Is There Pee in the Water?

Leptospirosis Risk and Vulnerability Analysis, Peru

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Acknowledgements:

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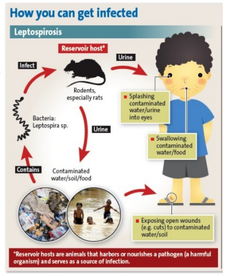
Introduction

Leptospirosis is a zoonotic bacterial infection caused by spirochetes of the genus *Leptospira*. This neglected tropical disease is widespread in Peru and other tropical regions (Bharti et al. 2003) due to hot and humid climates coupled with dense human to mammal reservoir populations (Johnson et al. 2004). Many animals (wildlife, rodents, livestock, and pets), and occasionally humans (Ganoza et al. 2010), can be asymptomatic carriers of the bacteria, excreting them in urine. Most humans are infected via contact with infected urine, either directly or from contaminated water or soil ((WHO) 2003). Exposure is common in urban slums, in water recreation, and agricultural endemic areas of . Humans symptoms range from mild and flu-like, to jaundice, respiratory distress, and death, and can be confused with the symptoms of viral hemorrhagic fevers like Ebola (Bharti et al. 2003). In livestock it causes reproductive failure and losses in milk production and growth rates, damaging livelihoods in addition to animal well-being (Lilenbaum and Martins 2014).



Source: http://wiki.ggc.edu/wiki/FILE:Lepto-infection.jpg

Presence of leptospirosis in wild and domestic mammals (Bunnell et al. 2000) and in humans (Cruz et al. 2002) has been established in several regions of Peru. For example, in Iquitos, seroprevalence of in humans is 12-28% (Johnson et al. 2004). However, local or national control of the disease remains elusive. This weighted risk analysis predicts what areas are at risk by examining environmental transmission risk factors including land-use, flood zones, and ecozones as a proxy for precipitation/humidity, soil types, and elevation. This risk is added to data on the poverty gap and population density to approximate vulnerability. Population density also highlights areas where a maximum number of people will be affected by any intervention. The end goal of this work is to highlight areas of high risk and vulnerability that could be targeted for research or interventions.

Methods

Environmental Risk Analysis

Raster calculator was used to perform a weighted risk analysis on environmental risk factors as shown in the factor table.

Vulnerability and Population Density Bivariate Map

Poverty gap and population density were added to show (1) vulnerability and (2) areas where high density allows for increased intervention reach. Weighted risk and poverty were combined to give vulnerability to the disease. For simplified visualization, both vulnerability and population density were reclassified into three groups to reduce color confusion.

Research Questions

- Where should interventions be targeted?
- Where are people at highest risk of contracting leptospirosis?
- Which people are predisposed to worse health outcomes from leptospirosis infection (high vulnerability) due to poverty and/or population density?

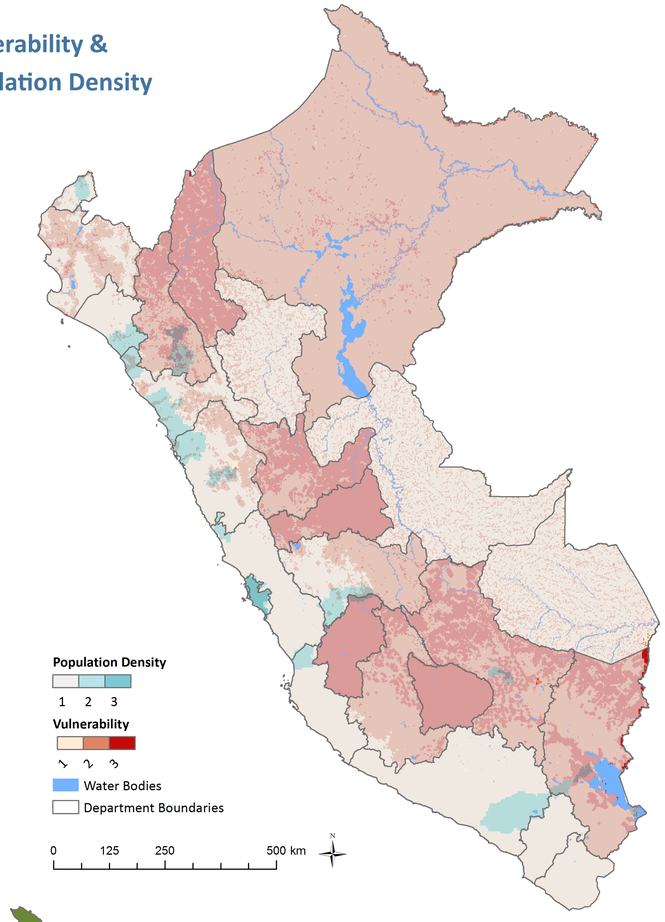
Risk Factors	Weight	Score 1 (Low Risk)	Score 2	Score 3	Score 4	Score 5 (High Risk)
Ecozones (proxy for soil, climate, elevation)	20%	Deserts and xeric shrubland	Sub/tropical broad-leaved dry forests, pastures and montane scrubland	Grasslands, savannas, and tropical and subtropical scrub	Tropical humid broadleaved forests and subtropical	Lakes, mangroves
Distance to Flood zones (km)	40%	> 10.1	5.1 - 10	2.51 - 5.0	>0 - 2.5	0
Land Use Types	40%	Non-vegetated, sparsely vegetated	Primarily grassland (>60%), primarily forest (>60%)	Forest/other vegetation with agriculture, agriculture/other mosaic	Cropland, cropland/ pasture, agriculture with forest/other vegetation, agriculture/ 2 other land cover types	Inland water
Poverty Gap (in quantiles)	-	2.91 - 10 (slight poverty)	10 - 17.09	17.09 - 24.18	24.18 - 31.27	31.27 - 38.36 (deep poverty)
Population Density (persons per sq km)	-	< 58	58 - 1070	1070 - 2452	-	-

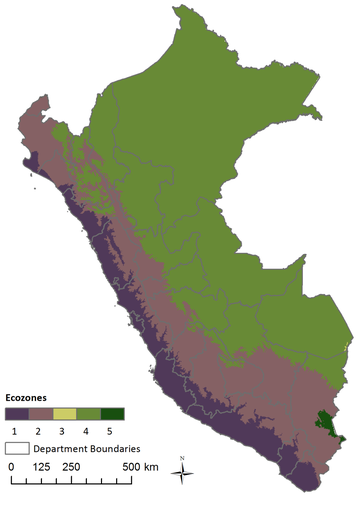
Data Sources:

Food and Agriculture Organization of the United Nations, the Center of Conservation Data at the National University of Agriculture at La Molina, GADM, the Ministerio del Ambiente of Peru, Natural Earth, the Center for International Earth Science Information Network, and the Digital Chart of the World.

Data Projection: Universal Transverse Mercator Projection, Zone 18S

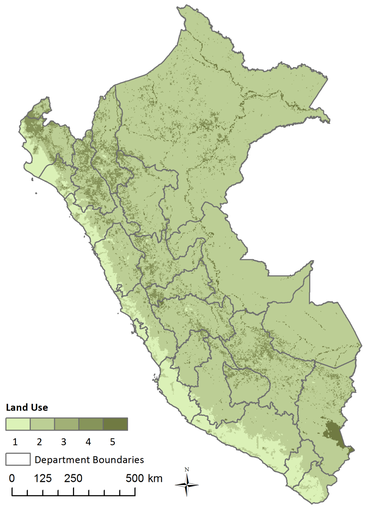
Vulnerability & Population Density

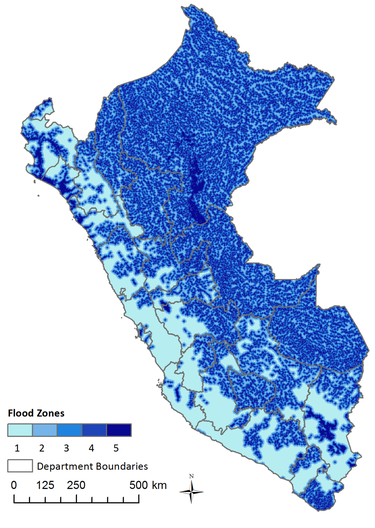




Ecozones were ranked according to their elevation, humidity, likelihood of standing water/waterlogged soils as these are all risk factors for *Leptospira* bacteria being able to survive for significant amounts of time in the environment. The polygon layer was then reclassified based on the ranking, which can be examined in the factor table.

Land use was ranked according to involvement of agriculture, and likelihood of waterlogged soils. Occupational infection with leptospirosis is common in agricultural settings, especially those involving irrigation for rice cultivation or other purposes, and livestock rearing. The raster was reclassified following the factor table.

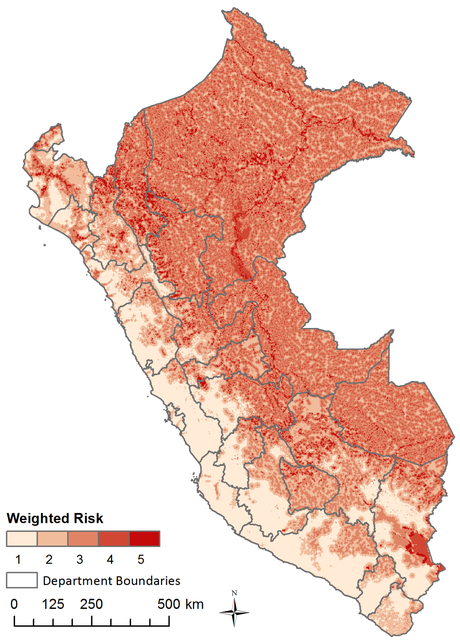




Flood zones, of the coastal departments from the Peruvian government, was merged with areas prone to flooding from FAO data and a buffered layer of water bodies and rivers to attain full country coverage. Use of the euclidean distance tool created a raster which was then reclassified based on distance to flood zones, ranked as seen in the factor table.

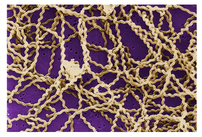
Limitations and Conclusions

This analysis relied upon data from a variety of sources, from the year 2000– 2010. The flood zone layer was incomplete, covering only the coastal half of the country, and the approximation for the rest of the country may overestimate risk because it does not take slope into account. The population layer is from 2000, so that risk factor is likely to have a broader effect than this analysis visualized due to population growth. Land use did not include information on urban/rural differences, and so this information is only represented by population density. Predicted risk is not tested here, but its accuracy should be prior to the implementation of any large intervention. A pilot study would be appropriate.



In order to design public health interventions capable of reducing incidence rates of leptospirosis in Peru, understanding risk factors and vulnerability to those is key. This spatial data on risk factors at country level will be compared with experimental data (Rosenbaum et al. 2016) showing leptospirosis seroprevalence in the San Martín region. The specific study locations in the Alto Mayo Valley exemplify the rural agricultural exposure route to leptospirosis. Testing of humans, livestock, wildlife will allow for verification of the local transmission route. This analysis provides a resource for public health hoping to target high incidence of the disease. However, incidence and/or prevenlance should be verified prior to implementation of any intervention, which the Rosenbaum study aims to accomplish.

Leptospira spirochetes



http://phil.cdc.gov/PHIL_Images/20050308/22ad4ce53a1648feb011a7d6dd26fbb6/138_lores.jpg

Poverty gap is a ratio of how far the mean income of a population falls beneath the poverty line, defined as half the total median household income (OECD 2016). Poverty gap data was obtained from the Peruvian government and joined to the departmental boundary layer to create a map of poverty layer. It was symbologized with quantiles to visualize 5 levels of the incidence of poverty in Peru.