The credibility of small island overpopulation: A critique of population density maps as a proxy for overpopulation

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Abstract

Concerns about overpopulation are still prevalent in many public policy and scientific debates. In many instances, the population density ratio (people/km^2) is commonly used as a proxy variable for overpopulation, which results in the assertion that small islands and territories are overpopulated. This article takes as a case study a population density choropleth map, within the entry *overpopulation* of the cyber-encyclopedia Wikipedia, to analyze the use of population density as a proxy for overpopulation. From a theoretical perspective, a definition of overpopulation based on the objectionable concept of carrying capacity is fundamentally flawed. In addition, even on its own terms, the map's nation-state scale creates a methodological bias since population density is an area weighted formula that provides considerable weight to large scarcely populated national regions. The class intervals of population density are an arbitrary choice that misrepresents the intensity of population density since its cut-off points do not follow an exponential sequence. Both methodological choices consistently represent islands and small territories as extraordinarily dense and therefore overpopulated. This depiction reinforces the imagery of islands and small territories as anomalous places of structural faults. Research claims based on

population density as a proxy for overpopulation lack credibility, even according to their own logic.

Introduction

Someone who googles *overpopulation* in 2011 will find near 2.5 million sites to visit, about 750,000 images to see, close to 325,000 blogs in which to participate, near 55,000 articles to read, around 5,000 youtube.com style videos to watch, and almost 400 books to buy. Far from being a unique 20th century obsession spurred by Cold War imperatives, concerns of overpopulation still inspire many contemporary political and scientific debates. Recent internet-based political and popular science publications have legitimized new anxieties about overpopulation. For example, the political magazine Mother Jones features an article that refers to population growth as the last taboo (Whitty, 2010), the National Geographic Eye in the Sky series on overpopulation presents multiple pictures and satellite images of overpopulation and its environmental consequences (National Geographic, 2006), and Scientific American presents an online article with the catchy title *Good Riddance to the Population Explosion* (Mims, 2010), a short article that accompanied the September 2010 special issue called *The End*.

Google fans may also find that there are about 435,000 pages in which the word *overpopulation* appears together with the word *map*, providing credibility to the assertion that the internet-based map is the most available and widely-used map of contemporary times (Peterson, 2010). In just a few seconds, and practically free of charge, computer literate citizens have available at their fingertips thousands of full color zoomable maps on overpopulation. However, computer literacy does not imply map literacy. More than half of the educated population of the United States does not have the basic competency to understand maps (Peterson, 2010). Without map literacy skills, maps on overpopulation can be highly persuasive even if based on a flawed theory or on wrong cartographic elements.

The widespread access to map making technologies and their easy publication in the internet facilitates the circulation of cartographies of all sorts. Since there are multiple sites for the production of geographical knowledge, Harvey advocates for the study of how geography is formulated, used, and applied in different institutional settings (Harvey, 2002). Following Harvey's advice, this paper analyzes the geographical knowledge presented in a map of population density as a proxy for overpopulation. More specifically, this article takes the first map on Wikipedia's entry on overpopulation, *Map of Countries by Population Density* (Contreras, 2007), as a case-study for analysis (Map 1). When population density is used as a proxy for overpopulation, small islands and territories are clearly identified as overpopulated places. Is this research claim credible? To examine the credibility of a research claim one must focus on the adequacy of the theoretical reasoning and the rigor of its methods (Abelson, 1995). Therefore, this article examines the theoretical soundness of the concept of overpopulation and the

cartographic elements of a map of population density used as a proxy for overpopulation.

Wikipedia's proxy for overpopulation

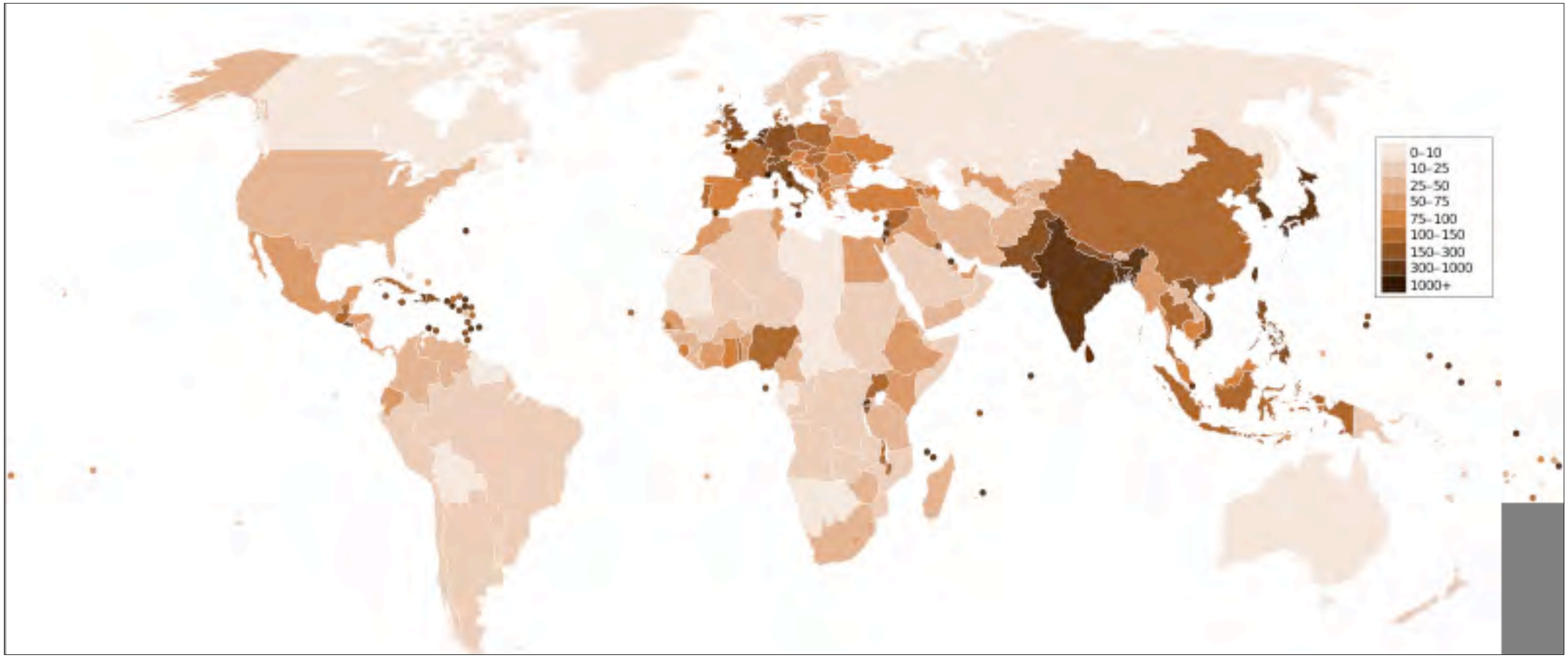
Wikipedia might be the most popular cyber-encyclopedia, published in about 240 languages, with over 3.3 million articles in its English version (Wikipedia contributors, 2010b). The open collaborative nature of Wikipedia makes it an encyclopedia that anyone can edit, which departs from the traditional paradigm of encyclopedia collections based on experts collaboration. While this open collaborative nature makes it prone to criticisms, empirical studies demonstrate that Wikipedia is quite reliable and verifiable, and excels in other epistemic values, such as power (how much knowledge can be acquired), speed (how fast that knowledge can be acquired), and fecundity (how many people can acquire that knowledge) (Fallis, 2008).

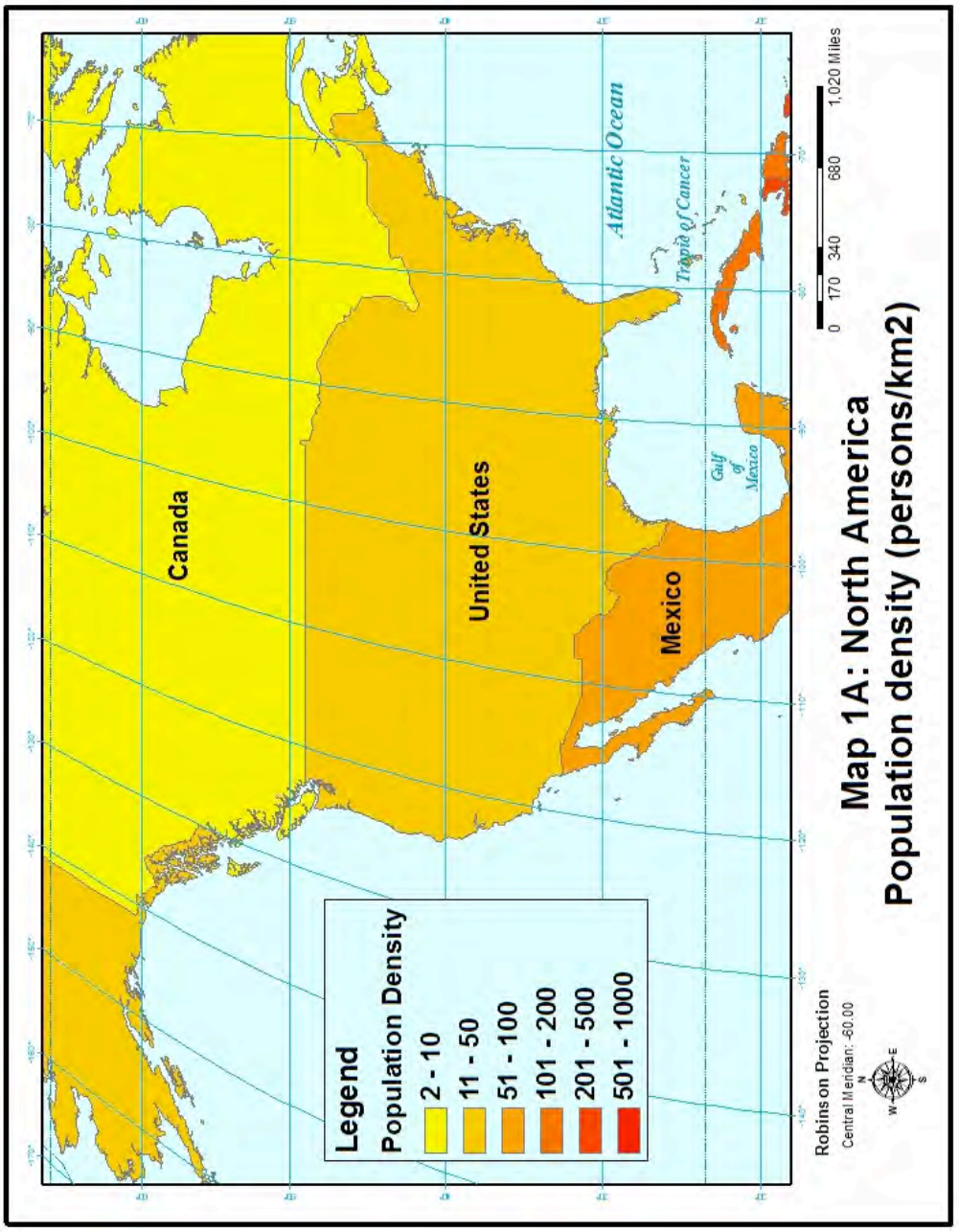
The comprehensive *overpopulation* entry of Wikipedia defines overpopulation as "a condition where an organism's numbers exceed the carrying capacity of its habitat" (Wikipedia contributors, 2010a). Wikipedia qualifies that definition asserting that "overpopulation does not depend only on the size or density of the population, but on the ratio of population to available sustainable resources," which means that population density is one of the different causes of overpopulation. Map 1 (*Map of Countries by Population Density*) is prominently placed in this *overpopulation* entry, as it is the first map and the first color graphic of the page. Since the apparently "inconsequential marginalia" help to communicate the cultural meaning of maps (Harley, 1989), the information that surrounds the map on this internet page is crucial to its understanding, conveying the message that overpopulation is closely related to population density.

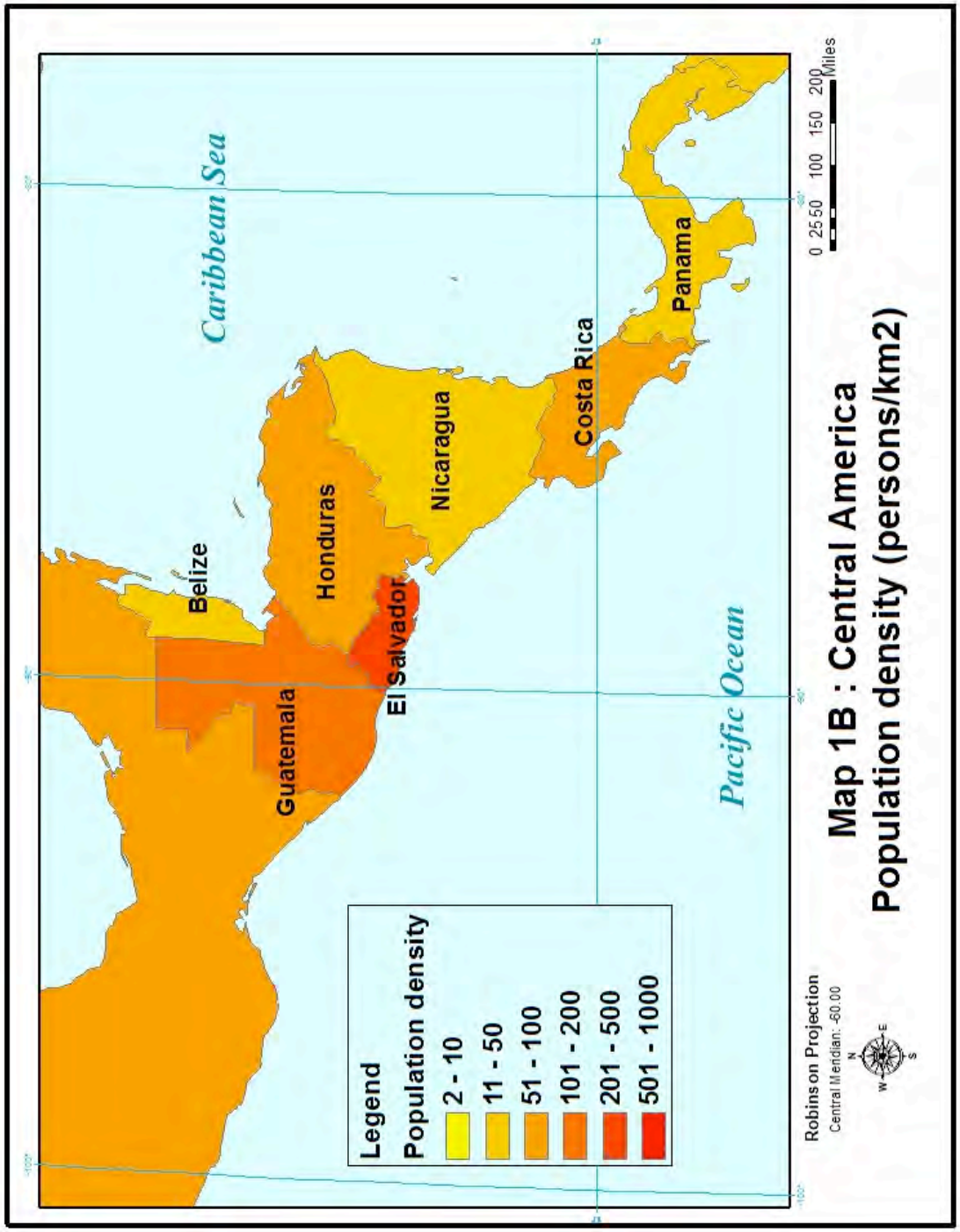
Consistent with Wikipedia's ambivalent definition of overpopulation, population density is used as a proxy variable for overpopulation. The use of a proxy variable (such as population density) is advisable when the value of the variable of interest (overpopulation) is unknown, presumably because of measuring difficulties. But overpopulation is not a concept inherently hostile to measurement, as opposed to, for example, happiness, morality, or beauty. Since those who believe in an impending or current population crisis have not been able to put together a formula to determine if overpopulation exists and where, the need of proxy variables for overpopulation suggests that they face theoretical difficulties.

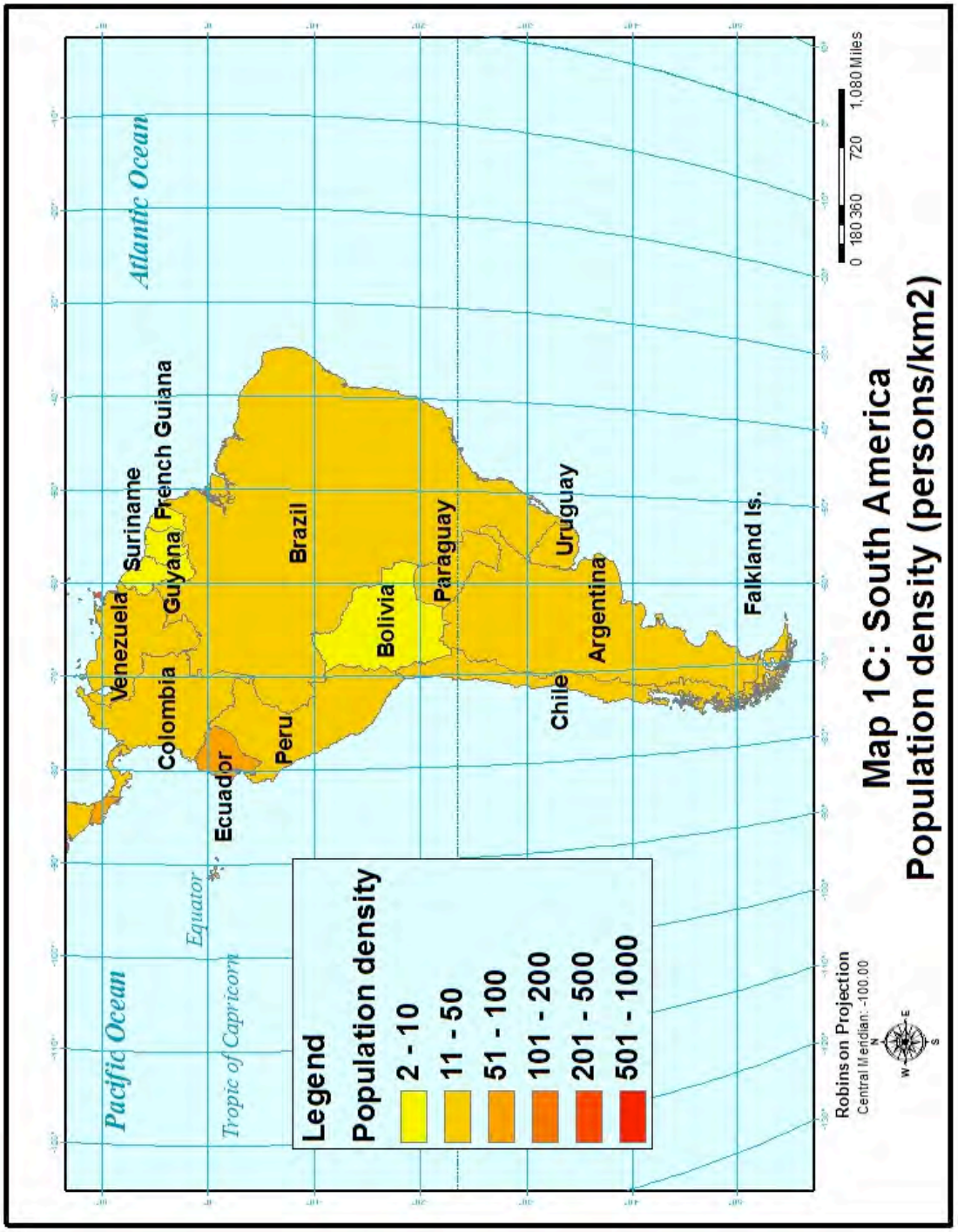
Map of Countries by Population Density. Numbers on the legend are in people per km^2, and all countries are smaller than 20,000 km^2 are represented by a dot.

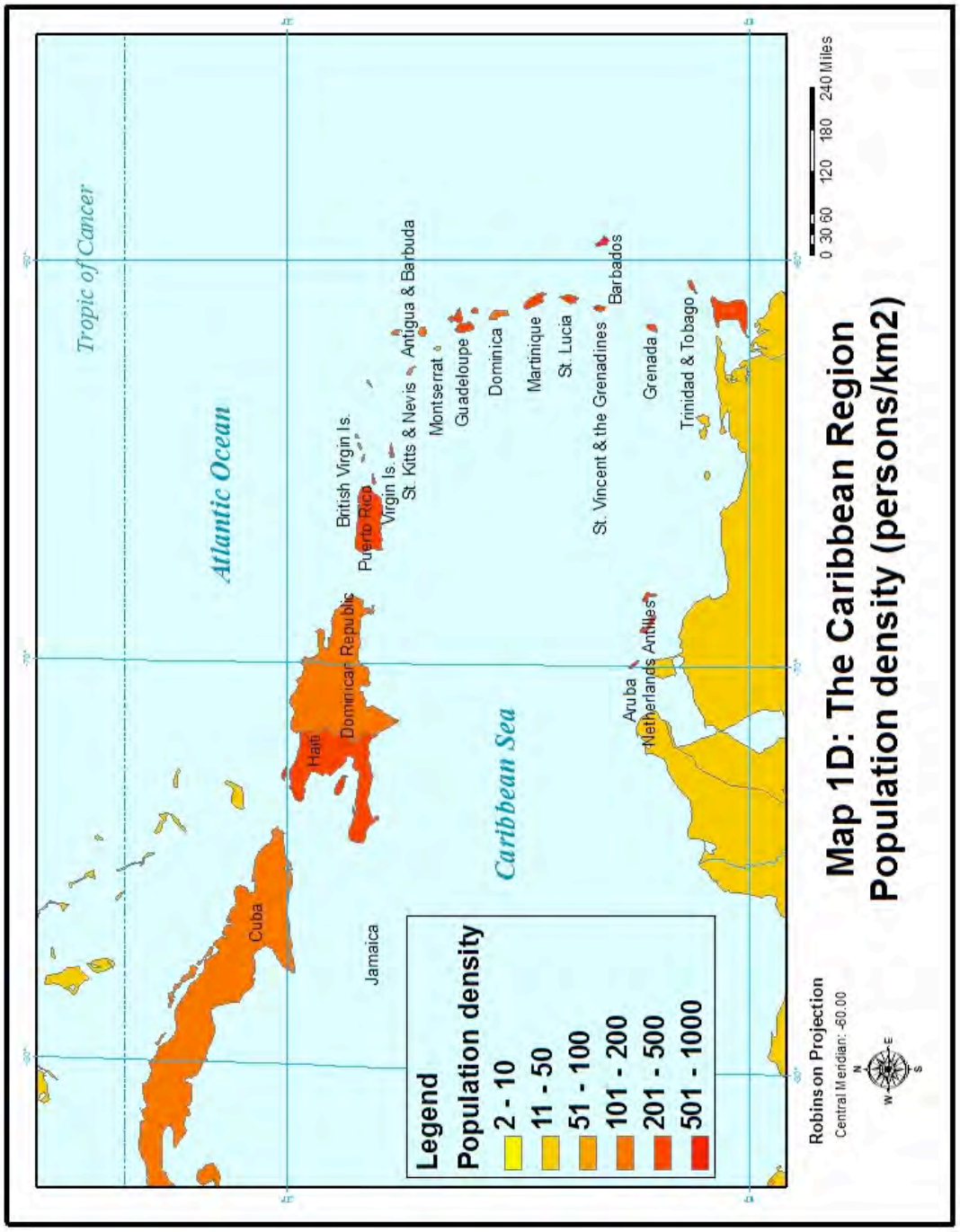
Map 1




Canada
United States
Mexico
Atlantic Ocean
Tropic of Cancer
Gulf of Mexico
Legend
Population Density
2 - 10
11 - 50
51 - 100
101 - 200
201 - 500
501 - 1000
Map 1A: North America
Population density (persons/km2)
0 170 340 680 1,020 Miles
Robinson Projection
Central Meridian: -60.00


Caribbean Sea
Pacific Ocean
Belize
Honduras
Nicaragua
Costa Rica
Panama
Guatemala
El Salvador
Legend
Population density
2 - 10
11 - 50
51 - 100
101 - 200
201 - 500
501 - 1000
Map 1B : Central America
Population density (persons/km2)
Robinson Projection
Central Meridian: -80.00
0 25 50 100 150 200 Miles


Map 1C: South America
Population density (persons/km2)
Legend
Population density
2 - 10
11 - 50
51 - 100
101 - 200
201 - 500
501 - 1000
Pacific Ocean
Atlantic Ocean
Equator
Tropic of Capricorn
Venezuela
Colombia
Ecuador
Peru
Brazil
Guyana
Suriname
French Guiana
Bolivia
Paraguay
Chile
Argentina
Uruguay
Falkland Is.
0 180 360 720 1,080 Miles
Robinson Projection
Central Meridian: -100.00


Tropic of Cancer
Atlantic Ocean
Caribbean Sea
Cuba
Jamaica
Haiti
Dominican Republic
British Virgin Is.
Puerto Rico
Virgin Is.
St. Kitts & Nevis
Antigua & Barbuda
Montserrat
Guadeloupe
Dominica
Martinique
St. Lucia
St. Vincent & the Grenadines
Barbados
Grenada
Trinidad & Tobago
Aruba
Netherlands Antilles
Legend
Population density
2 - 10
11 - 50
51 - 100
101 - 200
201 - 500
501 - 1000
0 30 60 120 180 240 Miles
Robinson Projection
Central Meridian: -60.00
Map 1D: The Caribbean Region
Population density (persons/km2)

Theoretical deficiencies with overpopulation

Wikipedia's definition of overpopulation is problematic since it is based on the concept of carrying capacity. In their book *The Population Explosion*, Paul and Anne Ehrlich explain what carrying capacity entails in relation to overpopulation:

> When is an area overpopulated? When its population can't be maintained without rapidly depleting nonrenewable resources (or converting renewable resources into nonrenewable ones) and without degrading the capacity of the environment to support the population. In short, if the long-term carrying capacity of an area is clearly being degraded by its current human occupants, that area is overpopulated (Ehrlich and Ehrlich 1991, p.38).

Sustaining the validity of the fundamentals of their 1968 book, *The Population Bomb*, and their 1990 book, *The Population Explosion* (Ehrlich and Ehrlich, 2009), the Ehrlichs understand carrying capacity as a fixed, real, and universal limit of resources that nature imposes into human communities. A thorough analysis of the history and use of the concept of carrying capacity reveals the gross inadequacies of such theoretical perspective (Sayre, 2008). Carrying capacity, far from being a fixed and static quantity, entails a dynamic process capable of enlargement by an appropriate management of the environment. Rather than a real limit obtained from empirical information on actual habitats, the concept of an upper limit to carrying capacity is the product of idealized mathematical curves generated by laboratory data. The claim of a universally valid estimation of carrying capacity must yield to more circumspect inferences since an estimate of a carrying capacity must be short-lived and is always contingent to specific local areas. The concept of carrying capacity conceived as the sole product of nature underrates the ability of humans to transform the environment through the use of technology and our capacity or adaptation.

Moreover, the Ehrlichs acknowledge that under their definition of overpopulation based on carrying capacity, "overpopulation might be corrected with no change in the number of people," but by changing the patterns of industrial production and consumption, however difficult it might be (Ehrlich and Ehrlich, 1991, p.40). This acknowledgement makes it evident that their concept of overpopulation is not an issue of excess population as the word suggests. Accordingly, overpopulation should be understood within its socio-historical context, a consideration that is at odds with the concept of carrying capacity espoused by these scientists.

These criticisms render the concept of carrying capacity untenable, making overpopulation a vacuous statement with no scientific validity. On theoretical grounds, the use of population density as a proxy for overpopulation does not compute. It is a way of providing the legitimacy of numbers to a concept that lacks

scientific validity. It is tantamount to scientifically measure something that, according to scientific criteria, we are not sure if it exists. Although from a different perspective, the Ehrlichs could not say it more clearly: "Density is generally irrelevant to questions of overpopulation" (Ehrlich and Ehrlich 1991, p.38).

Mapping population density

Wikipedia's *Map of Countries by Population Density* (Map 1) is a standard choropleth, a thematic map in which different areas are colored according to the class intervals that partitions the value range of a statistical variable. In Map 1, the specific population density of an area, measured in people/km^2, is represented by the intensity of brown tones within a set of nine class intervals. As the author explains (Table 1) all countries smaller than 20,000 km^2 are represented by a dot. In this map, a high population density is a common feature of many islands throughout the world.

Table 1
Summary information of Countries by Population Density Map

Description	A map of the world, with colours to highlight the population density of each country or territory. Numbers on the legend are in people per km^2, and all countries smaller than 20,000 km^2 are represented by a dot. The information was taken from. It is intended as a vector replacement for Image:World population density map.PNG. It is derived from Image:BlankMap-World6.svg, so thanks to everyone who has contributed to that. If you have any comments, suggestions, corrections, or requests for other maps, please contact me at my English Wikipedia talk page
Date	7 January 2007
Source	Own work
Author	Miguel Contreras, Guatemala
Licensing	I, the copyright holder of this work, hereby release it into the **public domain**. This applies worldwide. I grant anyone the right to use this work **for any purpose**, without any conditions, unless such conditions are required by law.

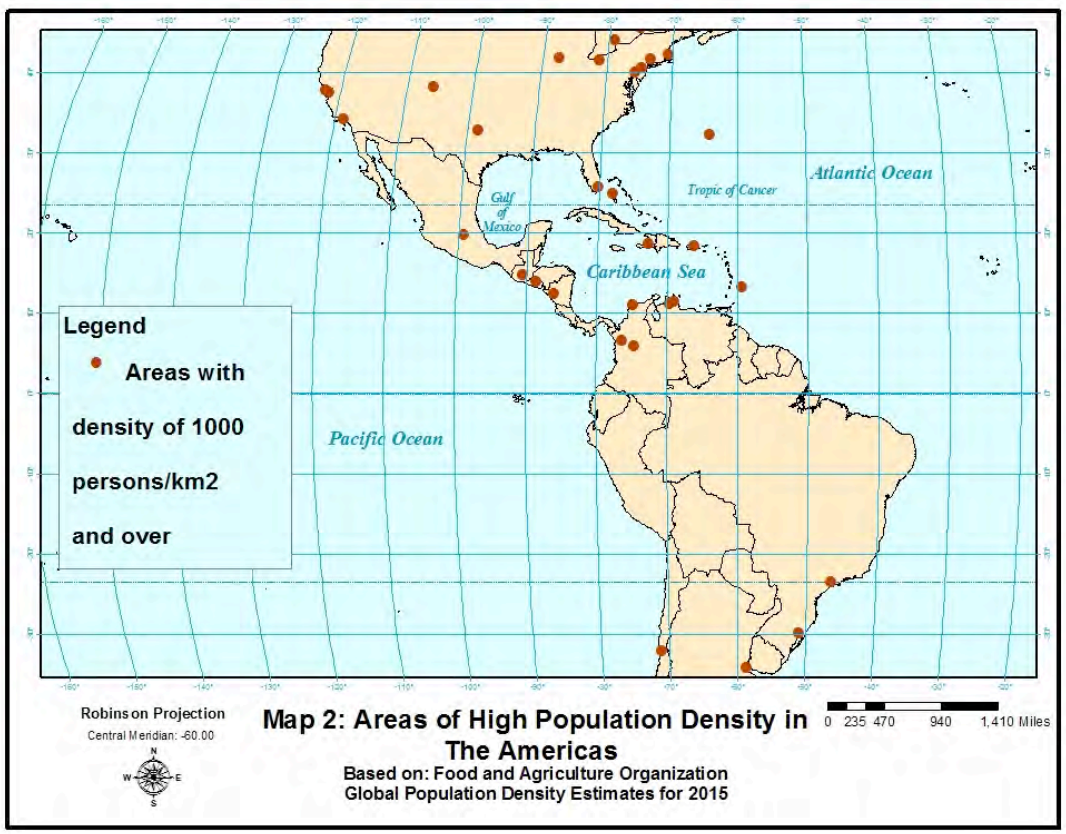
Source: http://en.wikipedia.org/wiki/File:Countries_by_population_density.svg

Maps 1A-1D allow the reader to observe the population density in North, Central, and South America, and the Caribbean separately, which makes it possible to substitute the dots of Map 1 with their respective islands. The general trend along the spotted islands reveals a clear pattern towards the darkest brown tones, which are the highest levels of population density. The North American region (see

Map 1A) reveals a low population density, similar to that of the South American region (see Map 1C), where the only exception is Ecuador, a country whose population density is one notch up in relation to its neighbors. The map of Central America (see Map 1B) reveals a higher population density than the previous two regions. The Caribbean region (see Map 1D), composed of an archipelago of smaller islands (with the exception of Cuba), exhibits a sharp contrast with its continental counterparts. Caribbean islands, such as Barbados (654 people/km^2) and Puerto Rico (446 people/km^2), hold the highest population density of the Americas; occupying the highest two levels of the class intervals for population density.

Cartographic critique: Geographic scales and class intervals

The concept of *geographic scales*, largely ignored in discussions on Caribbean overpopulation, becomes a key factor in the identification of a bias of Wikipedia's population density map (Map 1). The *cartographic scale* of a map, which refers to the correspondence between the distance on the map to the distance "on the ground" (Marston, 2000) does not represent a particular source of bias. Since Map 1 is a world map, its cartographic scale makes it difficult to identify particular places or to observe specific details of small areas, such as the Caribbean islands. Therefore, the use of dots to identify the areas with less than 20,000 km^2 is an adequate choice.



Each one of Maps 1A-1D uses different cartographic scales in order to map the different regions of the Americas into the size of a standard piece of paper, making it possible to avoid the use of dots to represent islands. The geographical scale of Map 1 is that of the nation-state. Since the population density of a nation-state is the average of the population densities of its regions weighted by the size of the regions (Craig, 1984), the numerical design of population density assigns a heavier weight to large scarcely populated areas, while assigning a lower weight to heavily populated areas if they are small. The population density is, therefore, dependent upon the geographic scale taken as the unit of analysis: when the actual size of the unit of analysis diminishes, the population density increases. The measurement of population density becomes increasingly higher if the researcher focuses the attention into subnational units, such as provinces, cities, neighborhoods, or a residential block. As a consequence, the scale of the nation-state is a misleading frame for apprehending the spatiality of population density. When large continental nation-states are compared with small island nations (or small territories) using a statistical indicator that is susceptible to the size of the territory, the comparison is based on mismatching geographical scales.

Map 1 and Maps 1A-1D use the intensity of a color in order to portray the intensity of the population density ratio. The division of the color scheme in Map1 into nine different brown tones may appear as a good strategy to capture the broad spectrum of densities around the globe. However, the appropriate establishment of class intervals of a color scheme for population density should be guided by theoretical considerations that inform the selection of cut-off points in order to avoid arbitrariness.

There are multiple ways of calculating the average of two population densities (density1 and density2), one is through their arithmetic mean, which is

$$arithmetic\ mean\ =\ \frac{(density1\ +\ density2)}{2}$$

and another through their geometric mean, which is

$$geometric\ mean\ =\ \sqrt[2]{(density1)\ (density2)}$$

The appropriate way of averaging population densities is through the use of their geometric mean, and not through their arithmetic means (Craig, 1984). As a result, the class intervals of population density should follow an exponential sequence in which, for example, the cut-off points are 1, 10, 100, 1000, etc. Under this exponential sequence, each cut-off point of class intervals equals the geometric

mean of its two adjacent numbers. A comparison of the cut-off points of population density of the class intervals of the maps of this article appears in Table 2. The selection of the sequence of cut-off points for population density other than an exponential progression, such as that of Map 1, is arbitrary. As a result, there is a misrepresentation of the intensity of population density in Map 1.

Table 2
Comparison of cut-off points of population density maps using the exponential sequence as the standard

Exponential	Map 2	Maps 1A - 1D	Map 1	FAO Map
0	0	0	0	0
1		2		2
				5
10		11	10	10
		51	25	20
			50	51
			75	
100		101	100	100
		201	150	200
			300	500
		501		
1000	1000		1000	1000

Critical cartography: The politics of geographic scales and class intervals

There is no natural, optimum, pre-determined geographical scale to be used in social research. The scale of the nation-state, while extremely relevant for geopolitical purposes, is deceptive when dealing with population density. Island studies scholars, whose work necessarily rests on a conscious geographical imagination, are aware of the importance of the choice of geographical scales in research. In island studies, the choice of geographical scale is equivalent to a selection of a methodological standard of comparison. Island scholar Geoffrey Baldacchino explains that

> … there is no better comparison for an island than another island. There may also be no better comparison for a mainland than an island, since the processes and dynamics that occur habitually on a mainland may be enhanced and exacerbated in an island setting. Yet, such deliberate

> comparisons remain exceptional: rather, many islands have been and continue to be looked upon with a larger, continental, typically metropolitan and/or neocolonial candidate as their backdrop, whenever comparisons are to be made. Islanders are as much party to this perverse relativity as nonislanders (Baldacchino, 2004).

Geographical scales define the researcher-made frame of a particular hierarchy of geographical units, a frame that makes them *epistemological constructions* (Jones, 1998). As epistemological constructions, the geographic scales impose limits to the questions to be asked by a researcher as well as to the possible answers to be obtained. The choice of a particular set of geographical scales in Map 1 manufactures a particular answer, the proliferation of dark brown dots among many islands because of their high population densities.

It is not surprising, therefore, that nine out of the first ten countries and territories with the highest population density in the world are very small, with territorial extension less than 1,200 km^2, such as Macau, Monaco, Singapore, Hong Kong, Gibraltar, and the Vatican. In this list, there are six islands, Macau, Singapore, Hong Kong, Malta, Bermuda, and Sint Maarten (Wikipedia Contributors, 2011). Since there are about 550 million people living on islands (almost 10% of the world population), and close to 43 of the world's nation states are exclusively island states (about 20%), and, in addition, many nation-states have island regions (Baldacchino, 2006), the analysis of island phenomena free of continental biases should not be ignored or trivialized. Traditional differences between a continent and a large island are more a matter of contested conventions, and not a matter of strict empirical criteria. When the size of an island is defined as between 0.1 and 1,000,000 km^2 (Depraetere, 2008), Europe-Asia-Africa, America, Antartica, Australia, and Greenland are not considered islands but continents.

The selection of the cut-off points for the nine class intervals of brown tones of Map 1 manufactures another effect by assigning island and small territories the most intense brown colors. For example, the French Caribbean islands of Guadeloupe (249 people/km^2) and Martinique (356 people/km^2) have a darker brown tone that that of continental France (114 people/km^2) (Wikipedia Contributors, 2011), indicating a higher level of population density. If exponential cut-off points are used, continental France, Guadeloupe, and Martinique should have the same brown tone corresponding to the class interval of 100-1000 people/km^2. A scrupulous researcher, who would like to establish more and smaller class intervals, can select as cut-off points the series of 1, 3.16, 10, 31.6, 100, 316, and 1000, to preserve the principle of an exponential sequence. In this sequence, any cut-off point (31.6, for example) represents the geometric average of its two adjacent cut-off points, $31.6 = \sqrt[2]{(10)\,(100)}$. Under these appropriate intervals, continental France should be assigned the same brown tone of highly

dense (and supposedly overpopulated) Guadeloupe, within the class interval 100-316 people/km^2.

Moreover, the comparison of continental France with Guadeloupe is possible since France as a nation-state excludes overseas regions and departments, which are in turned juxtaposed as separate geographical units. Under this spatial frame of geographic scales, the specific population density of a French subnational region is identified *only* if it is an overseas region or, basically, a former colony. Under this color and choice of geographic scale, overseas islands will look darker by design. In contrast, nearby offshore islands will share the color of the national "mainland," since they are pooled within the continental national average. The researcher's choice of geographic scale and class intervals of Map 1 consistently promote the establishment of difference and distance of former French and other European island colonies from their respective metropolis.

Mapping at other geographic scales

The biases identified in Map 1 are easily corrected with the introduction of a geographical scale at the sub-national level and an exponential progression of cut-off points for color tones. The *FAO Global Population Density Estimates 2015* (Food and Agriculture Organization - FAO, 2007) (available at: http://www.fao.org/geonetwork/srv/en/graphover.show?id=14053&fname=Map_2_03.png&access=public) is a punctilious world choropleth in which each pixel represents the estimated population density (people/km^2) for 2015, using the lowest subnational unit for which data were available. A simplified version of the FAO map, Map 2: *Areas of High Population Density in the Americas*, is free of the biases previously identified. Map 2 is consistent with a standard choropleth at the subnational scale in which the variable of interest has two class intervals with a cut-off point of 1000 people/km^2.

Map 2 does not portray islands as anomalies or special territories with the highest population density in the Americas. Since similar densities occur throughout the Americas, the singularity of the phenomenon of high population density among Caribbean island disappears, demonstrating that it is the result of a methodological artifact rather than an essential characteristic of these islands.

Conclusion

An essential element of a critical cartography rests on a simple premise fueled by a dialectical imagination: the cartographic representation of a region and its people says much about that region as it says about the map-makers that produced such representations. This article challenges the research claim that island and small territories are overpopulated. Theoretical and cartographic biases in a population density maps used as proxy for overpopulation are not a simple matter of inconsistent adherence to the rules of research methodology and appropriate map-making. The main biases identified in this article, the theoretical

flaws of the concept of overpopulation along with the selection of geographic scales and class intervals for population density denote the researchers' choices that unfailingly portray small islands as extraordinarily dense.

Is it appropriate to use population density as a proxy variable for overpopulation? Besides the theoretical issues already discussed, biased data maps can only misrepresent and obfuscate the phenomenon they try to explain. Such use is foreseeable if the map-maker is indifferent to or attracted by the depiction of islands and small territories as imagined geographies of anomaly. Critical cartographers have the urgent task of identifying widely accessible maps that contribute to the reproduction of such imagery, where methodological sophistication end up producing an ideological mystification.

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