Short Report

Amazonian Societies on the Brink of Extinction

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ABSTRACT: Objectives: Greater Amazonia harbors as many as 100 locations of isolated indigenous peoples. Few options are available to assess the demographic health of these populations given their limited contact with the outside world. Remote sensing offers one option.
Methods: An isolated village in Brazil near the Peruvian border is visible with Google Earth imagery from 2006. The area of the fields and village, as well as the living area of the four longhouses, are measured and compared to population-by-area measurements for 71 other Brazilian indigenous communities.
Results: The estimated population of the village is no more than 40 people. A village as small as this one, if it has become disconnected from a metapopulation, risks imminent extinction if it has fallen below a minimum viable population size.
Conclusions: An active remote surveillance program is urgently needed to track the movements and demographic health of isolated peoples in hopes of improving their dire chances for long-term survival. They need protected areas that are large enough to mitigate against external threats. Am. J. Hum. Biol. 00:000–000, 2014.

INTRODUCTION

Lowland South America harbors most of the last indigenous societies to have limited contacts with the outside world. All past contacts between Europeans and indigenous societies over the last 500+ years have been unequivocally devastating, resulting in the loss of over 90% of the original indigenous population (Bodard, 1974; Hemming, 1978; Ricardo and Ricardo, 2011). Currently, the smallest known populations are the recently contacted five Akuntsu, four Juma, and a sole surviving man "Tanaru," all in the Brazilian state of Rondônia (Ricardo and Ricardo, 2011; Vaz, 2011). Limited information is available as to the demographic health of populations that remain isolated, but they are also likely critically endangered and on the brink of extinction.

Population estimates are vital to judging whether or not isolated populations have any chance of being protected from the many external threats of disease, displacement, deforestation, and mining that threaten their existence. A longitudinal population record is needed to evaluate whether the currently limited measures of protection are sufficient or if policies are in immediate need of augmentation. Governmental agencies like Fundação Nacional do Índio (Vaz, 2011) and nongovernmental agencies like Instituto Socioambiental (Ricardo and Ricardo, 2011) attempt to track purported locations of isolated, endangered peoples. As many as 100 locations have been identified mostly by brief encounters or aerial surveys. However, these attempts do not include any systematic effort to census isolated populations beyond rough estimates based on occasional sightings.

There is considerable difficulty and danger associated with censusing isolated populations on the ground, hence remote censusing using satellite imagery offers an attractive alternative. Much remote sensing work in the Amazon Basin focuses on logging (e.g., Asner et al., 2005), but progress has also been made linking household and community level data to land-use change (e.g., Fox et al., 2004). The statistical methodology for estimating population sizes from spatial data (i.e., field areas, number of houses, or room area) is a standard approach in archaeology (Brown 1987; Chamberlain, 2006; Hassan, 1981) and anthropology (Hamilton et al., 2007, 2012). In this vein, we take area measurements using satellite imagery from an isolated village to compare against population-by-area measurements for other Brazilian indigenous communities.

METHODS

One isolated village in the state of Acre, Brazil near the border with Peru is visible in Google Earth (Fig. 1a). This image from 2006 shows four longhouses in a clearing in the center and swidden (slash and burn) horticultural fields to the southwest and directly to the east. The area of the overall cleared area is measured using the polygon feature in Google Earth Pro. This area is then compared to a sample of 71 other indigenous Brazilian villages where it was possible to match locations with population estimates (Ricardo and Ricardo, 2011; National Foundation of Health http://sis.funasa.gov.br). These 71 villages are all in forested areas so cleared areas are easy to demarcate and measure in Google Earth Pro. The most sampled regions are Northwest Brazil, Xingu River Basin, and Yanomami land in Northern Brazil for reasons of sufficient resolution of satellite imagery and well-documented village locations.

Several additional methods are used to estimate the population of this isolated village using a subsample of 25 villages where satellite imagery is of high enough resolution to allow measurement of the living area of houses. These include: (1) using the living area of the four longhouses

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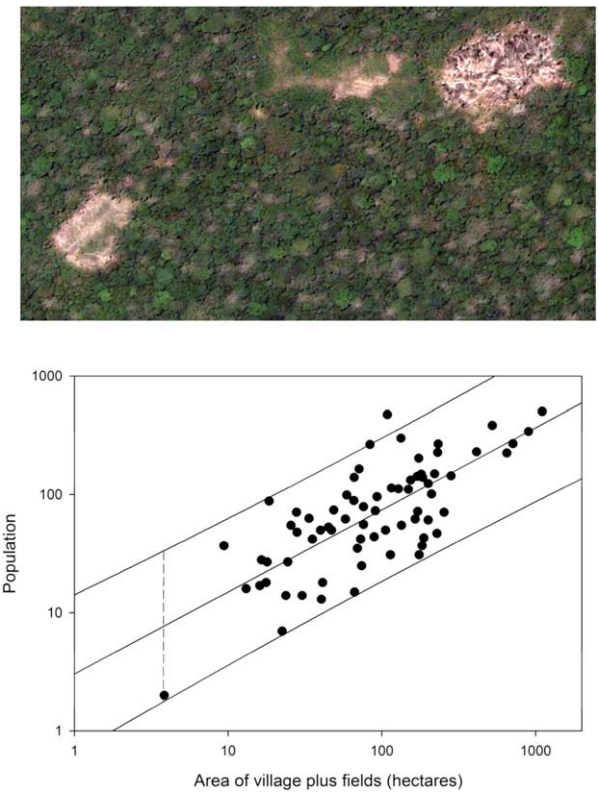

Fig. 1. (a) (top) Google Earth imagery for 2006 at −9.9412° latitude and −72.0402° longitude of an isolated village shows a clearing in the center with four longhouses and swidden horticultural fields to the southwest and directly to the east. (b) (bottom) Population-by-area graph for a sample of 71 indigenous villages. The best fit line and 95% prediction interval are shown on the graph with the isolated village's area marked with a vertical dotted line to represent the range of possible population sizes.

divided by the average living area per person from the 25 villages, (2) four longhouses multiplied by the average number of people per house, (3) living area of the four longhouses divided by the minimum living area per person (village of highest density of people per house) for a liberal estimate, and (4) four longhouses multiplied by the maximum number per house (again using the village of highest density of people per house) for another liberal estimate.

RESULTS

The overall cleared area of the isolated village is only 3.8 hectares. This area is at the extreme small end of the other indigenous Brazilian villages (Fig. 1b). Best fit line and 95% prediction interval are shown on the graph with the isolated village's area and possible population sizes denoted with a vertical dotted line. The population-by-area regression prediction interval and a variety of other methods using the estimated area of the four longhouses ($\sim$112 m^2) suggest a population of no more than 40 total people (including children and adults). The average estimated population across the six different methods is only 22 people (Table 1). A flyover in 2011 revealed at least nine people, although later that year the whole village reportedly left the area, perhaps in response to drug traffickers in the area (Pappas, 2011). More recent 2012 IKONOS and WorldView high-resolution satellite images show no trace of the village.

TABLE 1. Six different methods for estimating the population of the isolated village sorted from least to most

Population estimate	Method
6	Living area (112.2 m^2)/Average living area per person (17.4 m^2)
8	Predicted value from best fit line in Figure 1b
17	Four houses × average number per house (4.33)
22	Living area (112.2 m^2)/minimum living area per person (5.1 m^2)
37	Upper prediction interval from Figure 1b
40	Four houses × maximum number per house (10)

DISCUSSION

A small, isolated village like this one likely faces an imminent threat of falling below a minimum viable population if it is not connected to any other friendly villages of the same ethnicity. Many of the other isolated indigenous peoples in Amazonia may also be facing similar dire situations in terms of small populations struggling against an onslaught of external risks. Given the grim history of previous contacts with the outside world, forced contact seems ill-advised. We suggest that an active remote surveillance program is needed to track the movements and demographic health of isolated peoples in hopes of ameliorating their chances for long-term survival by guiding future policy decisions of national governments.

While all surviving Brazilian indigenous populations suffered extensive mortality during contact with the outside world, most of them exhibit positive growth rates within the first decade postcontact, provided at least some 20 or 30 people survived (Hamilton et al., 2014). To help ensure that currently isolated populations do not drop below minimum viable population size, it is necessary to quantify their population dynamics. If we could quantify the effects of external threats (i.e., deforestation, illegal mining, cattle-ranching etc.) on indigenous population dynamics and spatial ecology, we could use this information to shape policies in ways that mitigate against these threats, such as setting aside and enforcing larger protected areas. Indigenous land rights are key to long-term population viability. The first task is to geolocate isolated villages, perhaps using automated search algorithms to detect signs of habitation, and then track their patterns of migration and land-use through time. In this way, it may be possible to determine the boundaries of protected areas that are of sufficient size to buffer against external threats, support a recovering population base, and revive metapopulation structures. A slice of humanity's ethnolinguistic diversity hangs in the balance.

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LITERATURE CITED

Asner GP, Knapp DE, Broadbent EN, Oliveira PJC, Keller M, Silva JN. 2005. Selective logging in the Brazilian Amazon. Science 310:480–482.
Bodard L. 1974. Green Hell: massacre of the Brazilian Indians. New York: Dutton.

Brown BM. 1987. Population estimation from floor area: a restudy of "Naroll's Constant". Behav Sci Res 22:1–49.
Chamberlain AT. 2006. Demography in archaeology. Cambridge: Cambridge University Press. 256 p.
Fox J, Rindfuss RR, Walsh SJ, Mishra V, editors. 2004. People and the environment: approaches for linking household and community surveys to remote sensing and GIS. New York: Kluwer Academic Publishers.
Hamilton MJ, Burger O, Walker RS. 2012. Human ecology. In: Sibly RM, Kodric-Brown A, Brown JH, editors. Metabolic ecology: a scaling approach. Oxford: Wiley-Blackwell. p 248–257.
Hamilton MJ, Milne BT, Walker RS, Brown JH. 2007. Nonlinear scaling of space use in human hunter-gatherers. Proc Natl Acad Sci USA 104: 4765–4769.
Hamilton MJ, Walker RS, Kesler D. 2014. Crash and rebound of indigenous populations in lowland South America. Sci Rep 4:4541.
Hassan F. 1981. Demographic archaeology. New York: Academic Press. 298 p.
Hemming J. 1978. Red Gold: the conquest of the Brazilian Indians. Cambridge: Harvard University Press.
Pappas S. 2011. Reclusive Amazon tribe missing after attack. NBC News story. Available at: http://www.nbcnews.com/id/44066285/#.Uo4fOcSshca. Last accessed 17 April 2014.
Ricardo B, Ricardo F. 2011. Povos Indígenas no Brasil. São Paulo: Instituto Socioambiental. Available at: http://pib.socioambiental.org/. Last accessed 17 April 2014.
Vaz A. 2011. Isolados no Brasil. Política de Estado: da tutela para a política de direitos—uma questão resolvida? Brasília: Estação Gráfic.