Tropical Storm Gamma and the Mosquitia of eastern Honduras: a little-known story from the 2005 hurricane season

David M Cochran Jr*, Carl A Reese* and Kam-biu Liu**
*University of Southern Mississippi, Department of Geography and Geology, Hattiesburg, MS 39406, USA
Email: David.Cochran@usm.edu
**Louisiana State University, Department of Oceanography and Coastal Sciences, Baton Rouge, LA 70803, USA

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The 2005 Atlantic hurricane season was unprecedented in terms of storm activity in the United States, Mexico, Central America and Caribbean. Given the impacts of hurricanes Katrina and Rita, the Honduran Mosquitia sparked little attention despite being hit by two hurricanes and a tropical storm in 2005. This article recounts the history of these storms in the Afro-Caribbean community of Batalla, drawing from public weather advisories and testimony of local residents obtained through participatory research. We contextualise this local history with results from the first paleotempestological study undertaken in the Mosquitia to shed light on long-term risk of catastrophic storms in the region and to demonstrate the value of integrating these two research approaches. Our findings contribute to recent ethnographic research on hazards by describing how a coastal people understand and respond to tropical cyclones and how landscape change influences the vulnerability of a coastal area. Although residents have not witnessed a storm as intense as those documented in the paleotempestological record, their knowledge and perceptions show how tropical cyclones can be disasters while leaving behind no sedimentary records. The paleotempestological evidence, however, reminds us that catastrophic hurricanes have struck the Mosquitia in the past and will do so again in the future. Understanding the interactions between contemporary human perceptions and responses and long-term hurricane risk provides insight for emergency managers and local stakeholders to better prepare for such a catastrophic event.

Key words: 2005 hurricane season, Tropical Storm Gamma, paleotempestology, participatory research, vulnerability, Honduras

Introduction

The 2005 hurricane season brought an unprecedented number of tropical cyclones to the Atlantic Ocean, Gulf of Mexico and Caribbean Sea. The season began on 9 June with Tropical Storm Arlene, and lasted until 6 January 2006 when Tropical Storm Zeta hit the Alabama and Florida Gulf coasts. With 27 tropical cyclones, of which 15 became hurricanes, 2005 broke the 1933 record for the number of named storms (21) and the 1969 record of hurricanes forming in a single year (12). Seven tropical cyclones, both tropical storms and hurricanes, made landfall in the US in 2005. Six others struck Mexico, two passed through the Antilles, and two more hit Caribbean Central America. Hurricane Vince, the first documented tropical cyclone to strike the Iberian Peninsula, made landfall in southern Spain in early October (NCDC 2006).

The 2005 season was also noteworthy in terms of storm intensity. Of its 15 hurricanes, seven became
Category 3 or greater on the Saffir-Simpson scale and four grew to Category 5 at peak intensity (NCDC 2006). Three hurricanes (Wilma, Rita and Katrina) had the first, fourth and sixth lowest barometric pressures for tropical cyclones ever recorded in the Atlantic Basin. Given these statistics, it is no surprise that 2005 was the costliest year on record with more than US$150 billion in property damage and at least 2500 deaths. Hurricane Katrina alone caused 1833 deaths, all within the US (Knabb et al. 2006), and between US$81.2 and US$125 billion in losses (Gray and Klotzbach 2005; Johnson 2006; Ross and Lott 2006).

Most of the 2005 storm impacts, as well as media coverage, were concentrated in the Yucatán Peninsula, Gulf of Mexico and United States Gulf Coast. By contrast, little was heard from the Mosquitia of eastern Honduras, where two hurricanes (Wilma and Beta) and a tropical storm (Gamma) struck between October and November (Figure 1). Except for Wilma, these storms were relatively weak and little-known outside Central America, but nonetheless brought flooding and damage. Their impacts and the responses of local residents provide a good case study of small-scale disasters and tropical cyclone vulnerability in a region of Caribbean Central America inhabited largely by indigenous peoples and ethnic minorities.

The Honduran Mosquitia is certainly exposed to tropical cyclones. Between 1864 and 2005, 39 hurricanes struck or passed near the region. At least 54 tropical storms and depressions affected the Mosquitia between 1931 and 2005 (NOAA-NHC 2008). Hurricane Mitch, which made landfall 85 kilometres west of the Mosquitia in 1998, remains a benchmark for the region and for Honduras as a whole. Storm surge in the Mosquitia was slight, but flooding in the Sico-Paulaya, Patuca and Coco-Segovia watersheds, which drain large areas of the interior highlands, brought widespread damage. Mitch-related research in the...
Mosquitia has focused on the Río Patuca, and specifically on the influence of deforestation on flood intensity (Bass 2002; Cruz et al. 1999), resilience of local populations, and sociocultural and economic changes in riverine communities as a result of the hurricane (Cochran 2005; McSweeney 2005).

This article describes the impacts of Wilma, Beta and Gamma on the Afro-Caribbean Garífuna community of Batalla, located in the northwest Honduran Mosquitia. Drawing from public advisories and local testimony, we recount this neglected chapter in an otherwise closely watched storm season. We contextualise the story with results of the first paleotempestological study undertaken in the Mosquitia to provide insight into the long-term frequency of catastrophic hurricanes in the region. By juxtaposing a local account of the 2005 season with a view of long-term historical records, this article demonstrates the value of integrating these two approaches in research on place-based vulnerability and the responses and resilience of local populations to tropical cyclones (Bankoff et al. 2004; Cutter et al. 2000 2003; Wisner et al. 1994).

We begin with an overview of the Mosquitia, focusing on its natural environments and human-induced landscape changes that played a role in the events of 2005. We then describe the paleotempestological and participatory research conducted between May 2005 and January 2007, which form the basis of this article. We turn next to the paleotempestological results, including a 700-year history of catastrophic hurricane activity in the area based on sedimentary records from a coastal lagoon near Batalla. We then present the results of participatory research, starting with an account of what residents know about tropical cyclones, both past and present, and how they regard them within the context of everyday life. Finally, we integrate eyewitness testimony with public advisories and other reports to construct a local history of the 2005 storm season.

The apparent disjunct between the paleotempestological and participatory results is an important part of this work. Our paleotempestological findings, based on sedimentary evidence of storm surge, show the most recent catastrophic hurricane occurred long enough in the past to no longer be a part of the memories of local communities today. Furthermore, the impacts in 2005 were caused by riverine flooding rather than storm surge. As such, this research reminds us that the destructiveness of a tropical cyclone is not only a matter of intensity, but is also tied to human factors, including how residents interact with their environments and how they perceive and respond to hazards. Tropical cyclones can be disasters without leaving sedimentary records. This has important implications for hurricane research, as well as global change science, which relies heavily on proxy methods like paleotempestology, but often fails to integrate ethnographic findings. At the same time, paleotempestology has the potential to inform ethnographic research by reminding us that catastrophic hurricanes, whose impacts were more severe than any storm in living memory, have hit the Mosquitia in the past and will do so again in the future.

Study area

The Mosquitia is an isolated region that encompasses the Caribbean coastal lowlands of eastern Honduras and Nicaragua and extends inland to the foothills of the interior highlands of Central America (Wallace 1997). Barrier beaches line much of the Mosquitia coast and front a maze of lagoons, estuaries and wetlands. Pine savannas lie inland and stretch north–south across the region. Tropical broadleaf forests cover the western Mosquitia from Honduras into northern Nicaragua, and comprise the largest rainforest region in Central America today. Along major rivers and near settlements, human activity has converted these rain forests into mosaics of old growth and secondary stands, agroforestry plots, cleared farmlands and pastures (Herlihy 2001; Nietschmann 1973).

Agricultural colonisation by Hispanic Ladinos has played a key role in the transformation of forested landscapes in the western Mosquitia. Some Ladinos have lived there for decades, but most arrived recently as landless migrants from more densely settled areas to the west (Cochran 2005; Herlihy 2001). Ranchers and logging companies have encouraged colonisation to open up the region to timber exploitation and cattle ranching. Landscape change has been particularly intense in the Sico-Paulaya watershed, where agricultural land and pastures now stretch in an unbroken belt from the highlands to the coast (AFE-COHDEFOR 2001; Herlihy 2001). Below its confluence with the Río Paulaya, the Sico flows northeast to the coast, where it is known as the Río Tinto or Negro. Bacalar Lagoon, an old delta of this river, is located several kilometres west of its current mouth, and relict river channels are still discernible in its shape. For as long as residents can remember, when the Río Tinto- Negro floods, some of its water enters the lagoon from the south. Most agree that flooding in Bacalar has become more severe in recent years due to deforestation in the upper Sico-Paulaya watershed.

Batalla, an Afro-Caribbean Garífuna community and seat of the municipality (municipio) of Juan Francisco
Bulnes is located on the barrier beach that fronts Bacalar Lagoon. Buena Vista and La Fé, two small Garífuna settlements linked through kinship to Batalla, are located on the southern margins of the lagoon. Nearby is the Hispanic Ladino community of Palacios, which covers a large area of the interior side of the lagoon eastward towards the Río Tinto-Negro.

**Research activities**

This article is based on research we conducted in the Honduran Mosquitia between May 2005 and January 2007. An important aspect of this work involves reconstructing past hurricane activity from sediments of coastal lagoons. Bacalar and other lagoons in the region are fronted by barrier beaches that normally limit influx of sea water. Although located only a few hundred metres from the sea, these lagoons function as lakes, with fine-grained silt from nearby river systems providing most sediment deposited in their beds. In the event of a direct strike from a catastrophic hurricane, however, storm surge may inundate the barrier beaches and deposit sea water and sand into the lagoons. Paleotempestology involves analysing these lagoon sediments and using overwash sand layers as proxy evidence of past hurricanes (Liu 2004).

In May 2005 and January 2007, we collected 13 sediment cores from Bacalar Lagoon. Each core was subjected to loss-on-ignition analysis (Dean 1974), which involves collecting 1 cm³ samples throughout the entire length of the core and heating them to 105°C (for 24 hours), 550°C (for 2 hours) and 1000°C (for 2 hours). Measuring the loss at each respective temperature reveals the percentage of water (wet weight), organics (dry weight) and carbonates (dry weight). Normal lagoon sediments typically have higher amounts of water and organic materials, whereas hurricane overwash layers are comprised mainly of coarse sands and silts.

The second part of this research used participatory methods to document local knowledge of tropical cyclones and to record oral histories of the 2005 storm season and other historic storm events. In recent years, participatory methods have become increasingly valued as tools for data collection and empowerment in social science research (Chambers 1994). Use of this approach has grown in geography since the early 1990s, first with participatory research mapping (Herlihy and Knapp 2003) and later with participatory and public participation GIS (Elwood 2006; Sieber 2006). These advances suggest participatory approaches have great potential in geography as a way to improve data quality and to produce results that are more applicable to research subjects.

We conducted a participatory mapping project in Batalla between June and July of 2006, eight months after Tropical Storm Gamma. We began by meeting members of the town council (patronato) and other leaders to discuss our research. After these initial visits, the patronato of Batalla held a public meeting, attended by 30 residents, to discuss the project and select by group consensus local residents to work with us on the research team. We asked that both males and females be selected, that all should be literate and that all be longstanding and well-respected residents of the community. Batalla residents selected six of their peers – two women and four men – to work as surveyors and participants in this research.

We first organised a 5-day workshop with the research team, coordinating group discussions to collect basic data on Batalla and learn about local perceptions of natural hazards, disaster response strategies and patterns of vulnerability. The research team then collected oral histories of all tropical cyclones within living memory of residents and drew cognitive maps of impacts from the two most recent hurricanes (Fifi and Mitch) and tropical storm (Gamma) to hit the area. We relied heavily on elderly residents in this process, particularly in reconstructing the earliest storms, which dated back to the 1930s. Over several weeks, we administered a survey to document demographic and socioeconomic characteristics of all 129 households in Batalla. Finally, we conducted field excursions by foot and by boat with hand-held GPS units to map tidal surge and lagoon flooding from the three most recent major storms in the area. This was a key step in validating the hand-drawn maps and transforming them into cartographically accurate spatial data. At the end of the project, we organised another meeting, attended by 35 residents, where we presented our results and gave residents an opportunity to discuss the issue of tropical cyclones and their community. Later we presented a Spanish-language report that documented our research in greater detail to local leaders in Batalla and to personnel in various government agencies and NGOs that work in the Honduran Mosquitia.

**Results**

* A 700-year history of catastrophic hurricanes in the Honduran Mosquitia

Loss-on-ignition analysis of the Bacalar Lagoon cores revealed three distinct overwash sand layers, which
were AMS dated to around AD 1290, 1580 and 1780, plus or minus a few decades. Their presence suggests that the beach where Batalla now sits was inundated by storm surge from intense hurricanes (Categories 3, 4 or 5) at least three times over the past seven centuries, or about once every 240 years. We interpret these layers as evidence of direct strikes from catastrophic hurricanes for several reasons. Since 1864, the Honduran Mosquitia has been affected by 39 hurricanes, but has received no direct hits. Hurricanes Fifi, Greta and Edith passed close to Batalla, but remained some distance offshore. Hurricane Mitch made a perpendicular strike, but was far enough to the west to bring only minimal storm surge to the Mosquitia. These hurricanes were destructive, but we found no evidence of their impacts in Bacalar Lagoon. In this regard, it is significant that Batalla residents recalled none of these storms producing surges high enough to breach the barrier dunes, except for Mitch in a few localised areas. These clues lead us to believe that the paleotempestological signal in Bacalar Lagoon is only sensitive to direct, perpendicular strikes from large hurricanes that make landfall in close proximity to the area.

Interestingly, the most recent overwash layer dated to around AD 1780 and occurred either a few decades before or after the Garifuna came to the region after being marooned by the British in 1797 on the island of Roatán off the north coast of Honduras (Davidson 1982). Residents of Batalla and other communities along the northwest coast of the Mosquitia feel they know a great deal about hurricanes based on personal experience, but our research shows that none have ever lived through a direct hit from a catastrophic hurricane. Even the memory of one severe enough to leave a paleotempestological signal in Bacalar would be unlikely to survive for more than two centuries among an ephemeral, coastal people. Based on our research in Batalla, as well as in indigenous Miskito communities near Ibans Lagoon, 15 kilometres southeast of Bacalar, local memory of historic hurricanes only goes back to about the 1930s. The paleohurricane record therefore provides valuable insights not available from the knowledge base of coastal residents regarding the long-term vulnerability of the region to tropical cyclones.

**Local knowledge of tropical cyclones in Batalla**

Much of what Batalla residents know about tropical cyclones has been shaped by mass media, which is increasingly prevalent even in this isolated region. Group discussions with the research team during the participatory workshop revealed that almost all of the 129 households in Batalla owned transistor radios and about 60 per cent had access to cable television. Two landline telephones, part of the state-owned Hondutel network, provide national and international service. The local municipal government office (Palacio Municipal) has a satellite link used by several dozen residents to access the Internet. Batalla is located at the eastern end of an all-season dirt road that links it and neighbouring communities to more urbanised areas in the west. Residents maintain ties to family and friends elsewhere in Honduras and abroad. Numerous residents have lived in Miami, New York and other US cities where Garifuna immigrant communities have emerged over the last half-century (England 2006; Gonzalez 1988). Such worldliness defies prevailing images of people from isolated tropical regions, yet for centuries the Garifuna have been well known as travellers and economic migrants (Kerns 1997; Matthei and Smith 2008). Given their ties to the outside world, it is no surprise that Batalla residents are familiar with Western representations of tropical cyclones like the Saffir-Simpson scale and the timing of the hurricane season. The research team defined a hurricane as ‘a system that forms at sea from the evaporation and condensation of water’ and as ‘a collision of air masses that affects land and sea’. These definitions not only reveal their acquaintance with Western science, but also how the global media has influenced their perceptions of meteorological phenomena.

Despite their outward orientation, the Garifuna are closely tied to their Caribbean home and have a good memory of recent historical storms. The Batalla team, working with elderly residents, correctly identified 9 out of 11 hurricanes that affected the area since 1940. Tropical cyclones make lively conversation topics, largely because people fear them. Their descriptions of strong winds that ‘rotate like a motor’, pounding rain, high waves and coastal flooding are powerful reminders of their vulnerability to extreme weather. Most have lost property and have suffered illness and hunger from tropical cyclones. Those who attended our public meetings during this research generally believed that tropical cyclones are becoming more destructive in the area and they see this in part as a result of deforestation in the upper Sico-Paulaya watershed and around Bacalar Lagoon. Some regard increased severity of tropical cyclones as punishment from God for poor stewardship of local forest resources. Although the Garifuna are involved in deforestation, much blame is placed on nearby Hispanic Ladino residents, and especially recent colonists, whose role in forest clearance across the Mosquitia is well known (Herlihy 2001).

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Batalla residents are becoming concerned that deforestation in recent years has increased the potential of flooding on the Río Tinto-Negro. Given that Bacalar is part of an old delta of this river and is still linked to it by several relict channels, it is no surprise that flooding on the Río Tinto-Negro impacts the lagoon. Moderate flooding in Bacalar is a common event in the living memory of local residents, especially during severe storms like Hurricane Fifi (1974). What is worrisome is that lagoon flooding recently has become more frequent and severe, and this seems to coincide with forest clearance in the Sico-Paulaya watershed and around Bacalar. Flooding from Hurricane Mitch (1998) deposited such a large quantity of debris and animal carcasses in the lagoon that water quality was diminished for months afterwards. Likewise, the 2005 season, which peaked with Tropical Storm Gamma in November, brought flooding across a large area from the Ladino community of Chiquerito on the Río Sico northwest to the Caribbean coast.

Despite modern weather forecasting and greater access to transportation than in the past, most contemporary residents of Batalla do not consider evacuation a realistic option in the event of a catastrophic storm. This is partly out of concern for property, but also because they see few places nearby that they consider more secure than Batalla. Those who have left in recent storms generally have gone no further than Palacios or elsewhere along the southern margins of Bacalar Lagoon. After the events of 2005, however, more residents might opt to evacuate in the event of a future storm. Since then, residents have begun to move the community westward, where the barrier beach is more extensive and high, and recent lagoon flooding has been less destructive.

The 2005 hurricane season in the northwest Mosquitia

Between October and November 2005, two hurricanes (Wilma and Beta) and a tropical storm (Gamma) affected communities around Bacalar Lagoon and the Río Tinto-Negro (Figure 2). Impacts were less severe elsewhere in the region. Ibans Lagoon experienced flooding from Banaka Tingni, whose watershed lies to the southwest, and Payabila Canal, which connects Ibans to the Río Plátano. Floodwaters from the Río Tinto-Negro deposited a sand bar at the opening of Ibans, blocking outflow for several weeks until the obstruction washed away. Further east, from Brus Laguna to the border of Honduras and Nicaragua, coastal areas also experienced flooding. The following account, based on documents produced by governmental and non-governmental organisations, and the work of the Batalla research team, focuses on Bacalar Lagoon and the Río Tinto-Negro where the most intense impacts from these storms occurred in the Mosquitia.

Hurricane Wilma began as a tropical depression on 15 October southwest of Jamaica. It grew as it drifted south-southwest and became a tropical storm on 17 October. It shifted west-northwest and intensified into a Category 5 hurricane, achieving wind speeds of 296 kilometres (184 miles) per hour and a barometric pressure of 882 millibars, the lowest then recorded for an Atlantic tropical cyclone (Pasch et al. 2006). By the time Wilma had reached its peak between 18 and 19 October, however, it had already moved northwest of the Mosquitia. It weakened to a Category 4 storm as it continued westward and struck the Yucatan Peninsula near Cozumel on 21 October. It regained strength in the Gulf of Mexico and hit the Greater Antilles and Florida on 23 and 24 October before dying as an extratropical storm in the North Atlantic (IFRC 2005a; Pasch et al. 2006). As Wilma grew to a hurricane between 17 and 19 October, it passed about 240 kilometres (149 miles) north of the Mosquitia coast. As such, it was far enough offshore for its impacts around Bacalar Lagoon to be limited to rain, northerly winds and stormy seas (IFRC 2005a). Batalla residents remembered Wilma mostly for its rains, which fell steadily between 15 and 19 October. The Tropical Rainfall Measuring Mission (TRMM) of NASA estimated that the northwest Mosquitia received 150 millimetres (5.9 inches) of rain from Wilma, or about 6 per cent of its average annual total of 2500 millimetres (Vivó Escoto 1964).

The northwest coast of the Honduran Mosquitia enjoyed a period of good weather after Wilma that ended with Hurricane Beta, the 23rd named storm of 2005, which formed 90 miles north of Panama on 26 October (Pasch and Roberts 2006; Stewart 2006). Beta moved northward until it became a hurricane on 29 October. It then shifted west-southwest and grew to Category 2 strength before making landfall on 30 October at the mouth of the Río Grande in the Nicaraguan Mosquitia. Beta continued over land, bringing floods to eastern Nicaragua and Honduras until it died on 31 October (IFRC 2005b; OCHA 2005a). Its remnants continued northward and brought more rain to eastern Honduras. TRMM estimated Beta contributed 150 millimetres (5.9 inches) of rain to the Sico-Paulaya watershed, adding to what had fallen two weeks earlier with Wilma. Again, Batalla residents corroborated NOAA accounts by recalling heavy rains around the
end of October that brought enough water into the Tinto-Negro to moderately flood Bacalar Lagoon.

Good weather and calm seas returned to the northwest Mosquitia in early November. On 14 November, Tropical Depression 27 appeared 137 kilometres (85 miles) west of St Vincent in the Lesser Antilles (Stewart 2006). The system moved west for 4 days, losing cohesiveness and strength from wind shear in the upper atmosphere. On 18 November, its remnants made landfall on the Mosquitia coast at the mouth of the Río Patuca, although Batalla residents recall that rain from the storm began the previous day. Once onshore, the system continued along a southwesterly path into the highlands. On 18 November it merged with a tropical wave moving out of Nicaragua and developed over land into Tropical Storm Gamma, the 24th named storm of the year. Gamma moved north into the Caribbean Sea before turning south and dying near the Honduras–Nicaragua border on 22 November (Stewart 2006).

TRMM estimated 250 millimetres (9.8 inches) of rain fell in the northwestern Mosquitia during Gamma. Along with precipitation from Wilma and Beta, the area received an estimated 550 millimetres (21.6 inches) of rain between mid-October and mid-November, or 25 per cent of its annual total. Flooding and mudslides were widespread across northern Honduras, with heavy losses in floodplains. Gamma was responsible for 37 deaths, 34 of which occurred in Honduras. It also caused millions of US dollars in damage to infrastructure, property and agriculture in northern Honduras, particularly in the Mosquitia (IFRC 2005c; OCHA 2005b; US-AID 2005).

Batalla residents recall rains from Tropical Depression 27 began on 17 November and continued for 3 days as the system grew into Gamma. During this time, flooding from the upper Sico-Paulaya watershed made its way downstream, inundating an extensive area from the Ladino community of Chiquerito to the mouth of the Tinto-Negro and west along the coast to the

Figure 2 Impacts of Tropical Storm Gamma in the northwest Honduran Mosquitia

Source: Produced by David M. Cochran
Garífuna community of Tocomacho, causing heavy property losses and two deaths. The current in Bacalar normally flows eastward near the coast, but on 18 November, as flooding began, it shifted westward towards Graspís, where the barrier beach narrows to about 100 metres. Here, floodwaters cut through to the Caribbean Sea and pushed further west into the nearby Río Tocomacho. The most intense damage occurred at the centre of Batalla, where floodwaters cut a wide channel in the barrier beach to flow into the sea. At its greatest extent, the channel was 350 metres wide and 7 metres deep (DIPECHO 2005) (Plate 1). A third channel, smaller and less destructive, cut through Pueblo Nuevo, the easternmost barrio of Batalla. The western and eastern channels were sealed by drifting sand in the weeks after Gamma, but the central channel remained open to the sea until April 2006.

Flooding from Tropical Storm Gamma severely affected Batalla. The channel that cut through the centre of the community destroyed 34 public buildings and residences, including a primary school, local administrative offices, a hotel, part of the Catholic Church and numerous stores. Some 18 households suffered the total loss of their residences and another 100 had major damage (DIPECHO 2005). Two residents, both young men, returned to their homes as flooding began and died when the structures collapsed on top of them. Severe flooding also occurred in Palacios and nearby communities, as well as riverine settlements along the Río Tinto-Negro, but nowhere was it as damaging as in Batalla. Agricultural and grazing lands in the area suffered as well, and many residents complained of losses to agroforestry holdings, pastures and livestock.

Numerous foreign government agencies and international organisations provided food, supplies and shelter to affected communities in the Mosquitia and elsewhere in Honduras after Tropical Storm Gamma (OCHA 2005b; US-AID 2005; WFP 2005). COPECO, the Honduran governmental disaster mitigation agency, and various Honduran NGOs collaborated in these efforts and provided support. Mopawi, an NGO that has worked in the Mosquitia since 1985, helped facilitate international initiatives in the region while also coordinating its own relief work.

In the months after Gamma, many residents temporarily left Batalla. In July 2006, our household surveys documented 30.5 per cent of the population living outside the community and 61.2 per cent of households having at least one absentee member. Some of these were children and elderly members who left to avoid the difficult reconstruction period, but many were adults who found outside work and sent remittances to their families. Despite the hardships of such separations, most viewed temporary outmigration as a necessity. Even in January 2007, during our second coring expedition, large numbers of residents still remained away from the community.

The 2005 hurricane season led Batalla residents to doubt the long-term security of their community. Many began to see their beach environment as having become too exposed to be safe. Most were convinced that deforestation in the Sico-Paulaya watershed and around Bacalar Lagoon had increased their vulnerability to tropical cyclones. The central channel that formed during Gamma refilled with sand, but remains today an ephemeral place, devoid of vegetation, and prone to flooding at high tide. Some residents wanted to relocate Batalla to a more secure inland location or even break up the community. By January 2007, however, most accepted a proposal by the patronato to move the town centre westward, where the barrier beach is wider and higher and little damage had occurred during the 2005 floods. Some of those who had lost their homes from Gamma had already started to rebuild in this new area. During our second coring expedition, we found residents busy laying the foundations of a primary school in this new town centre. In the surrounding area, a dozen houses were already under construction.

**Discussion and conclusions**

The 2005 Atlantic hurricane season was unprecedented in terms of storm activity. Given the impacts of hurricanes Katrina and Rita along the US Gulf...
Coast, the Honduran Mosquitia sparked little attention despite being affected by two hurricanes and a tropical storm. This article recounted the history of these storms in the Afro-Caribbean community of Batalla, drawing from participatory research we conducted in 2006. This account is relevant to recent ethnographic research on natural hazards in that it provides a case study of how a coastal people understands and responds to tropical cyclones in a largely indigenous region of Caribbean Central America whose geographic isolation remains a challenge for disaster relief efforts (Bankoff et al. 2004; Cochran 2005; McSweeney 2005; Wisner et al. 1994). This local history also contributes to scientific understanding of how human-induced landscape change influences the vulnerability of coastal areas to tropical cyclones. Our results corroborate previous hurricane research in the Mosquitia by identifying a link between deforestation and flood intensity (Bass 2002; Cruz et al. 1999). Landscape change in turn has led to changes in human perception. In the wake of the 2005 storm season, local residents now see themselves vulnerable not only from the sea, but also from the rivers that flow through their coastal homelands.

We have contextualised this local history with results from the first paleotempestological study undertaken in the Mosquitia to shed light on long-term risk of catastrophic storms in the region and to demonstrate the value of integrating these approaches in hurricane research. The Honduran Mosquitia is clearly exposed to tropical cyclones, but the most recent direct hit from a catastrophic hurricane occurred about 200 years ago. Since 1864, most storms have followed the coast and have brought less severe impacts than with one striking from the north (NOAA-NHC 2008). Although local residents have never witnessed a hurricane as intense as those archived in local lagoons, they clearly have experience dealing with them. Their memories and perceptions form a critical part of this work by demonstrating that tropical cyclones can be disasters without leaving sedimentary records. At the same time, paleotempestology informs ethnography with a reminder of the long-term risk of catastrophic hurricanes. Integrating these two perspectives of hurricane vulnerability provides the necessary insights for emergency managers and stakeholders to prepare for such an event.

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