CASE STUDY | GALILEO HAS IN THE GALÁPAGOS

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Ecologist Charles Lehnen captures the location of a ground control point (GCP) before a drone flight on Santa Fe Island in the Galápagos Archipelago. His multi-year research project will use drone imagery captured over time, among other data points, to study the introduction of tortoises on the local ecology.
(Photo credits: Left, Mary Cate Hyde. Right, Charles Lehnen)

User
Charles Lehnen, Ecologist

Partners
Esri

Industries
Conservation, Ecology, Wildlife, Drones/UAVs

Challenge
During the 1800s, the endemic tortoises of Santa Fe Island went extinct, resulting in the iguana becoming the primary herbivore. However, a recent introduction of the Española Island tortoise has brought new dynamics to the island. Lehnen aims to investigate the impact of this reintroduced tortoise on the island's ecology, exploring aspects such as seed distribution, vegetation, and more.

Solution
Arrow Gold+™, Galileo HAS, DJI Mavic 3 Multispectral Drone, ArcGIS® Field Maps, iOS®, AI, ML, Python

Results
Lehnen's first trip yielded high-resolution multi-spectral drone imagery of the entire island. Students will analyze the imagery for vegetation data. Future trips will provide historical observations over time and hopefully provide insight into the tortoise's impact.

USING EOS GNSS AND GALILEO HIGH ACCURACY SERVICE IN THE GALÁPAGOS TO ANALYZE THE IMPACT OF NEW SPECIES ON SANTA FE ISLAND

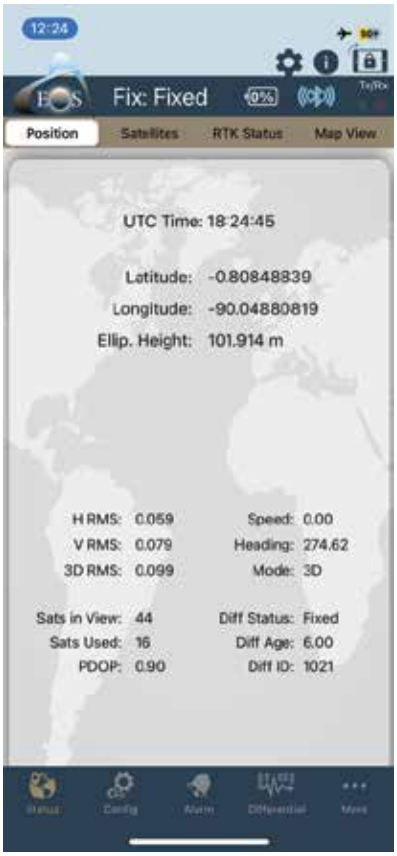
Santa Fe Island is a small island of 24 square kilometers in the middle of the Galápagos Archipelago, Ecuador. It is home to special tortoises and unique iguanas who share this treeless, rocky island with spiders, snakes, and giant centipedes.

Recently ecologist Charles Lehnen selected the island to perform his dissertation research for the University of Southern California in collaboration with Galápagos Conservancy and Fundación Conservando Galápagos as part of the Initiativa Galápagos Program. Lehnen's research centers around a single critical question related to environmentalists' "wild" idea to repopulate Santa Fe Island with tortoises: "What happens to these islands when keystone herbivores get put back?"

REWILDING AN ISLAND

Until recently, Santa Fe Island had not been home to tortoises for nearly 150 years. Once integral to the local ecosystem, the Santa Fe Island tortoise served as the island's main herbivore, responsible for seed dispersal, foraging, and nutrient cycling (the transfer of organic and inorganic matter between living and non-living environmental components, such as tortoise and soil). When the Santa Fe Island tortoise became extinct in the mid-1800s, the next most impactful herbivore — the endemic Santa Fe Land-Iguana — could not fully fill its absence. Thus, the island's ecosystem was permanently disrupted.

In 2015, local conservationists introduced an ecological replacement, the Española Island tortoise. This created an "ecological proxy," a concept whereby an existing species can adopt the ecological role of a similar but extinct species.



In Eos Tools Pro, Charles Lehnen achieved an average horizontal accuracy of about 5cm using the Arrow Gold+ GNSS receiver with Galileo High Accuracy (HAS) corrections. (Media credit: Charles Lehnen)

"We're hoping [the Española Island tortoises] are going to restore that ecosystem, and it's going to have a cascading effect on every other species there," Lehnen said. Lehnen's research, which will continue through 2026, will document the true ecological effects.

For millions of years, especially since the Santa Fe Island tortoise extinction, the Sante Fe Land-Iguana has had a significant and determinative effect on the island's plant communities. This stems from the iguana's selective grazing and foraging, and the resultant seed dispersal. Throughout the island, Lehnen hypothesizes these iguanas have typically distributed seeds in small areas. Now that the Española Island tortoises have been introduced, Lehnen theorizes that the tortoises could be having a transformative effect on the island's plant communities — as they would have had when the Santa Fe Island tortoises ruled. "The tortoises are carrying these seeds across the whole island," Lehnen said, "compared to the hundreds of years of isolated areas where iguanas distributed them."

Lehnen is also exploring the impact of the tortoises on both species' feeding behaviors by using long-term data collection and analysis. During his 2023 summer trip, Lehnen collected keratin samples from the shells and nails of the tortoises and from the nails and scales of the iguanas (while following strict Galapagos National Park safety and humane protocols). The team will send these samples to a university lab, where isotopes from the keratin can be analyzed to determine what the tortoises and iguanas have been eating. Over time, this data could provide insights — such as dietary overlap — into the current and diets of both species. The team also placed camera traps in hope of catching the two species interacting with the same or different parts of plants.

HIGH-TECH RESEARCH ON A REMOTE ISLAND

Lehnen's DJI Mavic 3 Multispectral drone required a lot of battery power, so they developed a workflow of charging solar batteries during the day and using a generator to charge them at night. With a goal of capturing the entire island in drone imagery, each day they hiked to launch locations and to set ground control points (GCPs). GCPs are survey points that can be easily identified in imagery to help drone pilots and drone software precisely geo-reference imagery.

To ensure GCP coordinates were extremely accurate, the team used an Arrow Gold+™ global navigation satellite system (GNSS) receiver to survey each location. The Arrow Gold+ connected to the new Galileo High Accuracy Service (HAS) correction service, which provides worldwide decimeter-level accuracy for free. Lehnen's results are the first recorded using Galileo HAS in the Galápagos. On average, he achieved approximately five cm-level accuracy. "The precision with [the Arrow Gold+ and Galileo HAS] was incredible," Lehnen said. "I will use one for every project I ever do."

WHERE TO, NEXT?

The summer 2023 trip was just the beginning of Lehnen's project. In spring 2024, Lehnen will lead a USC program that will engage undergraduates to help analyze his drone imagery for vegetation information. They will use artificial intelligence (AI) and machine learning (ML) to identify the distribution of vegetation, such as cacti, from the drone imagery. This undergraduate research project will help Lehnen and his team complete the otherwise manual labor of creating training and validation datasets for the ML algorithm. To classify vegetation, Lehnen will use Esri's ArcGIS® software and Python scripting; he can then use satellite imagery taken over the past 15 years to compare at plant distributions before and after the introduction of the tortoises. His findings — along with the lab's isotope-sample results and camera-trap imagery activity analysis — will help Lehnen determine where to focus his research on future trips. Three more trips are planned: one each in summer and fall of 2024, and a final trip in 2025.

Lehnen's work is important not only for how it stands to shape our collective understanding of the larger role species play before they go extinct, but also as a milestone for Lehnen's future as a scientist — in an area of the world famous for generating provocative revelations about our natural world.