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## Evaluation Brief: SERVIR Products and Tools

# Geospatial Information System for Fire Management in Guatemala

### Background

The Geospatial Information System for Fire Management (SIGMA-I) is a suite of Earth observation products designed to prevent and control forest fires in Guatemala's northern department of Petén. SIGMA-I was developed by Guatemala's Center for Monitoring and Evaluation (CEMEC) at the National Council for Protected Areas (CONAP) in Petén, with technical and financial support from SERVIR, a joint development initiative of NASA and the United States Agency for International Development (USAID).

The most widely used SIGMA-I product is a fire monitoring approach that produces near-real time data to map "hotspots," or thermal anomalies in ground surface temperature. During the annual fire season (typically March through June), CEMEC disseminates hotspot maps daily through an email listserv to alert key stakeholders in Guatemala's forest fire management network, known as the Forest Fire Prevention and Control System (SIPECIF), of likely forest fire activity. CEMEC also disseminates weekly and seasonal fire reports containing hotspot data, as well as climate and phenological data.

In addition to hotspot maps, SIGMA-I includes four forest fire assessment tools constructed from historical forest fire data:

**Fire Atlas:** Analyzes seasonal fire patterns based on 1998-2009 data from Landsat and other satellites. Assists in predicting the beginning and end of the annual fire season.

**Pattern Analysis and Ignition Cause Model:** Predicts the effects of 59 variables across 6 thematic axes on the occurrence of hotspots, based on 2002-2009 data.

**Dynamic Fire Risk Evaluation System:** Relies on rainfall and temperature parameters to evaluate fire risk.

**Synthesis:** A master report synthesizing findings from the other SIGMA-I components.

### FOREST FIRE IN PETÉN

Petén spans a third of Guatemala's national territory, encompassing 13 municipalities and over 800 communities. Home to the Maya Biosphere Reserve (MBR) and Tikal World Heritage site, Petén is highly susceptible to forest fire. Between 2001 and 2010, annual fire scarring ranged from 879 to 8,400 square kilometers. Guatemala's Secretariat for Planning and Programming recognizes forest fire as the most significant threat to Petén's forests. Forest fires spurred formal emergency declarations in Petén in 1998, 2003, 2005, 2013, and 2016.

### Product Details

- Developed by CEMEC in 2009-2010, with financial and technical support from SERVIR.
- Uses modelling and analysis of historic data from Landsat, Moderate-Resolution Imaging Spectrometer (MODIS), and other Earth observation data to develop informational resources for forest fire prevention and control.
- Generates daily hotspot maps that provide coordinates and visual representation of thermal anomalies in ground surface temperature, indicating likely fire locations.

This briefing is made possible by the support of the American People through the United States Agency for International Development (USAID). It was produced for review by USAID and was prepared by Management Systems International, A Tetra Tech Company; and Development and Training Services, a Palladium company, for the E3 Analytics and Evaluation Project.

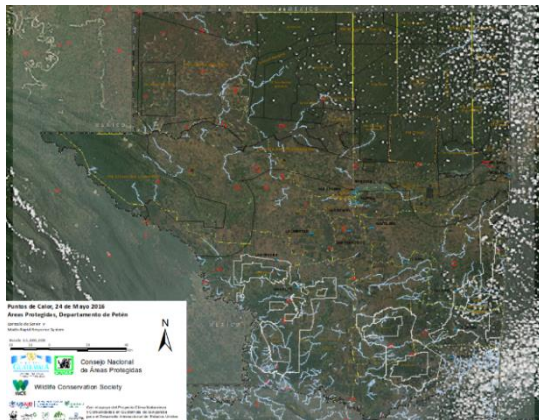
## Use for Decision-Making

Although CEMEC monitors hotspot activity nationwide, the SIGMA-I suite is fully integrated into forest fire management systems in Petén, both for immediate fire detection and for annual planning and fire prevention. Fire risk is highest during Guatemala's dry season, which begins in February, concludes in June/July, and corresponds with agricultural burning in advance of seasonal rains. Use of the SIGMA-I tools is thus highly integrated with regional agricultural activity.

### Use of Hotspot Maps for Fire Detection

Hotspot information is disseminated daily by email to first responders and government forest fire officials throughout Petén, as well as to non-government actors such as Wildlife Conservation Society (WCS), ProPetén, Defenders of Nature Foundation and University of San Carlos. In protected areas, response to hotspots (by CONAP or partnering non-governmental organizations) is automatic. In farming communities (known as "concessions" in the MBR), local councils enforce burn calendars for farmers. Where hotspot locations do not coincide with planned burnings, response teams are dispatched to locate and, if necessary, control the fire.

Large organizations commonly serve as intermediaries to disseminate hotspot information to local communities. WCS, for example, provides hotspot data to three communities, and ProPetén to eight communities. Organizations such as the Defenders of Nature Foundation and University of San Carlos' Center for Conservation Studies monitor designated protected areas such as Laguna del Tigre, Sierra del Lacondón, and other biotopes in Petén.



**HOTSPOT MAP DISTRIBUTED BY CEMEC, MAY 24, 2016. Image courtesy of CONAP.**

## Research Overview

The brief highlights findings from a case study conducted by the E3 Analytics and Evaluation Project as part of a three-year performance evaluation of SERVIR.

A team of U.S.- and Guatemala-based evaluators conducted research for this case study in March 2015. The team collected data via focus group discussions, semi-structured interviews, and site visits, supplemented by a desk review of relevant literature and specialized sectoral knowledge from local team members.

In total, the evaluation team conducted 16 interviews in Guatemala City and Petén. Interview and focus group participants were drawn from government agencies and non-governmental organizations working in the fields of forest management, disaster response, conservation, and municipal governance.

### Use of SIGMA-I for Planning and Mitigation

SIGMA-I also informs federal and regional planning decisions about the deployment of forest fire personnel and equipment. CEMEC's bulletins and reports are regularly monitored by SIPECIF, and SIPECIF officials report using SIGMA-I to identify areas with historically high forest fire rates and taking necessary strategic steps to mitigate fire risk. In 2014, SIPECIF officials in Guatemala City decided to replicate the CEMEC model at the national level. Outside Petén, however, authorities do not yet dispatch responders in response to satellite-generated hotspot maps.

## Factors Affecting Adoption and Use

Key informants cited several important factors that affect the adoption and use of SIGMA-I tools. Discussed below are data limitations, product limitations, and institutional factors affecting use.

### Data Limitations

Adoption and use of the SIGMA-I suite are limited by the geographic scope and currency of the data. Geographically, SIGMA-I operational products are largely confined to Petén. Petén remains the priority of Guatemala's fire prevention and control network, given the department's history and propensity for forest fire and the cultural, environmental, and socioeconomic value of the MBR. However, the Guatemalan government has expressed a desire to expand its fire systems to the rest of the country.



**A GREEN FLAG, PART OF GUATEMALA'S FOREST FIRE EARLY WARNING SYSTEM, INDICATES PERMISSIBLE CONDITIONS FOR AGRICULTURAL BURNING IN PETÉN.**

*Credit: Jared Berenter, dTS.*

SIGMA-I's tools are further limited by the currency of their data. As of March 2015, CEMEC's time series analyses of causality and risk are based on a 1998-2009 dataset. CEMEC intends to update SIGMA-I by adding to the core dataset to create a "SIGMA-II." Respondents noted the potential value of advanced or real-time climate forecast data, as well as current information pertaining to human activity and land use and land cover, which would allow decision-makers and first responders to focus monitoring efforts and assess the risk that a detected fire will spread.

### Product Limitations of the Hotspot Mapping Tool

Hotspot maps are a trusted source of information for identifying uncontrolled fire activity, but product attributes can limit the maps' utility under certain conditions. For example, hotspot maps detect heat anomalies at a one-kilometer spatial resolution; the maps do not depict the precise location of an anomaly or number of anomalies present within that one-kilometer range. The maps give responders an imprecise but important indication of a fire's location. Cloud cover, smoke, or tree canopy may also preclude the detection of fire using Earth observation data and necessitate other monitoring methods.<sup>1</sup>

### Institutional Factors Affecting Use

SIGMA-I tools have received institutional buy-in for forest fire management in Petén in part because they were developed and are now maintained by CEMEC. These products were further normalized by Petén's system of land use concessions. Under this system, communities agree to abide by conservationist land use practices in exchange for the right to engage in agriculture or timber harvesting in the MRB. Use of hotspot maps and upkeep of the SATIF is mandatory in MRB concessions.

Conversely, there are also institutional factors impeding the use of satellite-based forest fire monitoring products, primarily at the federal level. In 2009, administrative authority over the management of SIPECIF shifted from semi-autonomous budget authority to institutional oversight by Guatemala's Coordinating

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<sup>1</sup> CEMEC noted in April 2016 its intention to incorporate Visible-Infrared Imaging Radiometer Suite fire products to its MODIS fire monitoring systems to allow for greater spatial resolution.

Agency for Disaster Reduction; in 2014, oversight was transferred to CONAP. These institutional relationships impact resource allocation, political buy-in, and decision-making.

## Product Impact and Value

Prior to 2016, when severe fire conditions were expected, the modern CONAP-led fire management system in Guatemala had not been tested by a fire event of significant magnitude to allow for a full assessment of impact. Field interviews and secondary data, however, indicate that the use of SIGMA-I for early warning systems, responsible agricultural burning, and informed deployment of resources for forest fire prevention has contributed to significant improvements in forest fire management in Petén. Forest fire response data provided by Guatemala's National Forestry Institute indicate overall declines since 2006 in cumulative surface area damaged by fire, surface area damaged in proximity to cultivated areas and forests, response time to forest fires, and resources used to control forest fires. WCS officials noted that in the three communities where it operates, no uncontrolled forest fires have occurred since adoption of the SIGMA-I tools and initiation of the SATIF system.

A reduction in documented "intentional" fires during this time further supports reports from WCS and others that the use of satellite imagery to detect fires has built community awareness and had a sensitization effect in Petén communities. People are now less likely to engage in illegal agricultural burning, for example, knowing that illicit fires are likely to be detected by CONAP and its partners.

Critical to these successes is the fact that SIGMA-I and its hotspot maps are part of a larger pool of information that contributes to planning and decision-making regarding public-sector investment and institutional presence in Petén. On-the-ground reporting and ground patrols monitor fire activity as well as threats unrelated to fire, such as deforestation and the trafficking of wildlife and cultural artefacts. CEMEC and other actors conduct periodic aerial monitoring, particularly over isolated areas and during critical periods. The impact of SIGMA-I is contingent upon adequate and continued investment of resources for these various components to operate effectively.

### Recommendations

The evaluation team recommends the following measures to increase SIGMA-I's usage and impact:

1. **Bring SIGMA-I up to date** - The SIGMA-I suite should be updated to reflect the most recent available climate, ecosystem, and land use data in Guatemala.
2. **Expand the geographic scope of data-driven forest fire response systems** - CEMEC/SERVIR should coordinate with key actors to expand the hotspot and other Earth observation monitoring and response systems nationwide. In particular, communication hardware and capacity building in remote communities will assist in the growth of Earth observation data-based forest fire management.
3. **Engage in focused community outreach and sensitization** - Continued outreach with targeted local and federal government stakeholders, the private sector, and local communities can build upon a culture of data-driven forest fire management at the decision-making level and encourage fire sensitization and responsible fire behavior at the community level.
4. **Collaborate with interested parties to integrate forest fire management strategies with related programs** - Local communities subject to land management agreements are receptive to efforts to improve fire management. Cooperation with other conservation and agricultural programs may provide opportunities for product use, impact, and new approaches for coordinating land use incentives with forest fire management.