Detecting the Sound of Illegal Logging via IoT

By Claire Swedberg

Rainforest Connection has deployed a solution in 32 countries by which a wireless device listens for signs of illegal deforestation in progress and alerts officials, leveraging a LoRa connection from SpaceX.

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Sep 18, 2022In some remote forested regions around the world, Internet of Things (IoT) technology is keeping an ear out for the sounds of heavy equipment, which can be an indication of illegal logging. A solution that leverages solar-powered acoustic streaming devices, provided by [Rainforest Connection](#), uses LoRa-based connectivity to send audio to a server. Before that data transfer can take place, however, the device's built-in computer employs artificial intelligence (AI) and machine learning to analyze the sensor data being captured in the jungle or forest. By interpreting the sounds around them, the devices can differentiate a chainsaw from a natural sound—wind, for instance—and issue alerts to warn officials if logging or poaching is underway.

Rainforest Connection's Guardian wireless device resembles a leaf cluster and is mounted at the tops of trees. It captures power from the Sun via solar panels, connects via GSM cellular networks when available, or low-Earth orbit satellites via satellite technology from [Swarm](#) (acquired in 2021 by satellite company [SpaceX](#)), and forwards data to a cloud-based platform. The Swarm system uses a LoRa physical modulation to and from space, but Swarm's own networking protocol via satellite. Once installed, the device uploads a continuous recording of the surrounding environment's soundscape, explains Bourhan Yassin, Rainforest Connection's CEO.

Rainforest Connection uses acoustics for solutions designed to detect illegal activities such as logging or poaching in rainforests and ecosystems around the world, and to monitor biodiversity to aid conservation efforts. The 501C3 nonprofit company has been providing technology-based solutions for rainforest protection since it was launched in 2013. Deforestation is a global problem, taking place especially in countries with dense rainforests, such as Brazil and Malaysia. "Seventy to 80 percent of their greenhouse gas emission comes from illegal deforestation," Yassin says, adding that logging is the second largest contributor to such emissions.

Starting with Recycled Smartphones

The company's founders launched the Guardian platform as a potential solution for logging that was taking place unchecked in Sumatra, one of the Indonesia's Sunda Islands. Sumatra has an ongoing effort to protect its endangered gibbons, but the challenges related to habitat reduction were overwhelming. "We discovered that instead of spending their time [and resources] focusing on rehabilitating gibbons," Yassin recalls, "they were fending off loggers coming into the protected area."

The solution began with recycled cell phones donated from around the world, as well as custom software. Rainforest Connection built the phones into boxes with solar panels, then deployed them in Sumatra. The phones captured sounds and forwarded data using the cellular GSM network. Several years ago, the firm started building its own sensor devices using custom logic boards, and now it no longer employs cell phones.

The custom sensor devices capture surrounding environment sounds and forward that data using the cellular GSM network, and they have processing capabilities that the refurbished cell phones lacked. "We basically moved away from the recycled cell phones, and we had our own self-powered mini-computer," Yassin says. However, he notes, many areas lack cellular connectivity. "Obviously, there were issues in remote areas. We wanted to put these Guardian devices everywhere in the forest without having to worry about the availability of a GSM network."

Several years ago, Rainforest Connection began experimenting with low-Earth orbit satellites. In general, however, satellite technologies were both cumbersome to build into the Guardian devices and expensive to use. The company thus started working with Swarm on the latter's satellite technology solution. The firm built its own audio sensor devices and incorporated Swarm radios, which send data to the low-Earth orbit satellites via low-energy transmission, according to Sara Spangelo, SpaceX's senior director, cofounder and former CEO.

Capturing Real-Time Data with Satellite-based LoRa

Before deploying the technology, Rainforest Connection works with a partner local to a specific protected region, in order to identify an area of concern. The organization employs specialized personnel who can enter a forest and scale the trees to mount Guardian devices in the canopy, often at a height of 25 meters (82 feet) or greater. Rainforest Connection can also train local individuals to install the system themselves. The devices must be able to access sunlight, as well as transmit signals skyward, toward the satellites, with little obstruction.

Once the Guardian is installed, its microphone remains on at all times. The device's built-in processor analyzes the audio it receives before transmitting filtered data to the server. As a result, the sensors alert rangers on the ground of that threat and provide them with information enabling them to take action. The LoRa technology, Yassin says, was "a wonderful breakthrough in sending alerts in real time," and the Swarm system is now being put to the test.

"This is not just a backup communication for us," Yassin states. "The entire solution is based on the Swarm connectivity." That means detecting problems in the forest while something can still be done about them. "Being able to catch them in the act is very, very important." The ability to manage data at the device level before transmitting it via LoRa-based satellite has been crucial to the solution's success, he adds, since it significantly reduces the amount of information being sent. The LoRa protocol is designed for low amounts of data transmission at a time over large distances.

"Carrying that much data to the cloud, when you're recording 24-7, is quite a heavy load," Yassin explains, "especially when you're doing it in the middle of the forest. Being able to analyze on the device itself gives us this capability of filtering through the data or getting only the data that matters." Ultimately, he says, when accomplishing threat detection, users only need a small about of information about the data captured by the microphone.

Monitoring Biodiversity Through Sound

Another feature Rainforest Connection provides with its Guardian audio data is the biodiversity monitoring system. The organization employs scientists to create an algorithm around the sounds coming from a particular forest, to determine how much biodiversity exists (including sounds from birds, reptiles or mammals) in order to ensure a healthy amount of diversity is present.

Bourhan Yassin

A shortage of sound diversity is an indication that a forest might require rehabilitation or conservation programs. In either scenario—threat detection or biodiversity monitoring—data transmission relies on regular connectivity with orbiting Swarm satellites. More such satellites are being launched by SpaceX annually, Spangelo reports, and transmissions are typically possible at intervals of between every 90 minutes and every four hours. The devices are being used in areas close to the equator where satellite transmissions are less frequent than in other parts of the world.

Latencies vary by latitude, and the intervals of transmissions at sites are often sufficient, Yassin says, since logging operations tend to require the moving of heavy equipment and vehicles, which remain onsite for days rather than hours. Illegal loggers are typically large organizations, carving their way through forests and logging intensively. "It's not a small operation," Yassin says, "so after a couple hours, they will not have left the

area." Some illegal logging operations even build roads and conduct their work for an entire dry season without detection.

The devices come with two-way communication, enabling the company to send firmware updates and receive information regarding battery health and status. For technologies such as solar-powered IoT devices, the rainforest is an unpredictable environment. If a device falls off a tree, or if a howler monkey pulls it loose from its mounting on a branch, it will lose solar power, and the resultant lack of signal would be detected.

The Guardian device's reaches an area up to about 1.5 kilometers (0.9 mile), Yassin says, so it can accommodate an area of almost 7 square kilometers (2.7 square miles) with a single device. If the device is used for biodiversity, the coverage area is much tighter—usually around 500 meters (0.3 mile)—while listening solely for species vocalizations. The system can also detect anomalies such as gunshots, as well as listen for the presence of human voices or dogs, all of which could indicate poaching.

Achieving a Reduction in Deforestation

Sara Spangelo

To date, Rainforest Connection has implemented its technology in 32 countries around the world, including in Alto Rio, Brazil, and it has participated in projects supported by USAID. Its devices are deployed in Ecuador and Peru, as well as in parts of Southeast Asia, Europe and Africa. Most of its customers are conservation organizations, Yassin says. Since the devices were deployed, he reports, the sensors have transmitted alerts related to tens of thousands of detections, which have led to investigations.

The technology has not yet realized a net positive, due to the sheer amount of deforestation activities taking place in Brazil alone. Another challenge is a lack of enforcement by some national governments. But in the limited areas where the sensors have been deployed Yassin says, "[Guardian] makes a huge difference, and it did cause a reduction in deforestation as a result. I think our goal is to make this an open platform and make it cheap enough so anybody can [deploy] it anywhere."

In the meantime, Yassan says, Swarm's satellite network will continue to grow. SpaceX has added between 40 and 50 satellites since the acquisition, Spangelo notes, and in recent years the company has increased its technology production tenfold from last year to 2022.

Key Takeaways:

- Swarm's low-Earth orbit satellites are bringing connectivity to wireless sensors in remote rainforest locations where cellular transmission is impossible.
- Since being deployed with microphones, processors, AI and LoRa radios, the sensors have identified thousands of potential logging events.