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IPAM Amazônia

THE AMAZON IN FLAMES
DEFORESTATION AND FIRE DURING THE COVID-19 PANDEMIC

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Introduction

The Brazilian Amazon may soon be hit by a "perfect storm". An eventual interaction between the COVID-19 pandemic and the increase in deforestation, followed by fire, will have the potential to cause more deaths in the region. The dry and burning season, which begins in late June, may be equal or even more intense than the one that hit the region in 2019 (Silvério *et al.*, 2019; Alencar *et al.*, 2019).

This prediction derives from two factors. The first is related to the sustained growth of deforestation (Alencar *et al.*, 2020). A portion of what was deforested last year was not burned, due to combat actions carried out by the federal and states governments (Alencar *et al.*, 2019), and added to what fell this year. As a result, there is a vast expanse of land covered with dead and dry trees, waiting for the drought that is approaching to be burned.

The second factor stems from the first. If the entire calculated and detailed area in this technical note burns, the smoke will hit a population already vulnerable to the new coronavirus, which causes a severe respiratory syndrome, and which has led thousands of

Summary

- There is an accumulation of 4,509 km² of deforested areas in the Amazon which are waiting to be burned;
- With high deforestation rates as seen in 2019, we expect the deforested and unburned area to double in 2020;
- Four Brazilian States concentrate about 88% of this area, waiting for the burning;
- By land tenure, undesignated public forests concentrate the highest rate of deforestated and unburnt area in the Amazon (29%);
- In 2019, air quality in the most polluted municipalities in the Amazon was 53% worsen because of the smoke;
- The combination of fire and COVID-19 can result in an unprecedented burden on the already fragile and deficient health system in the Amazon, especially in the smaller cities furthest away from bigger and more significant urban centers.

Brazilian deaths. This nefarious combination can result in an unprecedented burden on the already fragile and deficient health system in the Amazon, especially in the smaller cities furthest away from bigger and more significant urban centers.

Therefore, it is urgent for the government and public institutions to put firm and structured actions in place to combat deforestation and, above all, burning. The focus should be given to where there is an accumulation of deforested and unburnt areas, between January 2019 and April 2020, as we present in this technical note. The results are also detailed considering the state and land tenure. Additionally, we assessed the effects of deforestation fires in 2019 on air quality in the region. This way, we hope to contribute to the efforts of public authorities and social organizations with the construction of strategies, to avoid an even more severe situation than that has already been experienced by the population due to the pandemic of the new coronavirus.

Method

Analysis of the deforested and unburnt area

To assess the volume and location of deforested and unburnt areas, we used the monthly data on deforestation alerts from the Deter program, of the National Institute for Space Research (INPE), for the period from January 2019 to April 2020 (available at TerraBrasilis[1]). Deter data related to degradation, such as that generated by selective logging or forest fire, were excluded from the analyzes. It is worth remembering that Deter underestimates the area deforested annually, but it can be considered a great indicator of the trend of deforestation (Alencar *et al.*, 2020). Thus, it is essential to note that the results indicated in this technical note are conservative.

To estimate the area deforested and not burned, we established a radius of one kilometer around each heat source made available by INPE's database of fires[2]. The focus records were captured by the Modis sensor onboard the Aqua satellite[3]. This spatial delimitation around each heat source served as a "proxy" for estimating the area under the influence of fire since the causes are not directly related to the burned area. Using this "proxy", we considered that the burnt area must be overestimated, when compared with the available burnt area data (e.g. Modis MCD64A1). The flames indeed reached an area less than a kilometer in radius around the heat source. It was assumed, then, that the interior of this circular area had burned. Then, we combine the burnt areas around the hot spots with the deforestation records recorded by Deter. The result was a conservative estimate of the deforested and unburned area for the period from January 2019 to April 2020.

Analysis of the impact on air quality

To demonstrate the potential impact on air quality, if the entire deforested area burns in the next dry season , we quantified the optical thickness of aerosols (solid particles) at 0.55 µm suspended in the air, during July to October 2018 and 2019. The data came from MODIS sensor image processing onboard the Terra and Aqua satellites (MODIS Atmosphere Monthly Global Product;

1. http://terrabrasilis.dpi.inpe.br/app/dashboard/alerts/legal/amazon/aggregated/

2. http://queimadas.dgi.inpe.br/queimadas/bdqueimadas. In Jan 22, 2019

3. The satellite uses a regular orbit and it captures daily data, in the beginning of the afternoon. Each hotspot results in a fire range within an area of one square kilometer.

MOD08 vs 006; Platnick *et al*. 2015)[4]. The optical thickness of the aerosol indicates the degree to which aerosols prevent the transmission of light by absorbing or dispersing light and is strongly correlated with smoke from burning (Oliveira et al., 2007). To visualize the increase in aerosol emissions during the dry period of 2019 (from July to October), when vast deforested areas burned, we also collected the data for the same period in 2018. It should be noted that the area deforested in 2018 was 30 % lower than that which had dropped in 2019.

Results

Analysis of the deforested and unburnt area

We estimated that between January 2019 and April 2020, **there was an accumulation of 4,509 km² of deforested areas, which are waiting to be burned** (figure 1). This amount represents about 45% of the total deforested during this period. Most of this area (3,848 km²) was deforested in 2019, while the rest (661 km²) was deforested from January to April 2020. If we consider that the months with the highest deforestation rates are usually May, June, and July (Alencar *et al* ., 2020), and if we maintain the same deforestation rates recorded between May to June 2019 (3,930 km², according to Deter), **we expect the deforested and unburned area to double by the end of July.** In this context, we estimated that a**bout 9 thousand km² of the forest will be cut to the ground in early August** when a large part of the burning occurs. I**f only 60% of this estimated area burns, we will have a fire season in the region similar to that of 2019,** with a drastic negative impact on the health of the population. If 100% of this area burns, we will be able to witness an unprecedented health calamity in the Amazon region, when

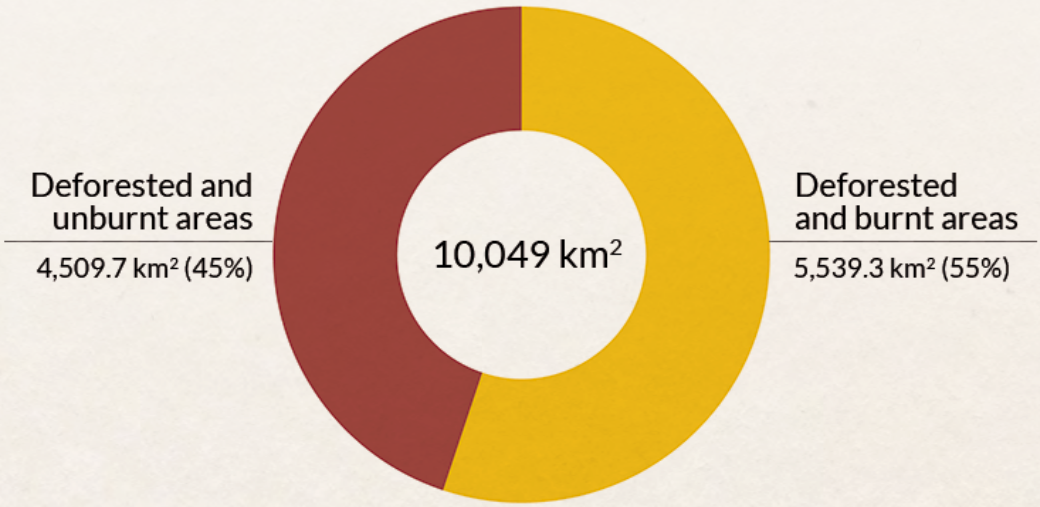

Figure 1.. Estimated burnt and unburnt deforested area, in the Amazon biome, between January 2019 and April 2020. *Source: IPAM, based on data from Deter and hot spots provided by INPE.*

4. Available at: https://disc.gsfc.nasa.gov/information/glossary?keywords=-giovanni%20measurements&title=Giovanni%20Measurement%20Definitions:%20Aerosol%20Optical%20Depth.

adding the effects of COVID-19. In this context, Pará stands out among the states of the Amazon. The rate of deforested areas to be burned in Pará reaches 42% of the total deforested for the entire period analyzed, followed by the states of Mato Grosso, Rondônia, and Amazonas, with 23%, 13%, and 10%, respectively (Figures 2 and 3).

The most critical regions in the state of Pará include: (1) an arc of fire that links the region of Altamira and São Félix do Xingu, with emphasis on the indigenous lands Itauna-Itatá, Apiterewa and Trincheira-Bacajá, in addition to the Protection Area Environmental (APA) Triumph of the Xingu; (2) the region along the Transamazônica highway (BR-230) from Altamira to Rurópolis, with emphasis on the Cachoeira Seca Indigenous Land; (3) the region of Novo Progresso and Castelo dos Sonhos, with focus on the National Forest (Flona) of Jamanxim; and (4) the Lower Amazon region.

Also in the state of Mato Grosso, a lot of deforested area still awaits burning, especially (5) in the municipalities of Colniza, Cotriguaçu, Aripuanã and Apiacás; and (6) in regions west of the Xingu Indigenous Park and in the region of Marcelândia and União do Sul.

In the other states of the Brazilian Amazon, the critical regions of concentration of area susceptible to burning are distributed: in Rondônia, (7) it is in the north of the city of Porto Velho. In the state of Amazonas, (8) in the municipalities of Apuí and Nova Aripuanã, along the Transamazônica in the southeast of the state, and (9) in the locality of "Boca do Acre", on the border between the states of Amazonas and Acre. In the state of Acre, we highlight the regions located in

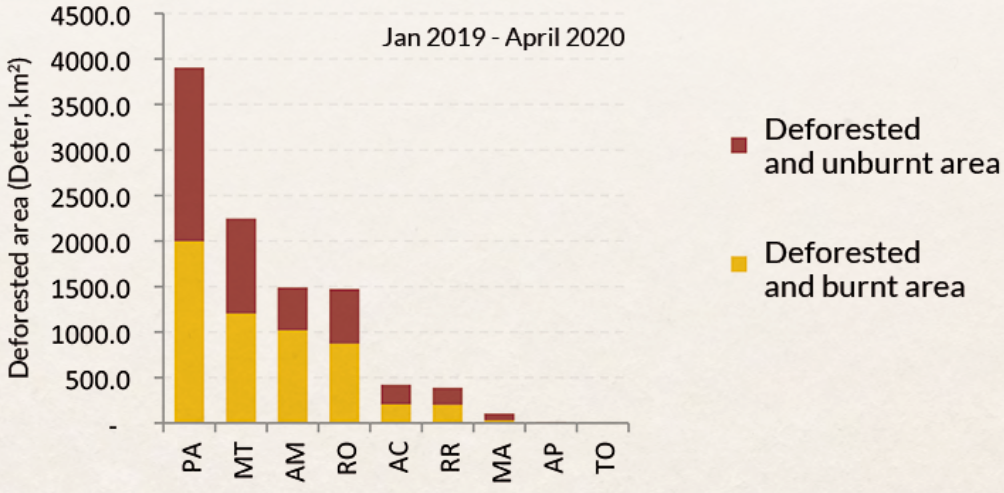

Figure 2. Estimated burnt and unburnt deforested area from January 2019 to April 2020 in the Amazon biome in the states of the Legal Amazon. *Source: IPAM, based on data from Deter and hot spots provided by INPE..*

the eastern portion of the state, especially (10) in the municipalities around Rio Branco and along the BR-364 highways, in the cites of Bujari and Sena Madureira, and BR-317, in the municipalities Senador Guiomar, Capixaba and Xapuri. In Roraima, the critical regions are concentrated (11) in the locations of Caracaraí and Rorianópolis (figure 3).

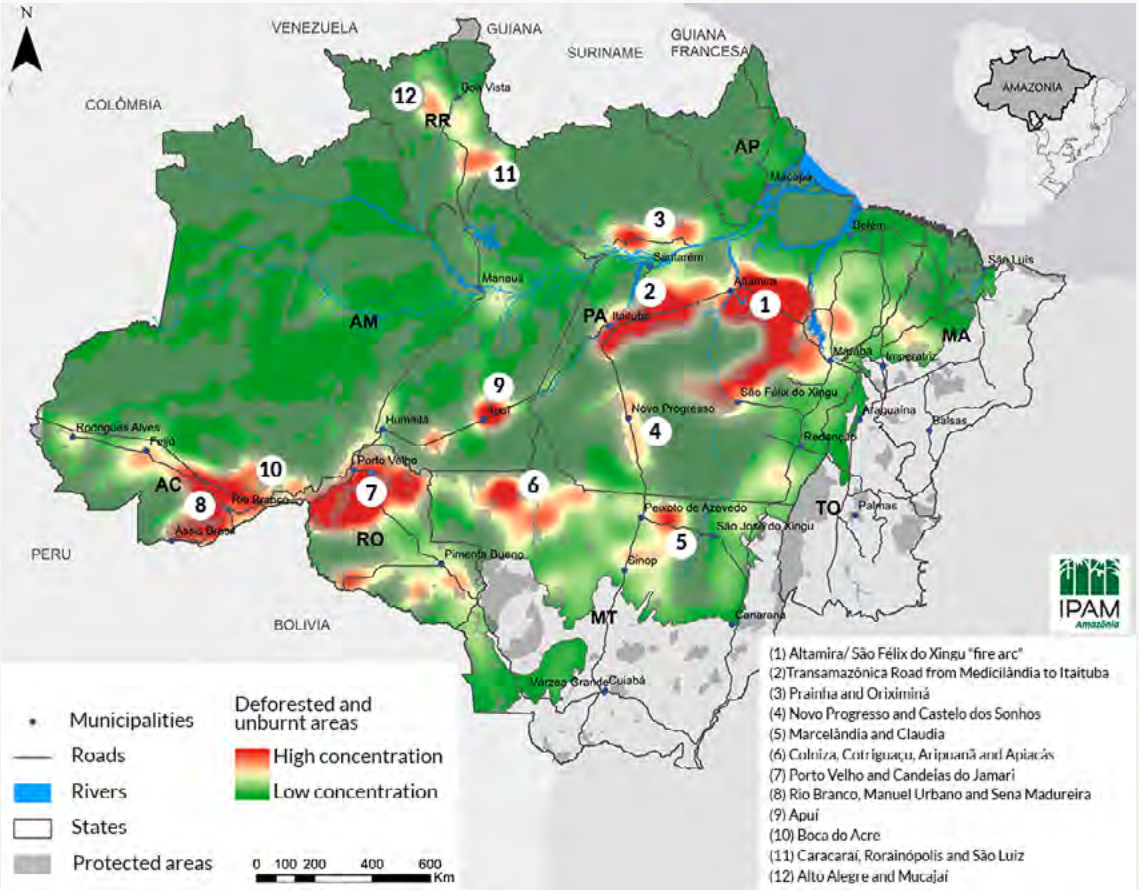

Figure 3. Estimated unburned deforested areas between January 2019 to April 2020. *Source: IIPAM, based on data from Deter and hot spots provided by INPE.*

The analysis of the results on deforested and unburned areas, by land tenure, confirms nowadays the high level of illegality that still affects public non-designated forests in the Amazon. It was in this category of land tenure that we estimated the most significant amount of deforested and unburned area (1,297 km²), representing 29% of the total (figure 4), followed by rural properties (26%) and settlements (25%). Additionally, we can add to the areas deforested and not burned from public forests to areas without official registry (9%).

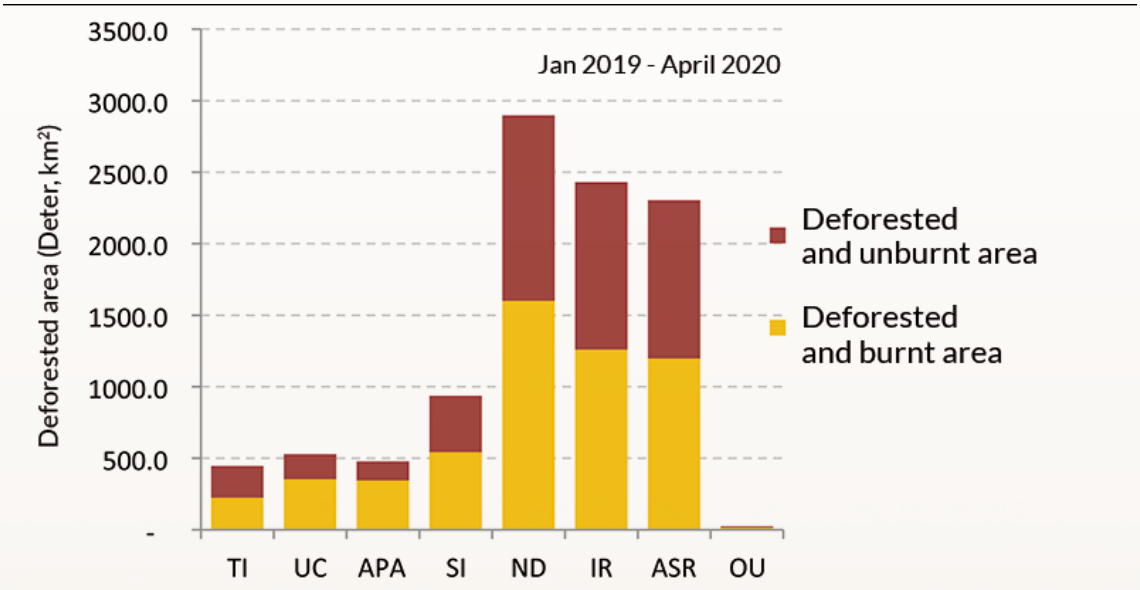

Figure 4. Estimated burnt and unburnt deforested area, by land tenure category in the Amazon: TI - Indigenous Lands; UC - Protected Area; APA - Environmental Protection Areas; SI - without official registry information; ND - Public non-destinated forests, state or federal; IR - rural property; ASR - rural settlements; OR - others. *Source: IIPAM, based on data from Deter and hot spots provided by INPE.*

Analysis of the impact on air quality

The smoke from the fires used to clean newly deforested areas, or from agricultural use in the Amazon, generates a large amount of aerosols, which reduces air quality (Oliveira *et al.*, 2007). These processes are related to the emergence of respiratory problems in the Amazonian population, especially during the dry season.

In 2019, the month of August had the worst rate of air quality in the region (figure 5), when 26 municipalities were affected by a high rate of fires and presented on average 53% more pollution by aerosols compared to 2018 (being minimal 54% in Machadinho D'Oeste and a maximum of 61% in Cujubim, both municipalities in the state of Rondônia; figure 6).

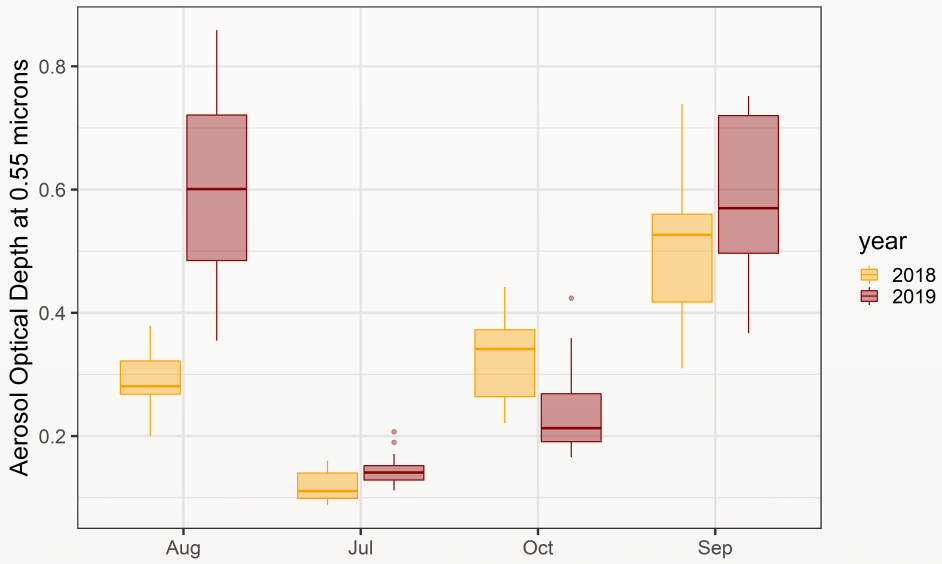

Figure 5. Comparison of the concentration of aerosols (0.55 µm) in the atmosphere during the peak fire months (July to October) for the years 2018 and 2019, in the Amazon. *Data source: Modis, onboard the Terra and Aqua satellites.*

Among the municipalities with the highest burning rates, in the period from July to October 2019, the following stand out (in parentheses, the numbers referring to the districts in figures 6 and 7): in the state of Acre, the municipalities of Tarauacá (1), Brasiléia (2) and Rio Branco (3); in the state of Rondônia, the citiesof Nova Mamoré (22) and Porto Velho (23); in the state of Amazonas, Canutama (6) and Boca do Acre (7); in the state of Mato Grosso, Aripuanã (13) and Colniza (14); and in the state of Pará, São Félix do Xingu (16) and other municipalities located on the route of Highway BR-163, where the so-called "day of fire" occurred (Matias, 2020), including the cities of Itaituba (17), Jacareacanga (18), Novo Progresso (19) and Trairão (20).

It is essential to mention that, even though these areas burned a lot in 2019, there is still a large concentration of deforested regions that have not yet been burned (figure 4).

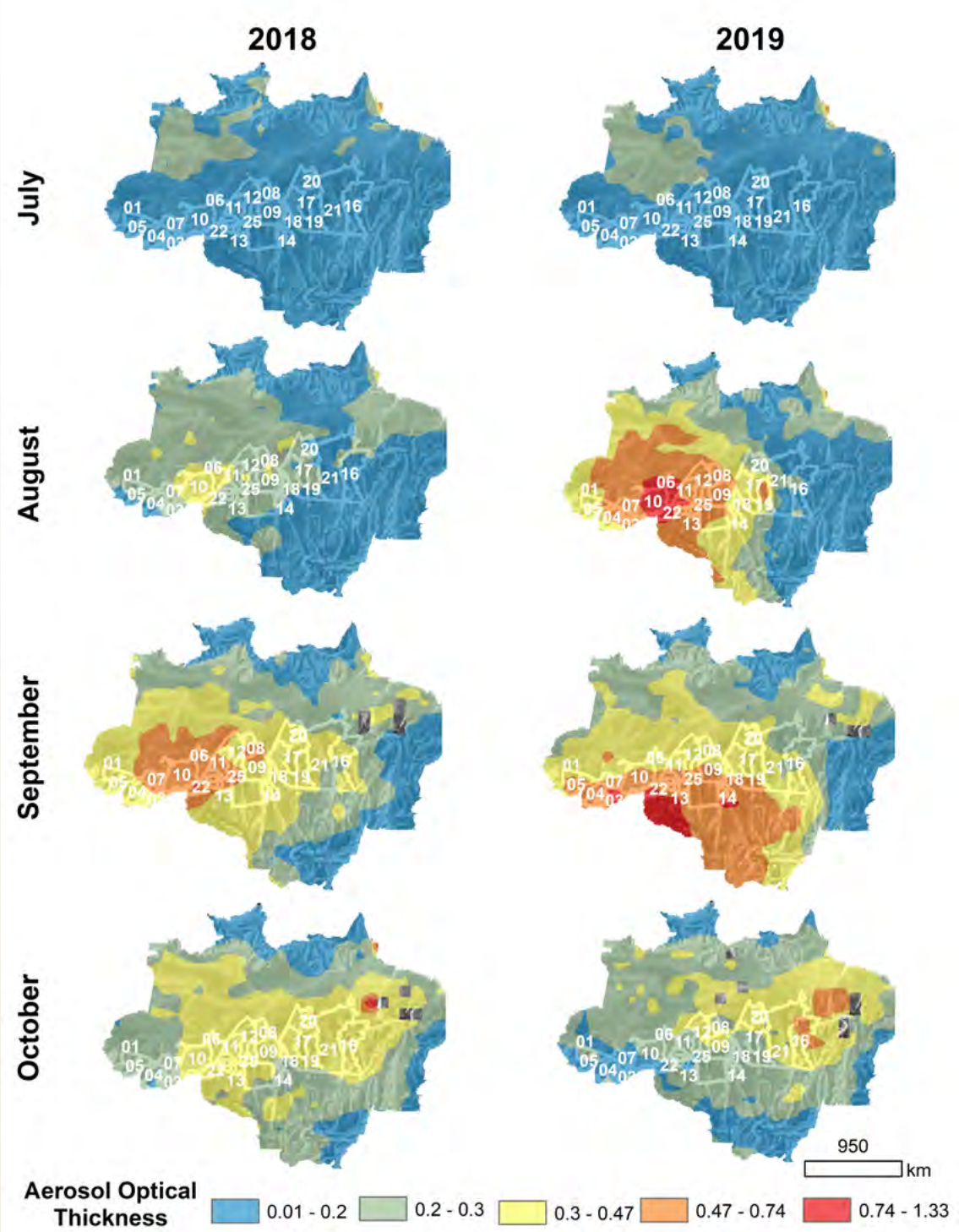

Figure 6. Comparison of the concentration of aerosols (0.55 µm) in the atmosphere during the peak fire months (July to October) for the years 2018 and 2019, in the Amazon; numbers refer to the municipalities that burnt the most. *Source: MODIS Product Monthly Global of Atmospheric Data; MOD08 vs 006; Platnick* et al., *2015.*

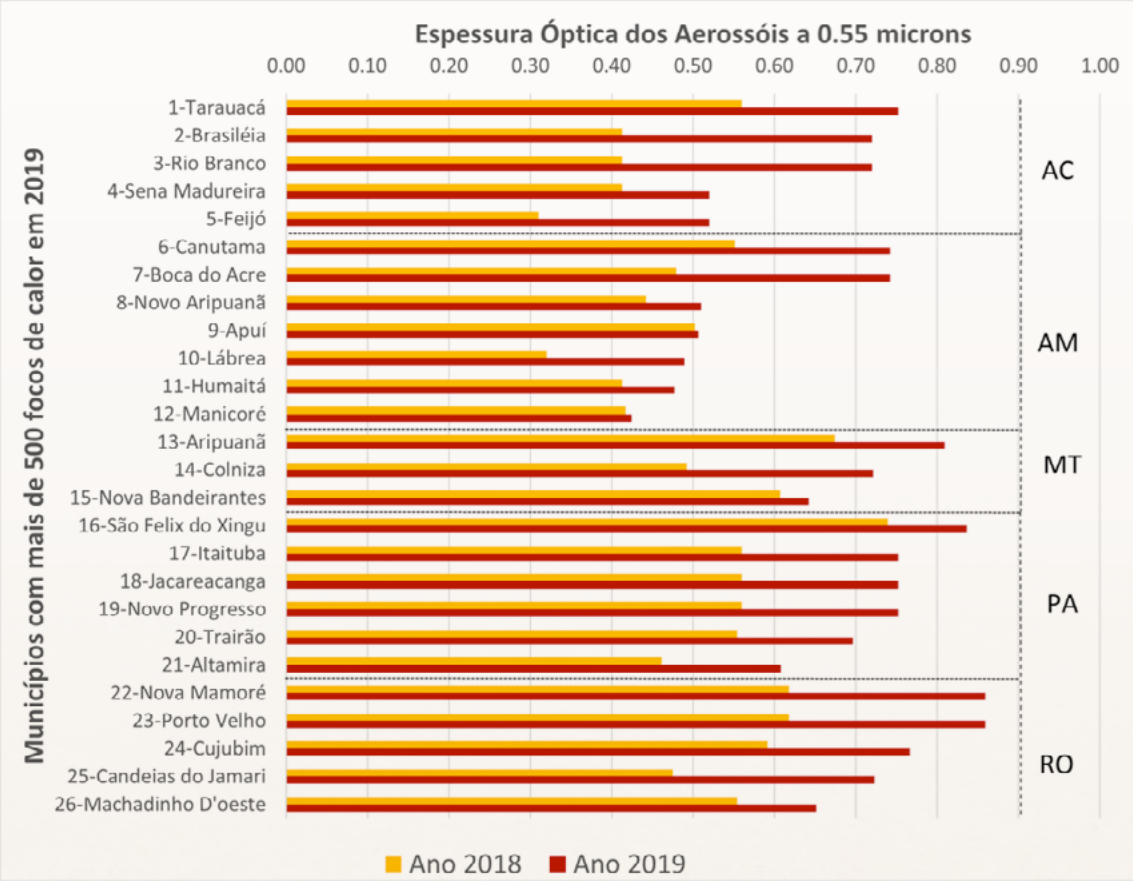

Figure 7. Highest concentration of aerosols (0.55 µm) in the atmosphere per Amazonian municipality in 2018 and 2019, with 500 or more hotpots in the fire season (Jul - Oct). *Source: MODIS ource: MODIS Product Monthly Global of Atmospheric Data; MOD08 vs 006; Platnick* et al., *2015.*.

Discussion

Our results suggest between January 2019 and April 2020, 45% of the deforested area, which represents 4,509 km^2, equivalent to three times the size of the city of São Paulo, will likely be burned in 2020. Four states (Pará, Mato Grosso, Rondônia and Amazonas) concentrate about 88% of this area, waiting for the burning. This process may occur from the end of June when the dry season begins in the region. The land categories that may be affected most by the flames are state and federal public non-destined forests.

The accumulation of this entire area still to be burned raises a warning. There is a risk that the dry season of 2020 will be marked by significant fires, at least comparable to those that occurred in 2019 (Silvério *et al.*, 2019; Alencar *et al.*, 2019; Alencar *et al.*, 2020). If these predictions are proved correct, there will be a production of vast amounts of smoke loaded with fine particles, affecting people's health (Aragão *et al.*, 2020).

Table 1. Number of cases, deaths, and incidence/inhabitants, related to COVID-19 in Brazil by geographic regions. *Source: https://covid.saude.gov.br, in May 31, 2020.*

Region	Cases	Deaths	Incidence/ 100,000 inhab.	Mortality/ 100,000 inhab.
Northeast	179,401	8,866	314.3	15.5
South	2,.056	549	76.9	1.8
North	107,752	5,690	584.6	30.9
Southeast	187,240	13,834	211.9	15.7
Midwest	17,400	375	106.8	2.3
Brazil	514,849	29,314	245	13.9

Every year, in the Amazon, smoke from burning sends a large number of people to hospitals, looking for treatment for respiratory problems (Barcellos *et al*., 2019; Machado-Silva *et al.*, 2020). The increase in the suspension of fine particles mainly affects the health of children and the elderly who live in the region (Aragão *et al.,* 2020). During this period, some cities would stay for weeks under a dense layer of severely polluted air, as was the case in the locality of Rio Branco and other cities in the state of Acre, in August 2019 (Melo *et al*., 2020).

This pessimistic scenario of public health can be quite aggravated, considering the pandemic of COVID-19. The number of inhabitants of the Amazon affected by the new coronavirus is growing (table 1). By the end of May 2020, the country had 29,314 deaths, 20% of which occurred in the North (table 1). The region has the highest incidence rate (584.6) and mortality (30.9) per 100 thousand inhabitants and has 107,752 confirmed cases or 20% of the national total.

Two concerns must be highlighted: the advancement of the new coronavirus among indigenous populations. Until May 25, there were 731 confirmed cases, 169 suspects and 116 deaths by COVID-19, among the 51 indigenous peoples in the Brazilian Amazon (Coiab, 2020). Small cities already show significant growth in the number of infected, which is the so-called "internalization" movement of the infection (Ramalho *et al*., 2020; Aragão *et al.*, 2020).

Under the effects of the pandemic, exposure to smoke or air polluted with fine particles (PM 2.5), resulting from fires, can increase the predisposition to infection by the coronavirus. According to a recent study, the increase of just 1 µg / m3 of particulates (PM 2.5) in the air is associated with an 8% increase in the mortality rate due to COVID-19 (Wu *et al.*, 2020).

An increase in the usual demand for treatments for respiratory diseases can put even higher pressure on a health system that is already close to collapsing. Even now before the fires, until May 11, 2020, the states of Pará and Acre have already registered that more than 70% of the Intensive Care Units, destined to COVID-19, are full (Pitombo *et al*., 2020). In the state

of Amazonas, on May 29, 2020, the ICU occupancy rate was 82%, lower than the almost 100% occupancy recorded a few weeks earlier, due to the increase in the number of ICU by the government.

It is essential to mention that in the state of Amazonas, only the city of Manaus offers Intensive Care Units (Maisonnave, 2020), which reflects the lack of infrastructure for high complexity emergency care in the interior of the Amazon. More than 20% of the population in the states of Amazonas, Pará and Mato Grosso, depend on commuting for up to four hours to reach the nearest municipality with conditions to attend to severe cases of COVID-19 (Fiocruz, 2020). Especially the smaller cities, if simultaneously affected by smoke from burning and infections by the coronavirus, tend not to support the demands of the population.

Recommendations

With this note, we intend not only to warn about the consequences for the health of the Amazonian population, of the dangerous combination of smoke from burning with the pandemic of COVID-19 but also to indicate that emergency plans implemented by governments in the region consider this alert.

The prognosis for the coming months is grave. **It is, therefore, urgent that the federal, state and municipal governments coordinate actions and strategy to prevent the vast area already deforested in the Amazon from being consumed by flames**. The cost of inaction by public authorities will not only be measured by the damage to biodiversity and climate change but by the human lives lost. Structured action is needed as soon as possible to curb deforestation and fires, especially illegal ones.

Rapid and coordinated actions will be necessary for the entire Amazonian drought period. In this sense, the **Decree 10.341** of the federal government[5], which establishes the Armed Forces action against illegal deforestation and the use of fire in Protected Areas and Indigenous Lands (with the exception of the use of the fire by traditional populations for subsistence), **should be extended from June 10th to the end of October,** when the drought period in the region ends. It is also necessary for the Armed Forces to assist states in the region in combating fires.

The fight against deforestation and fires in the coming months should take into account the geographical distribution of deforested and unburned areas (figure 1). The places where there is more devastation or are closer to roads are those with the highest risk of fire.

It is necessary to **monitor the risk of fires and new deforestation in the land categories most affected by illegal deforestation, in particular public non-destinated forests, both at federal and state levels**. This category of forests is coveted by land grabbers and speculators, and the occasional health risk there is particularly high, due to a large amount of cut forests that, if burned, will produce dense columns of smoke.

5. Decree nº 10.341, published in May 6, 2020, available at (in Portuguese) http://www.in.gov.br/web/dou/-/decreto-n-10.341-de-6-de-maio-de-2020-255615699.

State governments in the Amazon must monitor the progress of fires in the coming months in their territories. Some actions can minimize the problem's overlap, such as identifying critical regions where there is a high chance of smoke occurring and establishing moratoriums against burning and deforestation. If a previous action does not arrive in time, **it is essential to combine information on the low air quality with the increase of infected by COVID-19 and to assess the risks of overload in the health systems of cities.** These strategies can help to establish emergency plans, with immediate and targeted actions to fight the flames and adequate assistance to those affected.

Remote monitoring of the Amazon carried out by INPE is essential to support fieldwork by agents from IBAMA, the Federal Police and the Armed Forces, in the fight against deforestation and associated fires. It is crucial that these institutions are strengthened, and their employees valued, not only during emergencies but on an ongoing basis.

In the medium term, progress needs to be made in planning to control Amazonian deforestation. Emergency and one-off actions against illegality tend to be more costly. **It is necessary to establish a strategic plan to face the problem.** It is crucial to **resume the demarcation of indigenous lands and the territory of traditional populations and progress in the creation of new protected areas,** to help prevent deforestation. It is worth remembering that there are about 10 million hectares of abandoned or poorly used pastures (Working Group for Zero Deforestation, 2017). The expansion of agriculture and livestock must consider the recovery and recolonization of this area.

I**t is necessary that the Brazilian Congress does not support attempts to weaken environmental legislation or amnesty against land grabbing**, as was the case with the advance of the temporary Decree 910, now transformed into a Law 2633/2020.

Covid-19 will not leave the Amazon for the next few months. Just as it is necessary to establish measures to combat the transmission of the virus, it is also necessary to control deforestation and fire in this dry season, to increase the safety of the population.

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Annex 1: Concentration of aerosols in the atmosphere (AOT) from July to October 2018 and 2019.

Month	AOT 2018	AOT 2019	Difference 2019-2018	Percentage Difference
July	0.12	0.14	0.03	17.60
August	0.29	0.61	0.32	52.90
September	0.51	0.60	0.09	15.06
October	0.33	0.24	-0.09	-38.09

Annex 2: Concentration of aerosols in the atmosphere from July to October 2018 and 2019, for each state with municipalities that had 500 or more hot spots in the months from July to October 2019.

Month	State	AOD 2018	AOD 2019	Difference 2019-2018	Percentage Difference
July	AC	0.11	0.13	0.02	16.8
	AM	0.13	0.14	0.01	6.1
	MT	0.13	0.17	0.04	22.5
	PA	0.12	0.15	0.03	20.3
	RO	0.10	0.14	0.03	25.0
August	AC	0.24	0.50	0.25	51.1
	AM	0.27	0.48	0.20	42.8
	MT	0.34	0.75	0.42	55.3
	PA	0.30	0.65	0.35	53.7
	RO	0.31	0.77	0.46	59.3
September	AC	0.43	0.66	0.23	34.9
	AM	0.43	0.49	0.06	11.5
	MT	0.63	0.58	-0.04	-7.6
	PA	0.54	0.67	0.14	20.0
	RO	0.57	0.60	0.03	4.3
October	AC	0.26	0.20	-0.06	-30.4
	AM	0.32	0.26	-0.06	-21.9
	MT	0.40	0.24	-0.16	-67.6
	PA	0.34	0.24	-0.10	-40.7
	RO	0.35	0.25	-0.10	-40.8

Annex 3: Concentration of aerosols in the atmosphere from July to October 2018 and 2019 for each municipality that had 500 or more hot spots in the months July to October 2019.

Month	Municipality	AOD 2018	AOD 2019	Difference 2019-2018	Percentage Difference
July	Altamira	0.102	0.133	0.031	23.3
	Apuí	0.14	0.155	0.015	9.7
	Aripuanã	0.153	0.207	0.054	26.1
	Boca do Acre	0.106	0.142	0.036	25.4
	Brasiléia	0.095	0.124	0.029	23.4
	Candeias do Jamari	0.149	0.165	0.016	9.7
	Canutama	0.116	0.142	0.026	18.3
	Colniza	0.088	0.122	0.034	27.9
	Cujubim	0.088	0.135	0.047	34.8
	Feijó	0.126	0.127	0.001	0.8
	Humaitá	0.159	0.144	-0.015	-10.4
	Itaituba	0.106	0.142	0.036	25.4
	Jacareacanga	0.1	0.128	0.028	21.9
	Lábrea	0.137	0.126	-0.011	-8.7
	Machadinho D'oeste	0.088	0.135	0.047	34.8
	Manicoré	0.155	0.171	0.016	9.4
	Nova Mamoré	0.099	0.131	0.032	24.4
	Nova Bandeirantes	0.131	0.17	0.039	22.9
	Novo Aripuanã	0.091	0.112	0.021	18.8
	Novo Progresso	0.116	0.14	0.024	17.1
	Porto Velho	0.099	0.131	0.032	24.4
	Rio Branco	0.095	0.124	0.029	23.4
	São Félix do Xingu	0.145	0.168	0.023	13.7
	Sena Madureira	0.14	0.144	0.004	2.8
	Tarauacá	0.106	0.142	0.036	25.4
	Trairão	0.16	0.19	0.03	15.8
August	Altamira	0.319	0.608	0.289	47.5
	Apuí	0.267	0.506	0.239	47.2
	Aripuanã	0.343	0.809	0.466	57.6
	Boca do Acre	0.276	0.578	0.302	52.2
	Brasiléia	0.22	0.478	0.258	54.0
	Candeias do Jamari	0.286	0.723	0.437	60.4
	Canutama	0.276	0.578	0.302	52.2
	Colniza	0.323	0.721	0.398	55.2

Month	Municipality	AOD 2018	AOD 2019	Difference 2019-2018	Percentage Difference
August	Cujubim	0.3	0.766	0.466	60.8
	Feijó	0.2	0.377	0.177	46.9
	Humaitá	0.267	0.474	0.207	43.7
	Itaituba	0.276	0.601	0.325	54.1
	Jacareacanga	0.323	0.721	0.398	55.2
	Lábrea	0.226	0.444	0.218	49.1
	Machadinho D'oeste	0.3	0.651	0.351	53.9
	Manicoré	0.333	0.355	0.022	6.2
	Nova Mamoré	0.342	0.859	0.517	60.2
	Nova Bandeirantes	0.3	0.642	0.342	53.3
	Novo Aripuanã	0.271	0.51	0.239	46.9
	Novo Progresso	0.272	0.601	0.329	54.7
	Porto Velho	0.342	0.859	0.517	60.2
	Rio Branco	0.22	0.478	0.258	54.0
	São Félix do Xingu	0.379	0.836	0.457	54.7
	Sena Madureira	0.267	0.471	0.204	43.3
	Tarauacá	0.276	0.601	0.325	54.1
	Trairão	0.305	0.696	0.391	56.2
September	Altamira	0.461	0.568	0.107	18.8
	Apuí	0.502	0.477	-0.025	-5.2
	Aripuanã	0.674	0.532	-0.142	-26.7
	Boca do Acre	0.479	0.742	0.263	35.4
	Brasiléia	0.413	0.72	0.307	42.6
	Candeias do Jamari	0.475	0.403	-0.072	-17.9
	Canutama	0.551	0.742	0.191	25.7
	Colniza	0.492	0.681	0.189	27.8
	Cujubim	0.591	0.572	-0.019	-3.3
	Feijó	0.31	0.52	0.21	40.4
	Humaitá	0.413	0.477	0.064	13.4
	Itaituba	0.56	0.752	0.192	25.5
	Jacareacanga	0.56	0.752	0.192	25.5
	Lábrea	0.32	0.489	0.169	34.6
	Machadinho D'oeste	0.554	0.568	0.014	2.5
	Manicoré	0.381	0.367	-0.014	-3.8
	Nova Mamoré	0.618	0.72	0.102	14.2
	Nova Bandeirantes	0.607	0.441	-0.166	-37.6

Month	Municipality	AOD 2018	AOD 2019	Difference 2019-2018	Percentage Difference
September	Novo Aripuanã	0.432	0.386	-0.046	-11.9
	Novo Progresso	0.56	0.752	0.192	25.5
	Porto Velho	0.618	0.72	0.102	14.2
	Rio Branco	0.413	0.72	0.307	42.6
	São Félix do Xingu	0.739	0.681	-0.058	-8.5
	Sena Madureira	0.413	0.52	0.107	20.6
	Tarauacá	0.56	0.752	0.192	25.5
	Trairão	0.554	0.546	-0.008	-1.5
October	Altamira	0.389	0.359	-0.03	-8.4
	Apuí	0.261	0.213	-0.048	-22.5
	Aripuanã	0.438	0.278	-0.16	-57.6
	Boca do Acre	0.221	0.203	-0.018	-8.9
	Brasiléia	0.251	0.203	-0.048	-23.6
	Candeias do Jamari	0.36	0.352	-0.008	-2.3
	Canutama	0.274	0.182	-0.092	-50.5
	Colniza	0.358	0.166	-0.192	-115.7
	Cujubim	0.349	0.24	-0.109	-45.4
	Feijó	0.287	0.172	-0.115	-66.9
	Humaitá	0.263	0.213	-0.05	-23.5
	Itaituba	0.264	0.174	-0.09	-51.7
	Jacareacanga	0.358	0.17	-0.188	-110.6
	Lábrea	0.247	0.228	-0.019	-8.3
	Machadinho D'oeste	0.335	0.269	-0.066	-24.5
	Manicoré	0.417	0.424	0.007	1.7
	Nova Mamoré	0.348	0.191	-0.157	-82.2
	Nova Bandeirantes	0.421	0.268	-0.153	-57.1
	Novo Aripuanã	0.442	0.302	-0.14	-46.4
	Novo Progresso	0.274	0.182	-0.092	-50.5
	Porto Velho	0.358	0.191	-0.167	-87.4
	Rio Branco	0.251	0.203	-0.048	-23.6
	São Felix do Xingu	0.377	0.239	-0.138	-57.7
	Sena Madureira	0.287	0.213	-0.074	-34.7
	Tarauacá	0.264	0.203	-0.061	-30.0
	Trairão	0.4	0.313	-0.087	-27.8