

# Alicerces da Saúde Pública no Brasil 2

Daniela Gaspardo Folquitto  
(Organizadora)

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Daniela Gaspardo Folquitto  
(Organizadora)

# **Alicerces da Saúde Pública no Brasil**

## **2**

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## APRESENTAÇÃO

Saúde é definida pela Organização Mundial da Saúde como “situação de completo bem-estar físico, mental e social e não apenas ausência de enfermidade”. A Saúde Pública compreende um conjunto de medidas executadas pelo Estado para garantir o bem-estar físico, mental e social da população.

Neste contexto a busca pelo conhecimento nas diversas áreas da saúde como fisioterapia, psicologia, farmácia, enfermagem, nutrição, odontologia, meio ambiente são de grande importância para atingir o bem-estar físico, mental e social da população.

A Coletânea “Alicerces das Saúde Pública no Brasil” é um *e-book* composto por 44 artigos científicos que abordam assuntos atuais, como atenção básica, saúde mental, saúde do idoso, saúde bucal, saúde ambiental, cuidados com crianças e neonatos, atividade física, restabelecimento da movimento e capacidade funcional, nutrição, epidemiologia, cuidados de enfermagem, pesquisas com medicamentos entre outros.

Diante da importância, necessidade de atualização e de acesso a informações de qualidade, os artigos escolhidos neste *e-book* contribuirão de forma efetiva para disseminação do conhecimento a respeito das diversas áreas da Saúde Pública, proporcionando uma ampla visão sobre esta área de conhecimento.

Tenham todos uma ótima leitura!

**Prof. MSc. Daniela Gaspardo Folquitto**

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## SPATIAL DISTRIBUTION OF THE *LUTZOMYIA* (*NYSSOMYIA*) *WHITMANI* (DIPTERA: PSYCHODIDAE: PHLEBOTOMINAE) AND AMERICAN CUTANEOUS LEISHMANIASIS (ACL), IN VIEW OF ENVIRONMENTAL CHANGES IN THE STATES OF THE LEGAL AMAZON, BRAZIL

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**ABSTRACT:** Legal Amazon is an especially interesting region, due to the accelerated process of occupation and consequent deforestation it has undergone in the last decades. Furthermore, the region possesses a biologic diversity of the potential vectors, parasites and reservoirs. In these areas, *L. whitmani* is the main vector of ACL, can transmit *L. (V.) braziliensis*, *L. (V.) shawi* and *L. (V.) guyanensis*. This study aims to analyze the spatial distribution of *L. whitmani* and the dynamics of expansion and settlement of ACL in association with deforestation in the states of the Legal Amazon region, between 2003 and 2013. These data were compiled in a Geographic Information System (GIS), using the software ArcGis. From 2003 to 2013, 175,728 cases of ACL. The disease occurred with more

frequency on male individuals. The *L. whitmani* was found in 216 municipalities out of the 775 of the Legal Amazon region. The analysis showed the areas where cases of ACL with the presence of the vector were concentrated, and where they coincided with deforested areas. This was the case in the states of PA, MT, RO, AC and MA. The years of 2002/2003 and 2003/2004 carried the largest number of recorded cases of ACL. The variation in the number of cases of ACL in association with the presence of *L. whitmani* is constant. However, this research showed that the growth in this number of cases is more drastic in areas with environmental changes due to deforestation. These results can contribute to the planning of vigilance and control initiatives, and can serve as a subsidy to define priorities and carry out decision-making processes in the states and municipalities analyzed.

**KEYWORDS:** Environmental change, Deforestation, *Lutzomyia whitmani*, American cutaneous leishmaniasis

**RESUMO:** A Amazônia Legal é uma região especialmente interessante, devido ao acelerado processo de ocupação e consequente desmatamento sofrido nas últimas décadas. Além disso, a região possui uma diversidade biológica dos potenciais vetores, parasitas e reservatórios. Nessas áreas, *L. whitmani* é o principal vetor de LCA, podendo transmitir *L. (V.)*

*braziliensis*, *L. (V.) shawi* e *L. (V.) guyanensis*. Este estudo tem como objetivo analisar a distribuição espacial de *L. whitmani* e a dinâmica de expansão e colonização do LCA em associação com o desmatamento nos estados da Amazônia Legal, entre 2003 e 2013. Esses dados foram compilados em um Geográfico Sistema de Informação (GIS), utilizando o software ArcGis. De 2003 a 2013, 175.728 casos de ACL. A doença ocorreu com maior frequência em indivíduos do sexo masculino. O *L. whitmani* foi encontrado em 216 municípios dos 775 da Amazônia Legal. A análise mostrou as áreas onde os casos de LCA com a presença do vetor estavam concentrados e onde coincidiam com áreas desmatadas. Este foi o caso nos estados de PA, MT, RO, AC e MA. Os anos de 2002/2003 e 2003/2004 apresentaram o maior número de casos registrados de ACL. A variação no número de casos de LCA em associação com a presença de *L. whitmani* é constante. No entanto, esta pesquisa mostrou que o crescimento neste número de casos é mais drástico em áreas com mudanças ambientais devido ao desmatamento. Esses resultados podem contribuir para o planejamento de iniciativas de vigilância e controle, e podem servir como subsídio para definir prioridades e realizar processos decisórios nos estados e municípios analisados.

**PALAVRAS-CHAVE:** Mudança ambiental, Desmatamento, *Lutzomyia whitmani*, Leishmaniose Tegumentar

## INTRODUCTION

The transmission of the American Cutaneous Leishmaniasis (ACL) encompasses a straight relationship between microecological conditions, parasites, vectors and reservoirs; where environmental variables such as temperature, humidity, patterns of soils use and vegetation influence on the incidence and expansion of the disease, due to human proximity to wild zoonotic cycles (Ready 2008, Rangel & Lainson 2009, WHO 2010).

The ACL has a wide geographic distribution. In Brazil, it occurs in all regions, while it is more prevalent in the North, Northeast and Centre-West of the country, with diverse epidemiologic profiles (Gomes 1992, Marzochi 1992). In Brazil, ATL is caused by seven different species of dermatropic *Leishmania*, six being of the sub-gender *Viannia* and one of the sub-gender *Leishmania*. Transmission occurs through several species of parasites and reservoirs, forming the links of different epidemiologic chains (Brasil 2017).

In the Legal Amazon region, ACL is still closely connected to wild environments, where a great variety of vectors coexist with the parasites' primary and secondary reservoirs. When human beings use and occupy these biocoenoses, especially when developing activities related to extractivism and hunting, they are at risk of contracting the ACL (Lainson & Shaw 1994). In spite of that, other transmission profiles are also observed, which is the case of peri and intra-domiciliary transmission. These cases occur when residences are located in areas close to or inside forests, and when

domestic animals are raised in the house's surroundings. Here, phlebotomine vectors find abundant sources of nourishment, and use the forest as a shelter (Brasil 2017). It is important to consider that deforestation contributes to the adaptation of populations of vectors and wild hosts of the *Leishmania* spp. to environments outside forests. The human occupation of deforested areas makes their access to sustenance easier, and alters the conditions of human exposure to parasites (Gomes 1992, Basano & Camargo 2004).

Considering the epidemiologic patterns described above, it is relevant to highlight the presence of *Lutzomyia* (*Nyssomyia*) *whitmani* in important transmission areas of the North region of Brazil – particularly in the states of Amazonas and Pará. *Whitmani* is responsible for the transmission of *Leishmania* (*Viannia*) *shawi* and *Leishmania* (*Viannia*) *guyanensis* in these sites (Lainson 1981, Rangel & Lainson 2003, Lainson & Shaw 2005). On the other hand, in the states of Acre, Amapá, Rondônia, Roraima, Mato Grosso, Tocantins and Maranhão, the *L. (N.) whitmani* carries *Leishmania* (*Viannia*) *braziliensis* (Lainson & Shaw 2005, Costa et al. 2007, Rangel & Lainson 2009, Vilela et al. 2011).

The epidemiology of ACL is extremely complex and may be modified by any alterations in the cycle vector-host-men (Brasil 2017). Deforestation and urbanization processes are important examples of changes that may cause an increase in human and domestic animals' exposure to phlebotomines (Guerra et al. 2006, Pinheiro et al. 2010). The process of occupation in the Legal Amazon region is particularly worrisome, as 30% of wild areas have already been deforested, causing a series of environmental and socioeconomic impacts (<http://amazon.org.br/>). In view of this panorama, this study aims to characterize the spatial distribution of *L. (N.) whitmani* and the dynamics in the expansion and settlement process of ACL in association with deforestation. The analysis will be carried out for the years 2003 to 2013, and will focus in the states that are part of the Legal Amazon region.

## OBJECT E METHODS

### Study Area

The Legal Amazon is an area in the Amazon Rainforest, that encompasses the states of Acre, Amapá, Amazonas, Pará, Rondônia, Roraima and part of the states of Mato Grosso, Tocantins and Maranhão (Figure 1). The Legal Amazon is composed by the Amazon Biome, as well as some areas of Cerrado and Campos Naturais, covering approximately five million square kilometers and 59% of the national territory (Pereira et al. 2010). According to the 2010 Census, nearly 23 million people live in this region, distributed into 775 municipalities (IBGE 2014). Regarding the vegetation of the Legal Amazon, 63% of its area is covered by dense, open, seasonal forests; while 22% consists in non-forest native areas, such as Cerrados, Campos Naturais

and Campinaranas (Pereira et al. 2010).

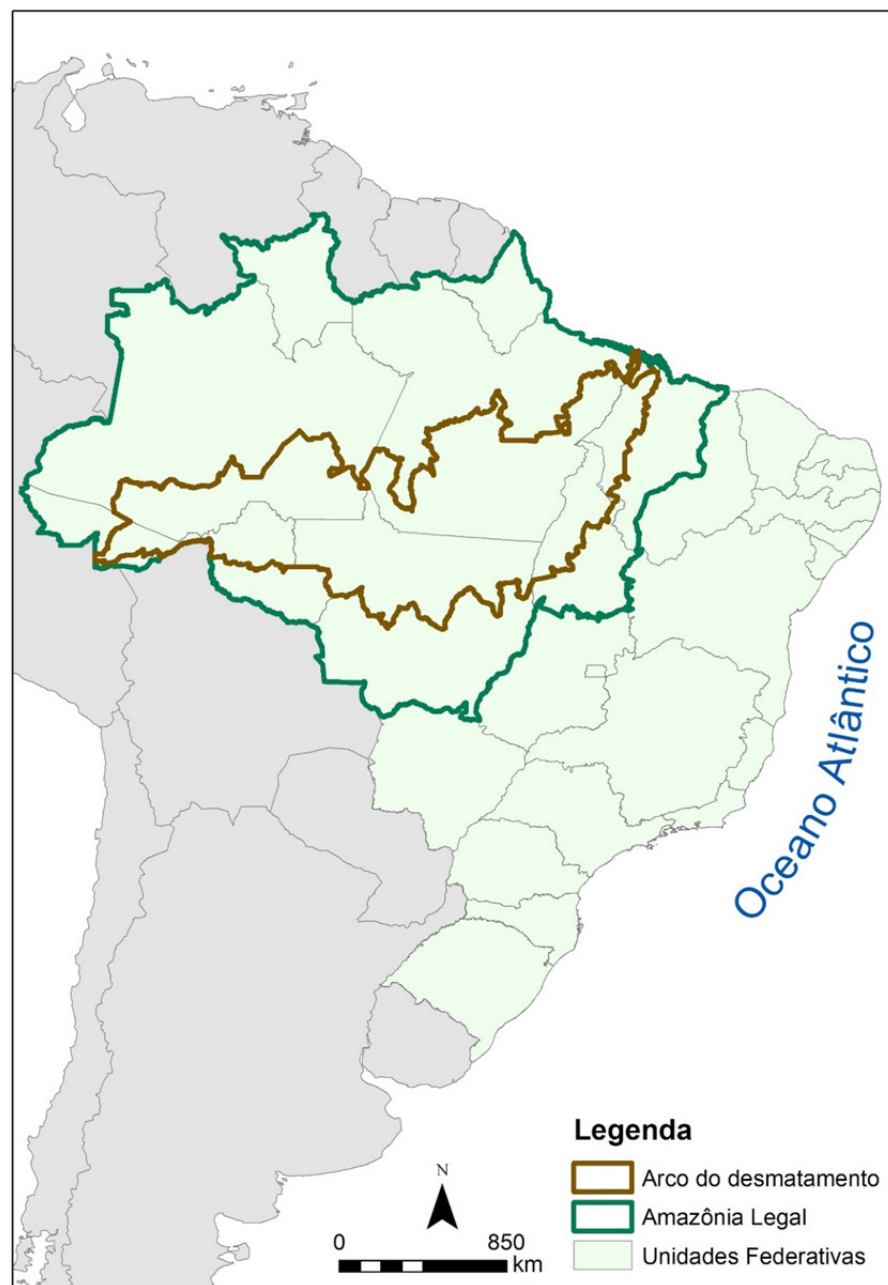


Figure 1. Map of South America, showing the Amazon Biome, countries of the International Amazon, the North Region of Brazil with the states that are part of the Legal Amazon, and the outline of the Deforestation Arch. Map developed by: Geoprocessing Cluster - LIS/ICICT/FIOCRUZ.

## Database

The municipalities where the vector *L. (N.) whitmani* was registered were characterized through bibliographic research, carried out from June to December 2014, using the following databases: LILACS (<http://lilacs.bvsalud.org/>), MEDLINE(<http://www.ncbi.nlm.nih.gov/pubmed>), SCIELO(<http://www.scielo.org/php/index.php>), SCOPUS (<http://www.scopus.com>) and CAPES (<http://catalogodeteses.capes.gov.br>). Different combinations of the key words “Psychodidae”, “*Lutzomyia (Nyssomyia) whitmani*” and “deforestation in the Legal Amazon” were used in the search mechanism. Non-published information obtained through State Health Secretariats and the main

scientific collections of phlebotomines in Brazil (Centro de Pesquisa René Rachou – FIOCRUZ, Instituto Evandro Chagas – IEC and Faculdade de Saúde Pública – USP) was also used to build in the vector's database.

In order to identify the occurrence and distribution of ACL in the period of 2003 to 2013, data was retrieved from the Information System on Notified Diseases – SINAN (<http://portalsinan.saude.gov.br/>).

Finally, data on deforestation in municipalities for the same period (2003 – 2013) was collected from the Project PRODES – Satellite Monitoring of the Brazilian Amazon Forest (<http://www.obt.inpe.br/prodes/index.php>). For each municipality, the increase in deforestation in relation to the previous year was calculated.

## Building Scenarios

The data described in the previous section was inserted into a Geographic Information System (GIS) environment, which allowed for integration of the information on *L. (N.) whitmani* presence, the number of disease cases, and the population of each area of study. In a first descriptive analysis, the index of ACL per 100 thousand people was calculated, and thematic maps were made for each year of analysis, crossing information on deforestation and disease indexes per municipality.

Further, spatial statistics methods were used to detect the relationship between the ACL indexes and deforestation. A positive spatial autocorrelation was detected between those two factors. The Moran Global and Local Indexes were used to investigate the existence of conglomerates of non-stationarity, meaning areas with their own spatial dynamics (Camara et al. 2002). There are two possible ways to treat global autocorrelation in a regression model: in case of spatial autocorrelation, using a Spatial Autoregression Mixed Model (SAR); or, alternatively, using the Spatial Error Model (CAR), when spatial correlation is not detected. It is expected that these results can help to quantify the strength of the correlation between disease occurrence and deforestation. The program ArcGis 10.4 was used to produce the thematic maps referring to spatial distribution and Geoda 1.4.6 was used for spatial statistics.

## RESULTS

The ACL is widely distributed throughout the Legal Amazon region, occurring in all its states. From 2003 to 2013, 175,728 cases of ATL were recorded in the states of the Legal Amazon (Table 1). The period with the highest number of cases registered was the year of 2003, and a decrease is observed in the following years (Table 1). The state with the largest number of recorded cases of ACL was Pará (25,22%), followed by Mato Grosso (19,91%). The lowest record was found in Roraima (2,35%) (Table 1).

The disease was recorded with more frequency in male individuals, which represented 78,55% of the affected in relation to female cases (Table 2). Regarding



age, a higher number of cases was observed in people with 20 to 39 years of age (Table 3).

Out of the 775 municipalities of the Legal Amazon region, the presence *L. (N.) whitmani* was registered in 216, associated with cases of ACL. Areas of ACL and vector concentration (Figure 2) associated with deforestation were identified in the states of Pará, Mato Grosso, Rondônia, Acre and Maranhão. Despite having extensive deforested areas, compared to other states, Amazonas and Roraima did not present a significant correlation between human cases and vector presence, mainly due to a low frequency of the later.

When comparing deforestation/cases with deforestation/index, the years of 2002/2003 and 2003/2004 carried the most records of human cases associated with a high index of deforestation (Table 4).

Figure 3 shows that the highest indexes of deforestation in the Legal Amazon region, which occurred throughout the 10 years investigated by this research, are mainly concentrated in the area called “Deforestation Arch” – extending from the South of Pará, through the north of Mato Grosso and Rondônia, to the southeast of Acre. These areas present a high concentration of cases of ACL.

State	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total	%
Acre	1483	1597	1447	1204	995	1057	1001	1114	971	1241	1009	13.119	7,46
Amazônia	3841	2255	1970	1575	2266	1857	1532	1243	2369	2341	1520	22769	12,95
Rondônia	2058	2250	1751	1264	1018	988	1101	981	730	1194	1270	14605	8,31
Roraima	335	169	287	292	342	360	459	649	230	460	541	4124	2,35
Amapá	582	1172	591	603	679	648	521	501	553	755	812	7417	4,22
Pará	5176	5497	4541	3687	4417	3823	3512	2452	3776	4247	3191	44319	25,22
Mato Grosso	4395	3925	3791	3339	2846	2665	4078	2624	1967	2783	2569	34982	19,91
Tocantins	644	581	527	546	493	418	616	626	447	501	545	5944	3,38
Maranhão	3835	3111	3464	2231	2383	1743	1737	2570	2892	2646	1837	28449	16,19
Total	22349	20557	18369	14741	15439	13559	14557	12760	13935	16168	13294	175728	100

Table 1: Registry of notified cases of American Cutaneous Leishmaniasis (ACL), in the states that cover the Legal Amazon from 2003 to 2013.

Estados	2003		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013		Total		Total
Acre	476	1007	508	1089	445	1002	380	824	284	711	320	737	279	722	315	799	286	685	357	884	277	732	3927	9192	13119
Amazônia	1037	2804	580	1675	501	1469	330	1245	516	1750	371	1486	333	1199	228	1015	432	1937	503	1838	329	1191	5160	17609	22769
Rondônia	195	1863	252	1998	257	1494	169	1095	126	892	131	857	126	975	125	856	96	634	135	1059	145	1125	1757	12848	14605
Roraima	53	282	20	149	70	217	58	234	67	275	60	300	73	386	122	527	48	182	79	381	99	442	749	3375	4124
Amapá	105	477	250	922	103	488	127	476	133	546	124	524	83	438	112	389	123	430	164	591	153	659	1477	5940	7417
Pará	1071	4105	1094	4403	897	3644	890	2797	894	3523	781	3042	787	2725	392	2060	784	2992	907	3340	576	2615	9073	35246	44319
Mato Grosso	556	3839	483	3442	558	3233	578	2761	447	2399	397	2268	700	3378	459	2165	415	1552	502	2281	522	2047	5617	29365	34982
Tocantins	176	468	174	407	133	394	136	410	122	371	117	301	134	482	157	469	116	331	103	398	133	412	1501	4443	5944
Maranhão	1199	2636	964	2147	1105	2359	679	1552	692	1691	500	1243	449	1288	638	1932	883	2009	821	1825	495	1342	8425	20024	28449
Total	4868	17481	4325	16232	4069	14300	3347	11394	3281	12158	2801	10758	2964	11593	2548	10212	3183	10752	3571	12597	2729	10565	37686	138042	175728

Table 2: Distribution of cases of ACL by sex (female and male), in the states that cover

the Legal Amazon. Period from 2003 to 2013.

States	2003				2004				2005				2006			
	10-14	15-19	20-39	40-59	10-14	15-19	20-39	40-59	10-14	15-19	20-39	40-59	10-14	15-19	20-39	40-59
Acre	174	206	543	225	168	200	566	233	147	222	542	216	142	153	427	170
Amazônia	330	561	671	609	191	293	943	446	170	232	904	350	126	225	710	295
Rondônia	60	292	1,147	417	92	330	1176	484	66	227	918	398	46	163	646	298
Roraima	31	65	177	40	9	31	65	43	25	35	142	45	19	46	128	58
Amapá	32	74	343	97	107	154	567	185	44	86	307	116	52	72	271	133
Pará	369	713	2506	931	417	826	2653	949	302	619	2292	793	249	498	1745	692
Mato Grosso	187	536	2231	1,042	161	459	1958	1013	165	409	1812	1,023	159	339	1562	917
Tocantins	47	68	258	147	38	58	259	147	38	48	207	145	44	37	233	133
Maranhão	277	529	1549	834	210	345	1263	736	250	388	1416	769	155	249	909	513

Tabela 3: Distribution of cases of ACL by age group in states that cover the legal Amazon. Period from 2003 to 2013

Estado	2007				2008				2009				2010			
	10-14	15-19	20-39	40-59	10-14	15-19	20-39	40-59	10-14	15-19	20-39	40-59	10-14	15-19	20-39	40-59
Acre	117	144	380	153	168	133	385	123	143	126	367	137	145	164	400	127
Amazônia	196	293	998	410	153	237	858	368	111	166	753	288	89	161	635	193
Rondônia	31	120	528	228	41	94	510	242	39	100	588	258	37	101	470	281
Roraima	26	70	152	60	28	53	175	67	38	80	211	92	58	106	302	113
Amapá	59	73	363	123	44	78	327	138	21	69	289	101	42	69	250	96
Pará	327	621	2,166	752	270	517	1842	713	249	430	1628	690	140	345	1197	518
Mato Grosso	123	299	1,352	753	114	232	1280	739	217	347	1829	1198	113	271	1143	758
Tocantins	27	40	221	122	19	28	153	125	39	54	248	167	50	61	240	155
Maranhão	165	291	1025	482	108	187	698	392	95	189	728	363	157	277	1176	475

Estado	2011				2012				2013			
	10-14	15-19	20-39	40-59	10-14	15-19	20-39	40-59	10-14	15-19	20-39	40-59
Acre	134	148	340	117	170	193	419	175	142	177	379	124
Amazônia	158	272	1166	512	245	304	1016	493	140	180	678	309
Rondônia	34	55	383	177	41	130	620	290	47	106	694	303
Roraima	19	25	107	56	29	65	232	90	31	85	239	113
Amapá	43	77	261	113	65	100	359	157	67	121	374	160
Pará	282	490	1841	703	293	577	2049	794	188	385	1660	632
Mato Grosso	103	142	809	577	129	246	1136	864	123	244	1076	723
Tocantins	38	39	175	109	24	44	216	129	29	46	233	120
Maranhão	231	339	1172	548	207	268	1139	565	108	171	782	396

Desmatamento/casos	<i>r</i>	<i>p</i> -valor	Desmatamento/taxa	<i>r</i>	<i>p</i> -valor
2002/2003	0,01692*	<0,001	2002/2003	0,02274	<0,001
2003/2004	0,01588*	<0,001	2003/2004	0,03852	<0,001
2004/2005	0,01271*	<0,001	2004/2005	0,02823	<0,001
2005/2006	0,00936	<0,001	2005/2006	0,01930	<0,001
2006/2007	0,00927	<0,001	2006/2007	0,02233	<0,001
2007/2008	0,00756	<0,001	2007/2008	0,01761	<0,001
2008/2009	0,00783	<0,001	2008/2009	0,02224	<0,001
2009/2010	0,00658	<0,001	2009/2010	0,01444	<0,001
2010/2011	0,01006*	<0,001	2010/2011	0,01149	<0,001
2011/2012	0,00839	<0,001	2011/2012	0,01398	<0,001
2012/2013	0,00704	<0,001	2012/2013	0,01224	<0,001

Tabela 4: Correlation between deforested area and human cases of ACL; deforested area and the incidence rate, in the states that cover the Legal Amazon, from 2003 to 2013

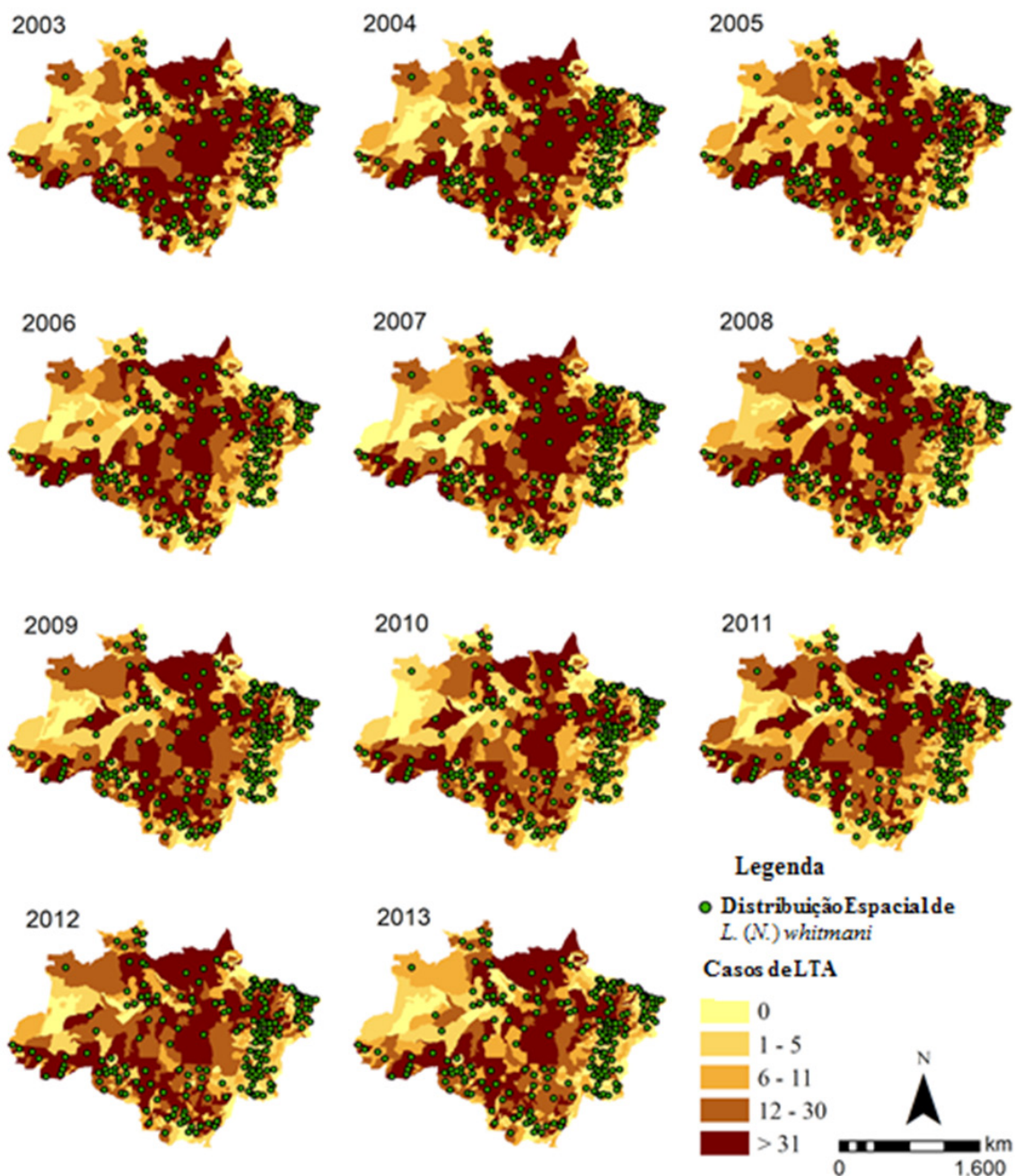


Figure 2. Space-time profile of human cases of American Cutaneous Leishmaniasis

in the Legal Amazon, in association with the spatial distribution of *L. (N.) whitmani*, in the period of 2003 to 2013. Map developed by: Geoprocessing Cluster - LIS/ICICT/ FIOCRUZ.

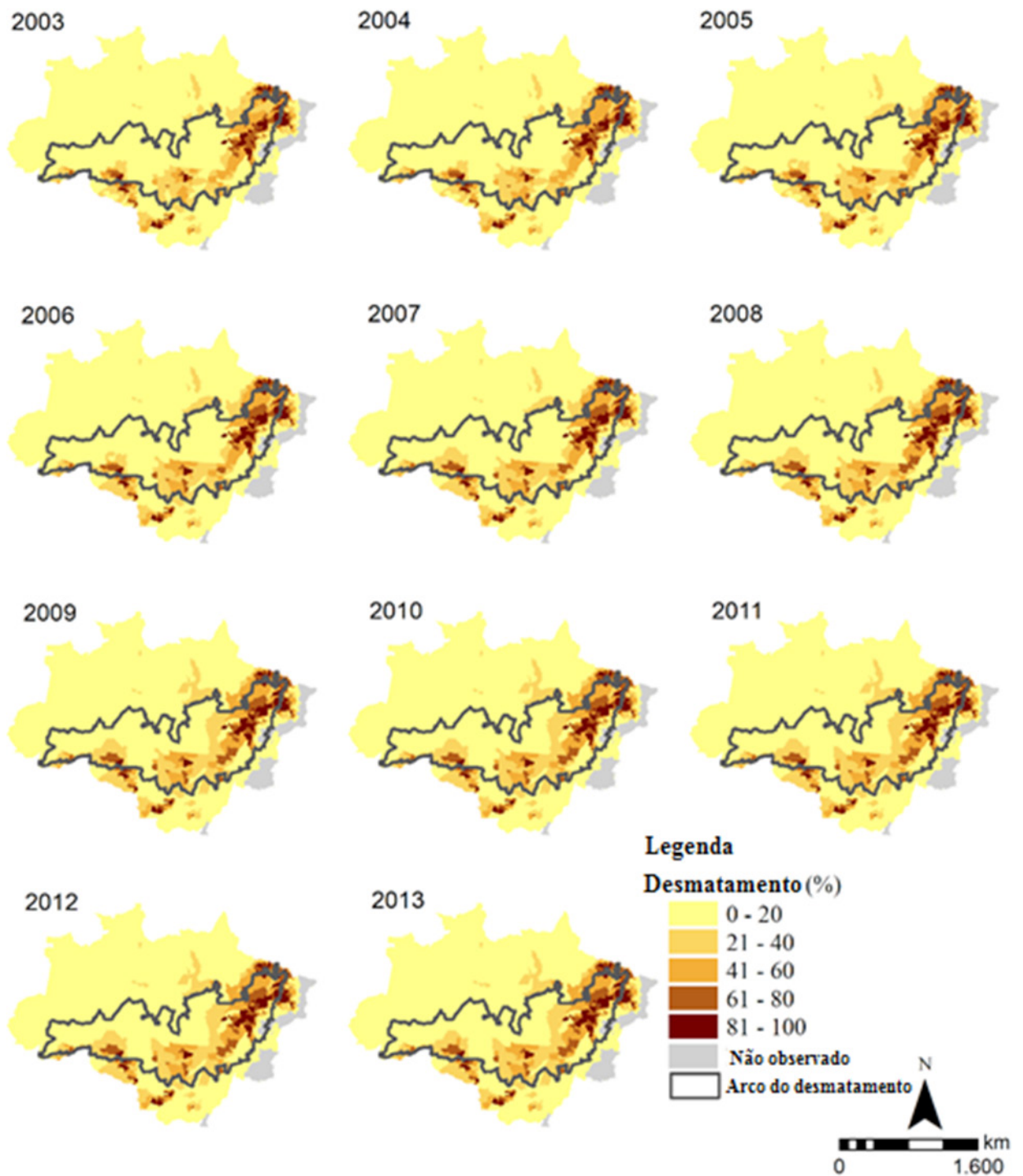


Figure 3. Space-time profile of the deforested areas in the Legal Amazon region, in the period of 2003 to 2013. Source: PRODES. Map developed by: Geoprocessing Cluster - LIS/ICICT/FIOCRUZ.

## DISCUSSION

The thematic maps show an important concentration of ACL cases in the “Deforestation Arch”. This region encompasses parts of the states of Pará, Mato



Grosso, Rondônia, and Acre. The expansion of ACL cases in these areas is closely related to its continuous deforestation, which enables vectors, parasites and reservoirs to find new and nurturing environmental conditions, as described by Rangel & Lainson (2009).

When a comparison is traced between the ten years of this study, the year of 2003 registered the highest number of human cases. According to the ACL Vigilance Manual, in that same year, autochthonous cases of ATL were recorded in all Brazilian states, which shows an expansion of the disease in the country. Comparatively, in the 1980s, American Cutaneous Leishaniasis cases had been recorded in 19 states of the country, and vigilance and control initiatives were already implemented at the time (Brasil 2017). The decrease in the number of cases of ACL in the years following 2003 was possibly related to control measures adopted by State Health Secretariats, as was observed in 2003 by Chagas et al. (2006) in the state of Amazonas.

The focal transmission of ACL is strongly related to environmental changes, be they natural or provoked by men. These factors influence on the increase or decrease in the disease's incidence (OMS 2010). Unbalances in the ecosystem determine the displacement of the wild cycle of the disease to peri-domiciliary environments (impacted areas). The consequences of this movement can be observed in the increase of ACL cases in different epidemiologic profiles.

According to the ACL Vigilance Manual, Brazil presents three epidemiologic patterns (Brasil 2017): (1) Wild – where transmission occurs in areas of primary vegetation. In this case, the disease is characterized as a zoonosis of wild animals, which can affect humans only when they are in contact with wild environments where the disease is circulating; (2) Occupational and Leisure – this pattern is associated to the disorderly occupation of forest environments and processes of deforestation to: build roads, hydroelectric plants, population settlements, to extract wood, to carry out farming activities, to conduce military training or for eco-tourism purposes; (3) Rural and peri-urban in occupied areas – in this case, ACL is related to migration processes, where the occupation of hills and conglomerates in urban centers is associate to secondary or residual vegetation.

The states of (PA) and Mato Grosso (MT) recorded the most elevated number of ACL cases, a fact that is directly related to deforestation and the presence of occupation clusters, formed by populations from several regions susceptible to the disease (Sabroza 1981).

Even though ACL may affect individuals from both sexes and all age groups (Brasil 2017), this study showed a highest frequency of the disease in males in productive age (20 to 39). This contributes to the argument that the transmission of ACL is connected to occupational activities traditionally developed by men, such as agriculture, cattle raising and gold-digging. França et al. (2009) observed that most of the individuals infected by ACL were, indeed, farmers or miners, reinforcing the argument that the occupation of rural areas contributes to facilitate transmission.



In the Legal Amazon, the *L. (N.) whitmani* was recorded in 216 municipalities - all impacted by processes of environmental degradation – in association with ACL cases. Currently, this phlebotomine is considered the most important vector of ACL in Brazil. Its relevance is mainly due to its role in transmission cycles related to the epidemiologic pattern of ATL 2. This epidemiologic pattern is frequently observed in Brazil, and constitutes the main evidence of the geographic spread of the disease (Rangel et al 2014). The *L. (N.) whitmani* was also considered the most important vector of *L. (V.) braziliensis* in areas of the Center-west region that suffered from environmental change due to human activities (Galati et al. 1996, Dorval et al. 2009).

Epidemiologic studies on the *L. (N.) whitmani* report that this vector presents different behaviors in different regions of Brazil (Lainson & Shaw 2005, Rangel & Lainson 2009). It can be associated to three parasites of ACL: *L. (V.) braziliensis*, *L. (V.) shawi* and *L. (V.) guyanensis* (Lainson et al 1979, 1981). Lainson (1988) even questioned the taxonomic status of this species, because of its diversified habits and its capability to inhabit sites with such varied environmental characteristics. The author states that the *L. (N.) whitmani* might be a complex of cryptic species. Regardless of the taxonomic discussions involving the species, this phlebotomine can still be seen as a notable example of adaptation to impacted environments (Costa et al. 2007, Shaw 2008, Rangel et al. 2014).

The state of Tocantins suffered from environmental impacts stemming from the construction of hydroelectric plants, farming activities and the establishment of new settlement areas. The increasing presence of ACL in the state is likely to be a consequence of ecologic changes resulting from these activities. The *L. (N.) whitmani* was found in most of the endemic municipalities in the state, especially in areas degraded by men (Vilela et al. 2008).

The state of Mato Grosso, followed by Pará, are the most deforested of the Amazon. Looking only at the Legal Amazon, the state of Pará is leading in deforestation and, simultaneously, on records of human ACL cases. The high incidence of the disease is likely to be associated to productive activities carried out in the region, such as: gold-digging, wood extraction, agriculture, deforestation to implement pastures, and the presence of a number of agrarian settlements close to forests and favorable climatic conditions for the vector. Similar results were observed by Azevedo et al. (2002) in Peixoto de Azevedo, in the north of Mato Grosso; by Sampaio & Paula [28] in the Federal District; and by Naiff-Júnior et al. (2009) in rural settlements in the AM-010 road, in the state of Amazonas.

Although climatic change sceneries predict the Amazon region to become drier (Passos et al. 1991, Joetzjer et al. 2013), more recent projections show that the well-known and progressive environmental degradation in the Amazon region, associated to climate change predictions, will make the Amazon more adequate for both ACL and the *L. (N.) whitmani* to circulate. This means that the disease and vector will have their areas with adequate conditions for spread extended in the future (Costa et al. 2018).

The results of these studies indicate that the expansion of ACL is related to deforestation, as a consequence of human activities such as agriculture and wood extraction. These activities are drivers of migration waves and the expansion of the agricultural frontiers, and cause environmental changes that facilitate the increase of the disease and its transmission dynamics (vector-parasite-reservoir).

## CONCLUSION

The number of recorded cases of leishmaniasis in association with the presence of *L. (N.) whitmani* varies constantly. Nonetheless, the increase in this number is particularly significant in areas where environmental changes occur due to recent deforestation, mining, the construction of roads, population settlements, among others. These circumstances facilitate the expansion of the disease and the vector, since productive activities and related demographic processes are the most important drivers of environmental change in the Legal Amazon region. In view of the relevance of these conclusions, the results of this research can serve as a tool to plan vigilance and control initiatives, to define action priorities, as well as to assist in decision making processes and resource mobilization in accordance with each region's particular needs and context.

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