Opinion Article

Measuring population growth around tropical protected areas: current issues and solutions

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Abstract

Do people migrate toward parks, and if so, why? These long-standing questions in conservation are especially important in tropical regions. It is there that rural human populations intersect with some of the world's greatest biodiversity, and protected areas are often the last line of defense in the fight to slow species extinctions. Detailed case studies have been the predominant source of insight into these issues, yet there has been a recent push for larger-scale analyses. Here we address the insufficiency of global datasets for answering global people-park questions. More than ever, it is of utmost importance that scientists get the correct answers when working at the intersection of human welfare and biodiversity conservation. Successful conservation of tropical biodiversity depends upon it.

Key Words: Protected areas, population, migration, conservation, biodiversity, tropical

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Immigration to tropical protected areas (PAs) is an important and contentious issue in conservation science. Scientists debate whether such immigration is a general pattern [1,2], the mechanism driving immigration [3], and which management approaches could (and should) be used to cope. In a recent paper, Scholte and de Groot [3] add new theoretical insight to the middle debate. They discuss the implications of three proposed mechanisms for immigration to PAs: 1) Frontier Engulfment, 2) Attraction, and 3) Incidental.

The Attraction model posits that the existence of the PA itself (and perceived benefits) preferentially draws people to its borders. These benefits might be potential employment directly through the PA itself, or through increased tourism and related businesses. Alternatively, in areas where PAs encompass some of the last remaining natural resources, the very resources the PA protects may serve to draw immigrants to the PA's boundaries. The Frontier Engulfment model is best illustrated by a PA initially located in a remote area, yet later overtaken by an "extraction frontier" like logging, and then even later by an "agricultural frontier" such as cattle or crops. This process has now been playing out in the Amazon's "Arc of Deforestation" for decades. The Incidental mechanism is more of a catch-all for population growth near PAs that does not fit into either of the previous two models. People evicted from inside PAs and settling immediately adjacent to the border, or PAs serving as human refuges during times of conflict are two of the potential Incidental mechanisms proposed by Sholte and de Groot [3].

Scholte and de Groot end their thesis by advocating the use of currently available global population datasets [4,5] to distinguish between these mechanisms and develop appropriate management strategies. Here, we explain why these datasets are unable to make this distinction. Until household-level population datasets are available at large scales, we advocate the application of remotely sensed land cover as a more appropriate tool for monitoring immigration to PAs.

As Scholte and de Groot suggest, distinguishing between Frontier Engulfment and Attraction is critical for the development of appropriate management strategies. Increased human population near PAs through Frontier Engulfment is almost inevitable as human population increases and new PAs are established (Figure 1). Only the overwhelming establishment of new PAs in remote areas or a net decrease in rural population could result in the alternative. In contrast to passive Frontier Engulfment, Attraction stems from an interaction between PAs and immigration. Simultaneously touted as beneficial to rural economies and maligned as counterproductive to biodiversity protection, the Attraction mechanism would greatly influence how people practice conservation were it a general characteristic of PAs.

Wittemeyer *et al*.'s [1] recent analysis was meant to test the Attraction model across large suites of PAs. While they claimed evidence for general Attraction trends, Joppa *et al*. [2] concluded that Wittemeyer *et al*.'s result was an artefact of mixing incomparable datasets. A critical point raised by several of the authors of available global population datasets is that such analyses are unable to detect Attraction using these data regardless of whether the pattern exists [6]. The reason is that, while historic global population datasets appear spatially explicit, they cannot resolve population within coarse administrative units. Since these administrative units are generally much larger than PAs and the distances over which Attraction effects are thought to manifest, it is simply impossible to resolve suitable counterfactuals from these data at appropriate scales to test for Attraction. Within an administrative unit, rural populations cannot be separated from urban populations and populations near protected areas cannot be separated from those far from protected areas.

Gridded global population datasets are hugely important for visualizing population patterns, but they must be analyzed with caution. These datasets are derived from surveys and their gridded format gives the illusion of much greater spatial resolution than actually exists.

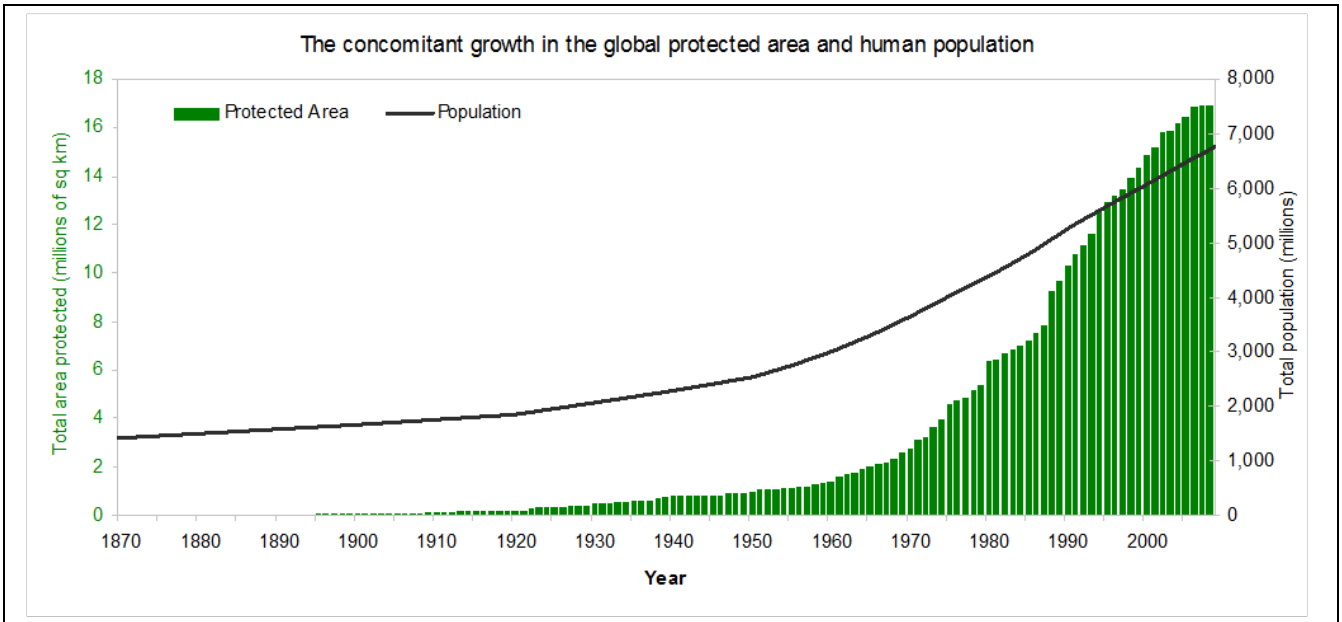

Fig. 1. The concomitant rise in both the total amount of area protected (bars) and global human population (line). Data on protected areas comes from the 2009 World Database on Protected Area [12]. The trend for human population from 1850 to 1950 calculated from Table 1 of PDDESA [13] while 1950 to 2010 used data from PDDESA [14].

The increasing availability of household-level population data may eventually make it possible to distinguish between Sholte and de Groot's models at scales large enough to test for general patterns. In the meantime, we advocate the use of remotely sensed land cover as an appropriate dataset for monitoring immigration near protected areas and testing for Attraction on relevant scales.

In Figure 2, we show data from satellite images, from PAs where several of Sholte and de Groot models of immigration might be rationally debated. Frontier Engulfment (Figure 1, top) is characteristic in the Brazilian Amazon Arc of Deforestation (red arrow) where human activity increasingly reveals the boundaries of the protected Xingu Indigenous Reserve (blue line). On a much smaller scale (Figure 1, middle), Pilanesburg Game Reserve (blue line) in South Africa is increasingly encompassed by suburban sprawl (red areas) even though it sits in the relatively rural and arid north of the country. There is no question that economic opportunities from the Sun City resort area on the southern edge of the Pilanesburg reserve are responsible for much of the development in this remote area. It remains unclear what role in attracting people has been played by economic opportunities directly stemming from big-game viewing in the reserve (which would exemplify the attraction model) compared with the opportunities associated with the Sun City casino, golf course, and conference centers (which would exemplify the incidental model). Lastly, (Figure 1, bottom) human activity (red areas) has increased along the road from Quepos to Manuel Antonio National Park in Costa Rica (blue line) and in the small town of Manuel Antonio. It is possible that

much of this infrastructure was built to accommodate the ~150,000 annual visitors that this small park (~16 km2) receives, thereby exemplifying the attraction model.

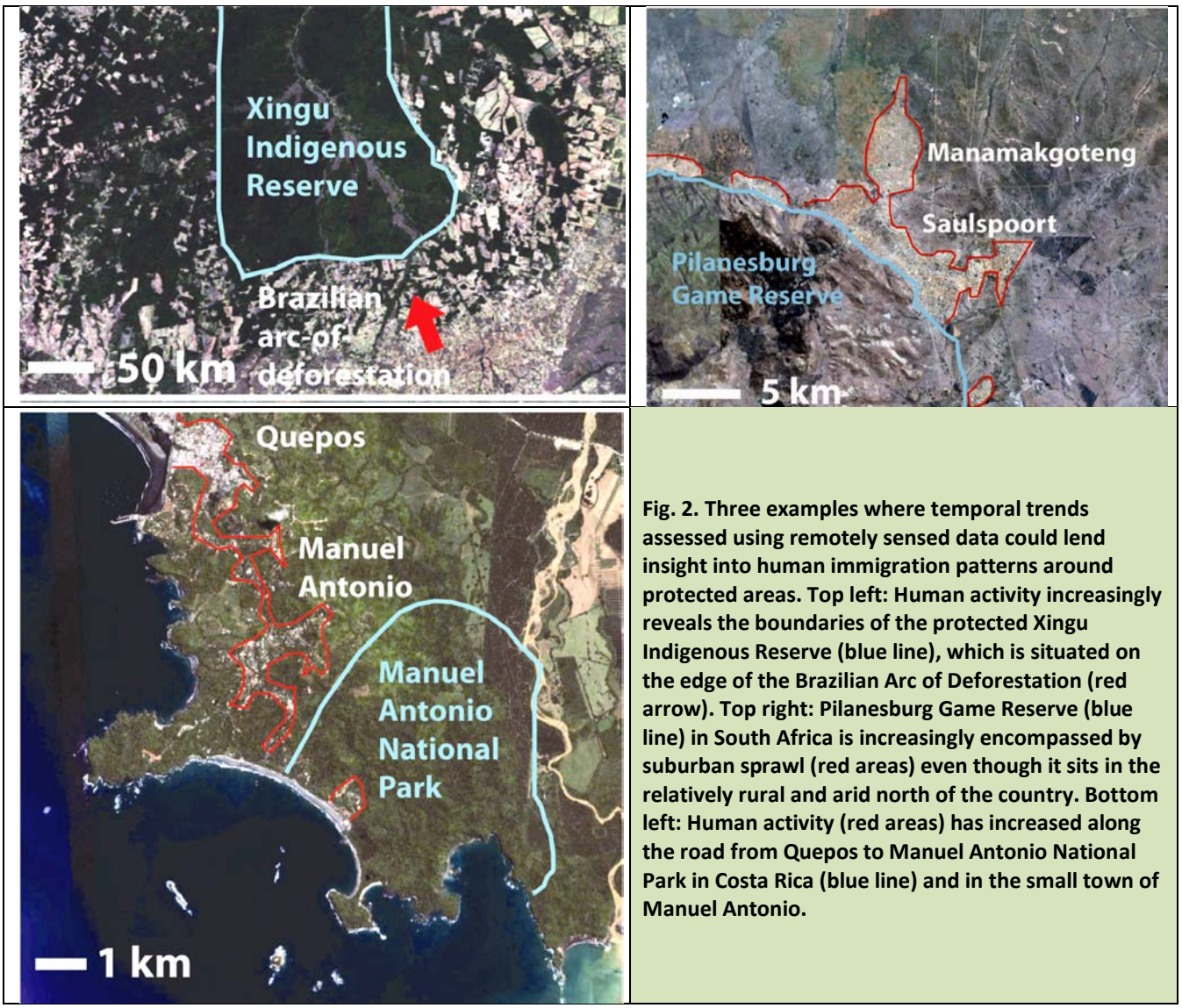

Fig. 2. Three examples where temporal trends assessed using remotely sensed data could lend insight into human immigration patterns around protected areas. Top left: Human activity increasingly reveals the boundaries of the protected Xingu Indigenous Reserve (blue line), which is situated on the edge of the Brazilian Arc of Deforestation (red arrow). Top right: Pilanesburg Game Reserve (blue line) in South Africa is increasingly encompassed by suburban sprawl (red areas) even though it sits in the relatively rural and arid north of the country. Bottom left: Human activity (red areas) has increased along the road from Quepos to Manuel Antonio National Park in Costa Rica (blue line) and in the small town of Manuel Antonio.

Using land cover as a proxy for population assumes that human presence is proportional to the amount of converted land. We believe that this assumption is warranted, given that most rural residents in developing countries rely on agriculture and biomass for food and energy. This makes it likely that their presence will be accompanied by land cover conversion. Although using remotely sensed data will invariably miss some immigration events, using land cover change (and other datasets such as nighttime lights [7], urban areas [8], and fire events [9]) has tremendous advantages over current gridded population datasets. First, unlike gridded population datasets, each grid-cell from remotely sensed data is an actual data point. Second, ensuring the continuation of Earth-observing missions [10] will provide the temporal dimension necessary for change detection (which often may not be available from surveys). Third, remotely sensed data are globally available at relevant resolutions, allowing for large-scale analyses of trends in and around PAs [11]. Fourth, in remote areas survey data are much more susceptible to reporting error than remotely sensed data.

ike Scholte and de Groot, we recognized the need for more sophisticated studies and better efforts to monitor the health of protected areas. But unlike these authors, we caution against the application of gridded global population datasets and instead advocate continued monitoring through remote sensing technologies.

Acknowledgments

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