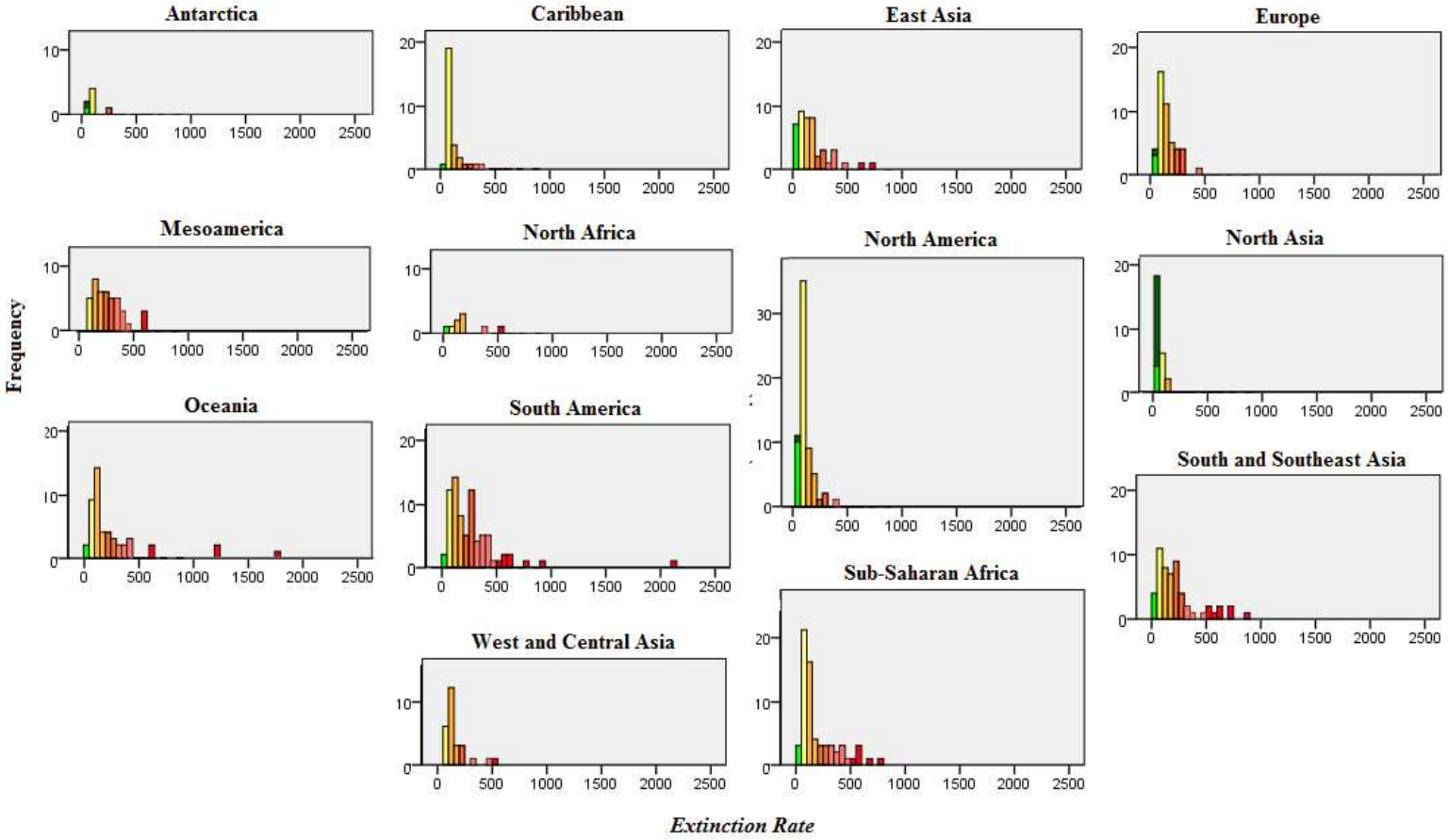
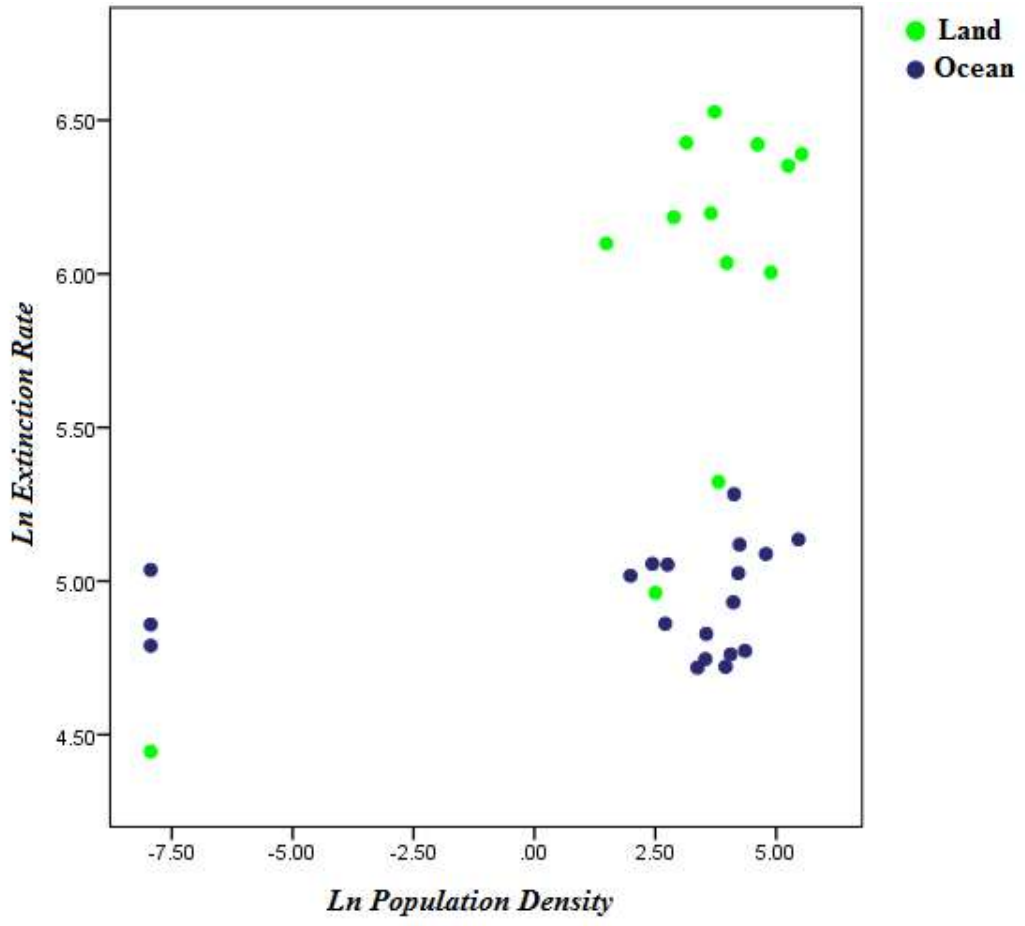


Figure B: Scatterplot of *Ln Extinction Rate* and *Ln Population Density* (sub)continental and FAO marine regions.



To calculate the population density for 19 FAO Marine regions, I divided the sum of population of all islands within and all coastal regions adjacent to the FAO region by the sum of the land area for these regions, and for 13 (sub)continental regions, I included all landlocked regions in the sums as well. An OLS regression of Ln Extinction Rate on Ln Population Density, Ln Surface, and a 'land dummy' for the (sub)continental observations, yields a standardized coefficient for population density of 0.267 (p-value=.020). However, this result is sensitive to the inclusion of Antarctica and the 3 Arctic oceans regions. Without these observations, the coefficient is almost half and no longer significant (.140, p-value = .157).

Table A: OLS regression *Ln Extinction Rate* and *Ln Extinctions* on controls

Dependent variables	*Ln Extinction Rate*	
Independent variables	(1)	(2)
Ln Land area	.084***	.073***
	(.019)	(.020)
Island	.559***	.456***
	(.135)	(.138)
Landlocked	-.345***	-.339***
	(.087)	(.084)
Antarctica[a]	-2.272***	
	(.393)	
Caribbean	-.886***	-.866***
	(.210)	(.224)
East Asia	-.476***	-.468***
	(.161)	(.157)
Europe	-.781***	-.755***
	(.159)	(.155)
Mesoamerica	.140	.132
	(.163)	(.160)
North Africa	-.368	-.209
	(.212)	(.319)
North America	-.944***	-.902***
	(.142)	(.137)
North Asia	-3.448***	-3.554***
	(.190)	(.195)
Oceania	-.287	-.105
	(.182)	(.191)
South and Southeast Asia	-.255*	-.179
	(.150)	(.148)
Sub-Saharan Africa	-.373***	-.344**
	(.142)	(.139)
West and Central Asia	-.326*	-.348*
	(.187)	(.185)
N	528	489
R^2	.490	.507

***, **, * indicate coefficients significantly different from zero at the 1%, 5%, and 10%, standard errors are shown in parentheses and standardized coefficients in brackets.

a. I did not find GDP per capita estimates for Antarctic regions, hence the empty entry in column (2).

Table B: Hundred regions with the highest extinction rates and countrywide protected areas.

Country (region rank)[a, b, c]	Extinction Rates	Terrestrial protected area (% of land)	Marine protected area (% of water)
Chile (1st, 5th, 46th, 48th, 51st, 58th, 77th, 81st, 90th out of 14 regions)	2115; 935; 433; 419; 413; 382; 334; 322; 303	18.3	3.9
United States (2nd, 63rd out of 50 regions)	1791; 373	13.9	31.7
French Polynesia (3rd, 4th, 15th, 64th)	1220; 1208; 639; 371	2.0	0.1
Malaysia (6th, 9th, 11th)	888; 728; 717	18.4	2.3
Ecuador (7th, 69th)	797; 357	25.8	75.7
Madagascar (8th)	793	5.0	3.4
China (10th, 60th, 65th, 66th, 82nd, 93rd, 97th out of 31 regions)	719; 379; 365; 364; 320; 298; 295	17.0	2.3
Japan (13th, 39th out of 7 regions)	645; 456	19.4	5.1
Brazil (14th, 18th, 21st, 23rd, 24th, 31st, 35th,43rd, 45th, 57th, 59th, 62nd, 80th, 95th, 96th, 100th out 27 regions)	640; 613; 592; 590; 587; 528; 495; 443; 442; 388; 380; 373; 327; 296; 296; 290	28.4	20.5
Indonesia (16th, 17th, 33rd, 54th, 99th out of 7 regions)	629; 616; 515; 396; 291	14.7	5.8
New Zealand (19th, 52nd out of 5 regions)	610; 411	32.5	12.5
Seychelles (20th)	595	42.1	1.0
South Africa (22nd, 38th, 55th, 56th, 86th out 10 regions)	590; 470; 395; 390; 315	8.8	13.4
India (26th, 36th out of 29 regions)	569; 483	5.3	2.1
Mexico (27th, 28th, 42nd, 61st, 70th, 71st, 72nd, 76th, 77th, 79th,89th, 91st, 98th out of 34 regions)	564; 552; 445; 378; 355; 352; 349; 334; 330; 304; 300;292	12.9	19.0
Sao Tome and Principe (32nd, 83rd)	516; 319	0	0
Sri Lanka (34th)	505	23.2	1.3
Turkey (37th)	472	0.2	0.4

Table C continued…

Greece (40th)	450	34.9	6.0
Mauritius (41st)	448	0.4	0.3
New Caledonia (44th)	442	54.3	56.6
Australia (47th, 68th, 85th out of 8 regions)	429; 363; 318	14.6	48.5
Cameroon (49th)	416	10.9	6.8
Tanzania (50th)	415	32.0	18.2
Jamaica (67th)	363	15.9	4.6
Philippines (73rd)	346	11.0	2.5
Armenia (74th)	344	24.8	---[d]
Cuba (75th)	338	12.4	7.6
Fiji (87th)	308	4.4	6.2
Brunei Darussalam (92nd)	299	44.1	1.5
Vietnam (94th)	297	6.5	1.8

a. For Saint Helena (rank 12) data on protected areas was not available at The World Bank. I chose to omit 25. Bioko, 29. Canary Islands, 30. Socotra, 53. Madeira, 84. Cabinda, 88. Andaman Islands for the table above, as the countrywide percentage of protection may give an especially poor reflection of regional protection.

b. 1. Juan Fernandez Islands, 2. Hawaii Islands, 3. Tubuai Islands, 4. Society Islands, 5. Antofagastas, 6. Sarawak, 7. Galapagos, 9. Peninsular Malaysia, 10. Yunnan, 11. Sabah, 13. Nansei-soto, 14. Rio de Janeiro, 15. Marquesas, 16. Sumatera, 17. Kalimantan, 18. Rio Grande do Sul, 19. South Island, 21. Bahia, 22. Western Cape, 23. Espirito Santo, 24. Chiapas, 26. Kerala, 27. Veracruz, 28. Oaxaca, 31. Minas Gerais, 32. Sao Tome, 33. Sulawesi, 34. Sri Lanka, 35. Sao Paolo, 36, Tamil Nadu, 38. Eastern Cape Province, 39. Kazan-retto, 40. Greece (exclusive Krete), 42. Guadelupe Island, 43. Goias, 45. Amazonas, 46. O'Higgins, 47. Tasmania, 48. Maule, 49. 51. Biobio, 52. North Island, 54. Jawa, 55. Kwazulu Natal, 56. Mpumalanga, 57. Alagoas, 58. Santiago, 59. Amapa, 60. Chongqing, 61. Queretaro, 62. Maranhao, 63. Alabama, 64. Tuamotu, 65. Guangxi, 66. Sichuan, 68. New South Wales, 69. Ecuador (mainland), 70. Guanajuato, 71. San Luis Potosi, 72. Nuevo Leon, 76. Hidalgo, tied for 77. Los Lagos and Revillagigedo Islands, 79. Puebla, 80. Para, 81. Tarapaca, 82. Guizhou, 83. Principe, 85. Victoria, 86. Guateng, 89. Jalisco, 90. Valparaiso, 91. Guerrero, 93. Hainan, 95. Rondonia, 96. Sergipe, 97. Tibet/Xizang, 98. Yucatan, 99. Bali, 100. Santa Catarina.

c. For Chile, United States, China, Japan, Indonesia, New Zealand, South Africa, India, Mexico, and Australia, the total number of regions is also displayed, the extinction rates outside of the top hundred are not reported for the sake of brevity.

d. Armenia is land-locked.