WORLD RESOURCES REPORT

Brazil: Drought and Fire Response in the Amazon

World Resources Report Case Study

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INTRODUCTION

The state of Acre in the Brazilian Amazon suffered two droughts of "once in a century" severity in 2005 and 2010 (Xu et al., 2011). In both years, the consequences included extensive wildfires, caused in some cases by pasture management fires escaping control and in others by deliberate deforestation. The fires raged from July into October, penetrating nearby virgin and degraded forests (Brown et al., 2006a; personal observations). The economic, social and environmental losses incurred in 2005 were in the order of USD100 million. The drought had a major impact on forest productivity and significantly reduced carbon stocks, with estimates of damaged forests ranging from 267,000 to 417,000 ha (Pantoja & Brown 2009).

The 2005 drought triggered an innovative, centralized response by Acre authorities to monitor wildfires and prioritize fire-fighting efforts, an initiative deployed again during the 2010 drought and also used by the state government to respond to flooding emergencies.

The state government set up a "situation room" in order to facilitate the flow of information and coordinate among government institutions. The situation room provided daily updates based on satellite data and overflights, allowing for more effective monitoring of forest fires and placement of fire-fighting crews. It also served to gather meteorological data for analyzing fire risk. . Based on its performance in 2005, the situation room was used again to combat forest fires in 2010. Additionally, the Rio Branco Municipal Civil Defense applied the concept when that city, the capital of Acre, was affected by floods in 2006, 2009, 2010, and 2011, with the objective of coordinating governmental agencies and civil society in their response to flooding.

An early drought coupled with the experience of 2005 resulted in the Governor of Acre declaring a state of alert on 9 August 2010, followed by the activation of the situation room. The situation room served as a platform to follow the evolution of burning in August, September and October, generating much more data than in 2005.

Indicators of fires in open areas as measured from satellites—known as fire hot spots or pixel counts —dropped progressively from a high in 2005 to a low in 2009, which led to a lowering of priority for fire control in Acre. The cause of this decrease is debatable; attributing it to fire prevention policies does not account for the fact that fire counts increased dramatically in 2010.

While the situation room did not significantly reduce fires in rural areas of Acre in 2005 and 2010, it did serve to help to preserve rural dwellings. The actions of the state government were enhanced due to the existence of numerous active research programs, which provided extensive amounts of data on fires, climate and rainfall, spanning several years. The programs also provided the government with several technical experts who participated in the situation room.

Media and civil society pressure also played a role in the government's response to the forest fires. The extremely high smoke levels in 2005 and 2010, often an order of magnitude above the recommended level set by the World Health Organization of 25 micrograms per cubic meter, affected urban populations, particularly in eastern Acre, generating local political pressure to reduce fires. Photos of smoke haze often appeared on the front pages of regional papers coupled with complaints about respiratory problems.

Finally, political leadership was a key factor. After being elected to the state government in 1998, the Workers Party (PT) entitled itself the "Government of the Forest" and became a regional leader in proposing public policies for conservation. The Party has now completed 12 years in power and has prepared a set of policies designed to reduce deforestation and burning.

SETTING

Situated in the Brazilian Amazon, Acre is Brazil's westernmost state. It borders the regions of Madre de Dios, Peru and Pando, Bolivia, collectively known as MAP region of western Amazonia. In a recent census, the population of Acre has risen to over 700,000 persons. Until recently, Acre had been known as one of the most remote regions of the Brazilian Amazon and tropical rain forests still cover more than eighty percent of the state. Acre has now become the nexus for two corridors linking central Brazil to Pacific Rim economies. Public administration provides about a third of Acre's GDP, which rose in 2007 to 5.8. billion reals, about 3.6 billon dollars at current exchange rates.. The economic activities have shifted from latex and Brazil nut extraction to the service sector, logging and cattle ranching. (Acre, 2009)

Acre contributes less than 5 percent of all Brazilian Amazonian deforestation with an annual deforestation rate of about 0.3%. Acre is known for its innovative public policies that address forest conservation and regional development (Kissinger, 2011). For example, in 2010, the state government launched a new system of incentives for environmental services called *Sistema de Incentivo a Serviços Ambientais*, or SISA. The integrated land-use planning process uses "ecological-economic zoning" to designate priority areas for conservation, deforestation pressure points, and suitable areas for increased production (Hawkins 2010).

The State of Acre has served as a key actor in a subnational effort of state governments from several countries to reduce emissions from deforestation and forest degradation. In November 2010, a memorandum of understanding was signed between the States of Acre, Brazil; Chiapas, Mexico; and California, USA to develop a program on carbon credits for avoided deforestation, a subnational effort that has arisen from a series of meetings of Governors from several countries, in parallel to national efforts directed at mitigating the effects of climate change.

Over the past few decades, several national and international research programs have made available extensive amounts of fire data and maps. Since the 1990s, near real-time fire monitoring has been part of the remote sensing program of Brazil's National Institute of Space Research (INPE). INPE's weather forecasting expertise has grown extensively and includes numerical predictions of wind strength, relative humidity, and rainfall, all of which influence fire propagation. Beginning in late 1980s, INPE's fire monitoring and early warning program provides comprehensive satellite-derived map updates for Brazil and its neighboring countries. The maps, which are updated every 3 hours, illustrate active fire locations with multiple layers showing fire risk, smoke dispersion and vegetation type, using both global data sets and information provided by both conventional and automated meteorological stations.[1]

In 1998, the Brazilian-led Large-Scale Biosphere Atmosphere Experiment (LBA) initiated studies on regional climate, land use changes. One component of the program funded by NASA, LBA-ECO, supported studies on land use and forest dynamics in Acre, resulting in capacity-building among local professionals and young scientists, many of whom studied fire distribution and the susceptibility of rainforests to fire (for example, Selhorst & Brown 2003; Mendoza, 2003).

Finally, local people became involved in fire-fighting through a program called PROARCO, organized by the Brazilian Institute for the Environment and Natural Renewable Resource Management (IBAMA) to support the development of brigades where local associations of rural producers are equipped and trained for fire-fighting.

TYPES OF RISK FACED

In both 2005 and 2010, Acre became the epicenter of severe droughts in Amazonia (Lewis et al., 2011; see Figure 1), and in both cases, extensive fires in open areas broke out, beginning in July and extending until October, with fires penetrating nearby intact and degraded forests (Brown et al., 2006a; personal observations). The fires were a result of pasture management fires escaping control as well as deliberate deforestation. Both droughts developed with relatively little warning. The drought in 2005 was considered to have a "one-in-a-century" probability (Marengo et al. 2008), yet a second, more widespread drought (Lewis et al., 2011) occurred within a span of six years (Xu et al., 2011; Figure 2). The 2005 drought had an extensive impact on the productivity of forests (the amount of biomass that trees produce) and caused a reduction in how much carbon is stocked in the forests, as the drought caused increased tree mortality and subsequent carbon loss by decay, in addition to the carbon

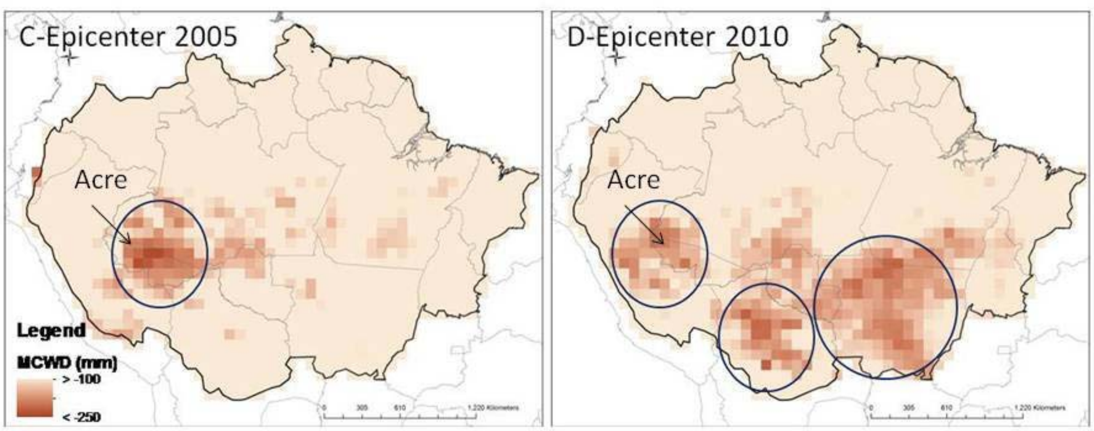

Figure 1. Acre as the principal epicenter of the 2005 drought and one of three epicenters in the 2010 drought in the Amazon Basin. MCWD is the Maximum Climatological Water Deficit from the decadal mean in mm. Adapted from Lewis et al. (2011) SOM, p.4.

[1] See (http://sigma.cptec.inpe.br/queimadas/perguntas.html) for more information.

dioxide released as a direct result of burning (Phillips et al 2009; Zahn and Running, 2010).

The close proximity of two prolonged droughts has raised the issue as to the resilience of these ecosystems and their carbon storage/sequestration capacity (Lewis et al., 2011).

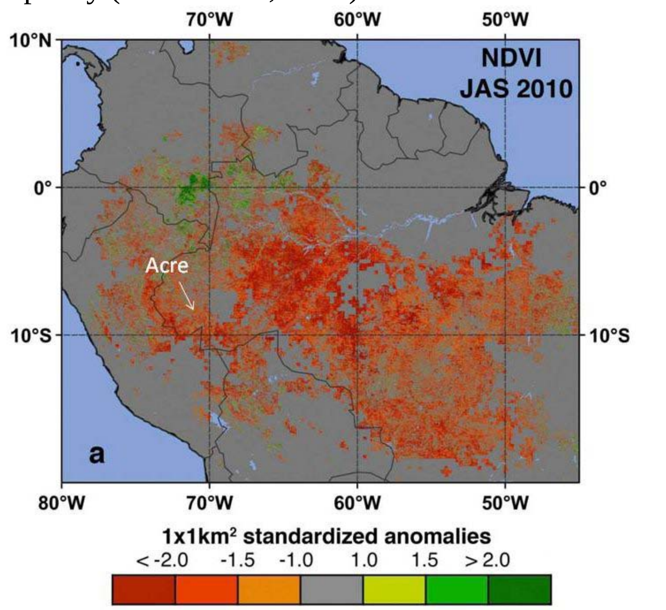

Figure 2. A decrease in greenness of vegetation during the period of July-September 2010, as measured by Normalized Difference Vegetation Index (NDVI). Adapted from Xu et al. (2011). This decrease was relatively widespread, suggesting that this drought had impacts across wide areas of Amazonia.

An apparent increase in the frequency of severe droughts in the Amazon Basin is consistent with the prediction of Cox et al. (2008), which shows a strong correlation between higher CO_2 concentrations and the frequency of severe droughts similar to that of 2005. Their model, however, shows such a correlation only with CO_2 concentrations above the current levels.

Although scattered reports had indicated that western Amazon forests could burn during severe droughts, the prevailing opinion was that those forests were too wet to be susceptible to the large-scale forest fires that had occurred in the drier, eastern Amazonia. Mendoza (2003) showed that during the drought of 1998 associated with an El Niño event, fires could propagate in the litter layers of eastern Acre. Additionally, Asner and Alencar (2010) have noted that in drought years, closed-canopy, moist forests become more susceptible to forest fires as compared to more open forests than in non-drought years.

The risks of severe droughts associated with a rising population and a growing deforested area, much of it planted with African *Brachiaria* sp. grasses that easily ignite in the dry season, has made Acre more vulnerable to fires and water shortages. However, such vulnerability can be addressed with innovative public policies to control fire and find fire-free alternatives for agriculture and pasture management.

POLICY INTERVENTION

In 2005, the first signs that a major drought was developing in Acre became clear in May; by late June, it was apparent that water levels would probably reach a record low for the Acre River, endangering water supplies for over 100,000 residents in the capital of Rio Branco, as the low water levels in the Acre River limited the output of fixed pumps. The state government and city water authority adapted to this situation by installing a floating pump and alerting the public.

By late July 2005, the drought had raised concerns that its continuation could cause forest fires (Brown and Pantoja, 2005). On August 17^{th}, the Governor of Acre issued a moratorium on fire use for clearing land, Counts of fire hot spots on satellite imagery, however, continued to rise dramatically, and by September 21^{st}, the Governor instituted a state of emergency which included the establishment of a situation room in the headquarters of the State Military Firefighters Corps (CBMAC) in Rio Branco.

During August, members of the LBA-ECO team were increasingly called upon for meetings with government officials, and produced informal bulletins of fire hot spots and smoke patterns derived from the web site of the National Institute for Space Policy. When the situation room was installed and organized by the State Civil Defense, the LBA-ECO team from the Federal University of Acre worked as volunteers to analyze satellite imagery and aerial photography from overflights of eastern Acre, providing daily briefings to the officials responsible for fire-fighting. These briefings were used to direct fire-fighting operations the subsequent day.

During September, Wilfrid Schroeder, then a Brazilian Ph.D. student at the University of Maryland who was also involved in the LBA-ECO project, analyzed the China-Brazil Earth Resources Satellite (CBERS-2) imagery. This imagery was available within days of overpasses, and Schroeder produced maps measuring the fire impact in previously deforested areas of eastern Acre, now agricultural lands and pastures. This information complemented that supplied by Alberto Sezter from the National Institute for Space Research (INPE) on fire risk, who prepared special products for Acre that helped planning responses for fire control

In late September, the Federal Civil Defense sent 100 firefighters from Brasilia to help in the effort, bringing the total contingent of professional firefighters to approximately 400, during which time the Brazilian Army and IBAMA brought three helicopters to help transport firefighters to specific sites.

While the responses of the State and Federal agencies were relatively rapid, they paled before the size of the crisis. Estimates of the open area affected by fires in pastures and agricultural lands ranged from 200,000 hectares (Brown et al., 2006b) to 370,000 hectares (Shimabukuro et al., 2009) and estimates of forests impacted by fire ranged from 267,000 to 417,000 hectares (see references above). Using 500,000 hectares as the estimate of fire impact in forests and open areas, the sheer magnitude of the challenge can be seen by dividing this number by the combined staff of about 400 professional firefighters: each firefighter would have been responsible for controlling fires in over 1000 hectares during the burning season. Just locating fire fronts was difficult, as fire hot spot estimates based on satellite imagery in Acre tend to underestimate fire events (Pantoja and Brown, 2007), so that direct overflights were necessary to pinpoint fire fronts, particularly those penetrating forests. Given the dimensions of the fires, the difficulties in locating fire fronts in the forest, and the limited human resources available, the situation room information only managed to direct helicopter flights and ground crews to fight a relatively small fraction of the fires.

Rains began in early October 2005, and by October 11th, the state of emergency was revoked.

In 2010, the Acre State Environment Secretariat (SEMA) received reports of forest fires in July and by August 9th, the Governor had declared a State of Alert with the installation of a situation room close to the Governor’s office. SEMA and the recently constituted Stae Commission on Environmental Risk Management (CEGdRA) assumed a coordinating role with the State Civil Defense and the State Military Firefighters Corps (CBMAC).

During the intervening five years since the drought of 2005 the CBMAC had established fire-fighting units in other municipalities outside of Rio Branco and Cruzeiro do Sul; however, the CBMAC staff state-wide did not increase appreciably since 2005. The unit for Upper Acre, for example, serves four municipalities, covering 15,000 square kilometers with a population of 55,000. The Unit has four firefighters per shift.

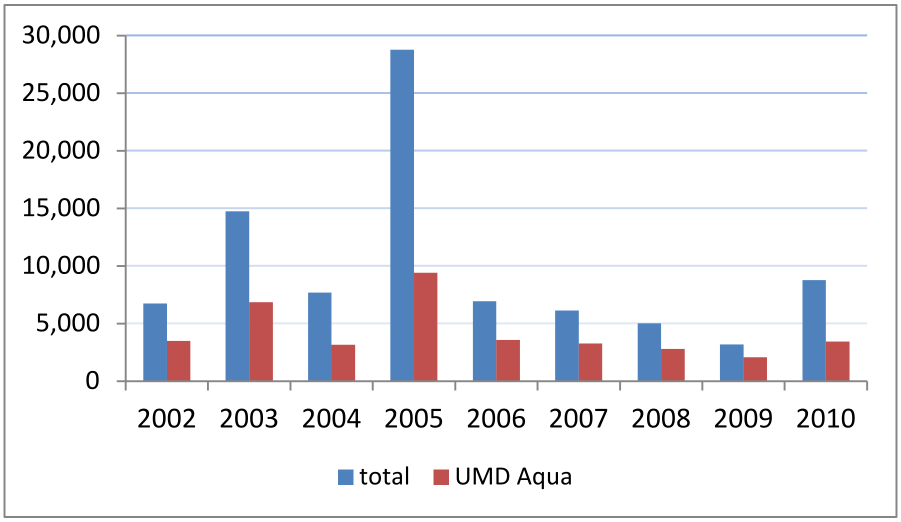

Figure 3. The distribution of hot pixels for the State of Acre for the years 2002-2010. The total includes all available satellite data. For comparison are the hot pixel data from the Aqua MODIS satellite, analyzed by the University of Maryland (UMD Aqua). Data from CPTEC/INPE. The peak in 2003 coincides with a very high rate of deforestation.

While forest fires can cover the largest areas, the most perceived fires occur along or within the peripheries of urban centers. During peak periods fighting these fires can consume all available CBMAC staff. Given that approximately seventy percent of Acre's population is urban, the State Government gives these periphery fires priority in terms of response.

Fire once established in drought-affected rain forests is extremely difficult to irradicate and tends to maintain itself during weeks. In 2010 the Bonal Sustainable Development Project (PDS) became emblematic of the challenges of controlling forest fires during droughts in the Amazon. The northern portion of the Bonal PDS had had extensive logging prior to being burned in 2005, making it exceptionally susceptible to fire in 2010. Forest fires in the 11,000 hectare forest reserve began in July with 60 hectares impacted, expanded in August to 900 hectares of impacted forests and ended with more than 1,500 hectares affected by fires. This expansion occurred despite several CBMAC missions that controlled the fires, but could not eradicate fire in tree trunks and coarse woody debris that serves as an ignition source during intense wind events.

Analysis of satellite imagery indicates that the total area burned (open area and forest) is above 200,000 hectares for the 2010 fires in Acre. This analysis will be refined in the coming months.

OUTCOME

The total number of hot spots for 2005, nearly 29,000, provides a scale for the fire events in eastern Acre, an area the size of Costa Rica. Due to the disparate scale of the number of fires spread over a large area and the limited resources available, firefighting during the drought in 2005 focused on saving rural dwellings, not on controlling fires.

However, the state experienced a steady drop in fire hot spot counts over the next few years. Figure 3 shows the evolution of total fire counts (the sum of hot spots detected by various satellites) since 2003 for the state of Acre, using its pre-2004 boundaries.

For the more typical dry season in 2006, state government agencies and IBAMA developed a program of capacity-building with over 1000 residents in eastern Acre, giving a one-day training course on firefighting. In late July, the Federal and Acre State Public Ministries (autonomous government agencies that represent public interest) recommended the prohibition of fires for 2006 These recommendations were backed by civil and criminal penalties, and the total of fire hot spots that year dropped to about 7,000.

In 2007, the Acre government presented the results of the second phase of the Ecological and Economic Zoning (ZEE) of Acre, part of a long-term policy to reduce both deforestation and fire risk. Forest fires were detected in the Manuripi Region of nearby Pando, Bolivia, but the annual fire count for Acre continued to decline to about 6,000.

In 2008, the Acre State government announced a series of programs, including one to put value on forest assets, and a state plan to control deforestation. The Federal and the Acre State Public Ministries recommended the prohibition of fires during the burning season in late July. The annual hot spot count dropped to 5,000 in 2008.

In 2009, major flooding occurred in April and hot spot counts continued to drop to nearly 3,000. The State Government became involved in national and international discussions about reductions of greenhouse gas emissions from deforestation and forest degradation (REDD). The Federal and Acre State Public Ministries proposed a civil action against the State of Acre, The National Institute of Agrarian Reform (INCRA) and IBAMA in order to eliminate the use of fire by 2011 and provide alternatives for rural producers. While the Acre State Government agreed with the goal, it did not agree with the timetable and contested the civil action.

In 2010, an extended drought affected Acre, particularly its western portion. Based on the experience of 2005, the Acre Governor decreed a state of environmental alert on August 9th and the situation room was activated. Fire spots surged to nearly 9,000 with reports of forest fires not only in eastern Acre, but western Acre as well. The Federal and Acre State Public Ministries recommended in August that the State apply criminal sanctions against those involved in fire propagation.

FACTORS THAT FACILITATED GOVERNMENT ACTION

The government response to the 2005 and 2010 drought and fire events was possible due to a series of factors:

- The Acre State Government had a cultural sensitivity to environmental issues due to political activism of current government officials during the 1980s when a leader defending local forest communities, Chico Mendes, proposed reducing deforestation.

- Pressure by media and civil society due to impact on everyday life was effective. Both in 2005 and 2010, smoke reduced visibility dramatically, impeded airline flights and caused respiratory problems in the state capital, leading to pressure for action.

- The State Government had embarked on a series of policy initiatives designed to reduce both deforestation and the use of fire by rural residents.

- The Federal and Acre State Public Ministries took a proactive role in defining responses to the threat of fire.

- The relatively easy access to information was made possible by the existence of satellite imagery for the fire detection provided by NASA, the U.S. National Oceanic and Atmospheric and Oceanic Administration (NOAA), and the China-Brazil Earth Resources Satellite (CBERS). INPE's web site of provided information on fire risk, hot spots, rainfall, and wind speeds that were made available to decision-makers

- An ongoing research program, the NASA-funded LBA-ECO project in Acre, meant that researchers were actively using fire-related data, and available for consultation by government officials. The LBA-ECO team had several students who were actively studying hot spot and deforestation data.

- The PROARCO team had provided capacity-building for local groups in selected municipalities of the state to help with fire-fighting efforts.

- In 2010, a social network of those who had prior experience with fire studies became part of the technical expertise of the federal, state, and municipal governments, as several former LBA-ECO students had been hired by IBAMA, SEMA, and the Rio Branco Municipal Environment Secretariat.

BARRIERS TO ADOPTING AND ADVANCING THE INTERVENTION

Although many factors came together to help the government take swift action, there were some impediments during the droughts and fires of 2005 and 2010.

- Lack of prior experience of wide-scale burning in 2005. While parts of eastern Amazonia had experienced widespread forest fires, such fires were relatively unknown in the western Amazon before 2005, although scattered reports suggested that such fires were possible.

- The financial and human resource base for action is limited for state government actions, particularly for sustainable rural development. Acre has an area of 160,000 km^2, with 30,000 to 40,000 rural families. Capacity for effective extension work throughout the state is limited.

- The use of fire is culturally-embedded and economically cheap in Acre. The effective dissemination of alternatives to the use of fire has been limited. Without alternatives, fire prohibitions will not be successful.

- Difficulty in ascribing responsibility for fire propagation, as well as limited enforcement capacity, has meant that few are prosecuted for propagating fires during periods of prohibition.

- Risk management was not used to address potential disasters. Rather the approach was to prioritize preventive actions during the dry season, not in the months preceding it.

- Lack of recognition that the increased frequency of fires and floods entails new scales of addressing the problem.

- The Civil Defense approach of involving all segments of society has been limited to sporadic training activities with little follow-up. This has resulted in a loss of continuity in building local responses for fire control.

CONCLUSIONS AND LESSONS LEARNED

- Contingency planning and implementation must be instituted several months prior to the dry season.

- The increased frequency and severity of natural disasters of flooding, droughts and associated fires, coupled with the increased likelihood of such events in the future, means that new approaches must be taken for effective responses and incorporated into contingency planning. These approaches involve more societal participation and designing urban and rural systems of greater resilience.

- The UN Hyogo Action Plan for Disaster Risk Reduction is applicable to Acre's planning process and can provide indicators for building resilience in communities for disasters. It offers a generic approach for risk analysis at the local, state and national levels.

- Given the magnitude of recent and projected future disasters, the principles of civil defense for preparation, prevention, response and recovery need to be disseminated throughout the region. One way of initiating this dissemination is through a directed program in the formal school system, which involves a third of Acrean society.

- Anecdotal information indicates that agricultural productivity has dropped in recent years, consistent with observations on net primary productivity. This suggests that a proactive rural extension program needs to be instituted to strengthen resilience to climate perturbation.

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