Project/Concept Name

Project Providence[1]

Foreseeing the impact of deforestation on biodiversity of Tropical Forests

Partners:

Instituto de Desenvolvimento Sustentável Mamirauá

THE sounds of silence FOUNDATION

CSIRO

UFAM

[1] noun. (often initial capital letter) the foreseeing care and guidance of God or nature over the creatures of the earth. (Dictionary.com)

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Brief Description

Tropical forests are rapidly disappearing from our planet as a consequence of deforestation from cattle ranching, logging, mining, oil drilling, agricultural expansion, construction of roads and dams, and expansion of urbanized areas. This process is aggravated by global warming and has resulted in a dramatic increase in the natural rate of species extinction and consequent loss of biodiversity. Remote sensing satellites and science aircraft provide a wealth of monitoring data at a global scale to monitor changes in forest cover and land use, but at relatively low spatial and temporal resolution, and without the capacity to monitor biodiversity under the canopy; hence their usefulness is severely limited. At the same time, methods to monitor biodiversity below the canopy, over large areas, using standard protocols, and over long time periods are still logistically and financially prohibitive. Project Providence proposes a breakthrough in the way we monitor biodiversity in Tropical Rain Forests by creating a technology (i.e. Providence nodes) that will allow continuous monitoring of biodiversity under a standard protocol, with identification of more species than any other technology available, with real-time identification, wireless data transmission, and low energy consumption to last long periods without the need of maintenance. Each Providence node will be self-contained, and will include visual, acoustic and motion sensors, as well as an energy harvesting power source, short and long-range communication systems and the capability of integrating to other sensors. In Providence, the research component will be minimized and existing software and hardware solutions will be used. Notwithstanding, Providence nodes will integrate for the first time species recognition through audio and imaging techniques in a single hardware node with also the ability to monitor tags. Providence will also provide the capability to monitor the Amazon at unexplored scales through a network of nodes and allow monitoring of key species' population density estimations by analysing their biological activity.

This will allow researchers, managers, NGOS, governments and the general public to understand, monitor and foresee the impact of changes in forest cover and integrity on biodiversity in the Amazon.

Topic/Background

"Small changes in the tropics can have huge ramifications for the entire earth system [...]. Changes in rainfall in the Amazon lead to changes in rainfall in North America and Europe and Asia. What happens in the tropics determines what happens to the earth's biodiversity. We are on a tropical planet. We just don't realize it because so many of us live in the colder latitudes."

Yadvinder Mahli (http://wunc.org/post/how-climate-change-affecting-tropical-forests#stream/0)

Tropical forests are rapidly disappearing from our planet as a consequence of deforestation from cattle ranching, logging, mining, oil drilling, agricultural expansion, the construction of roads and dams, and expansion of urbanized areas because of human population pressures. This process is aggravated by global warming and is expected to cause the substitution of forested areas by dryer habitats, lower water levels in the Amazon River Basin (compromising ecological processes and transport of people and produce), the increase in the frequency and scale of forest fires, and altered rain patterns that impact agriculture and energy generation by hydroelectric dams. It has also resulted in a dramatic increase in the natural rate of species extinction and consequent loss of biodiversity.

Challenges of Surveying Biodiversity in Tropical Rainforests (The Problem)

Remote sensing satellites and science aircraft have provided a wealth of monitoring data at a global scale to monitor changes in forest cover, but at relatively low spatial and temporal resolution, and without the capacity to monitor biodiversity under the canopy; hence their usefulness is severely limited. At the same time available wildlife survey methods, besides being inefficient for most species, are expensive, logistically complex to deploy and even harder to maintain under a standard protocol in the long run. They rely extensively on manual, in situ human surveys, and are infeasible for long-term monitoring. Scientific missions require trained personnel and take days to cross relatively short distances in the deep forest, often with significant risks for the participants.

Our Proposal: Project Providence (The Solution)

In this project, we propose the development of Providence, a distributed, wireless sensor network (WSN) whose sensing nodes are specifically designed for fauna biodiversity assessments. This network will enable continuous and autonomous monitoring of wildlife under the canopy of the Amazon Forest. Providence will allow researchers, managers, governments and the general public to be conscious of the impact of changes in forest cover and integrity on wildlife in the Amazon by identifying key indicator species and monitoring their distribution and behaviour continuously into the future. Providence will permit for the first time establishing current conservation status and to be alerted by any change that would threaten the Amazon.

Providence will bring together and extend the state of the art in wildlife monitoring, species identification, data compression and transmission, and energy management. Each Providence node will be self-contained, and include visual, acoustic, thermal, motion and environmental sensors, as well as energy harvesting systems, onboard energy management, and a long-range communications channel to a base station. By combining multiple sensor modalities, the system will be able to detect a much larger array of species than other methods currently used (e.g. camera traps, sound recorders, or human in situ assessments).

Low-cost data transmission systems have severe bandwidth limitations in tropical forest environments. To reduce bandwidth requirements, each node will perform onboard data

compression, as well as multimodal vision- and sound-based species classification and recognition. This will allow short species “labels” to be transmitted in real-time, while selected and compressed data and images can be “trickled” down to the base station as possible. Our project will use existing databases of visual and acoustic signatures for the detection and classification of key species, while extending these databases incrementally over time.

A prototype Providence network with multiple static sensor nodes will be developed and tested extensively in the Mamirauá protected reserve in the Central Amazon region; in addition to biodiversity estimates, detailed evaluations of system performance will be obtained for future improvements. We believe that the integration of the technologies discussed above will revolutionize the way we monitor biodiversity in tropical forests.

Providence Project Objectives

1. Real-time detection and identification of key species combining acoustic and visual cues.
2. Obtaining a baseline level of Amazon wildlife activity during the day and night.
3. Detecting changes in species distribution and behaviour due to environmental pressures.

Project Phases

Phase 1

A prototype Providence network with multiple static sensor nodes will be developed and tested extensively in the Mamirauá protected reserve in the Central Amazon region (Fig. 1). This system will serve as a proof of concept, demonstrating the ability to acoustically and visually identify a selected subset of species. In addition to providing initial biodiversity assessment, detailed evaluations of system performance will be obtained and used for future improvements.

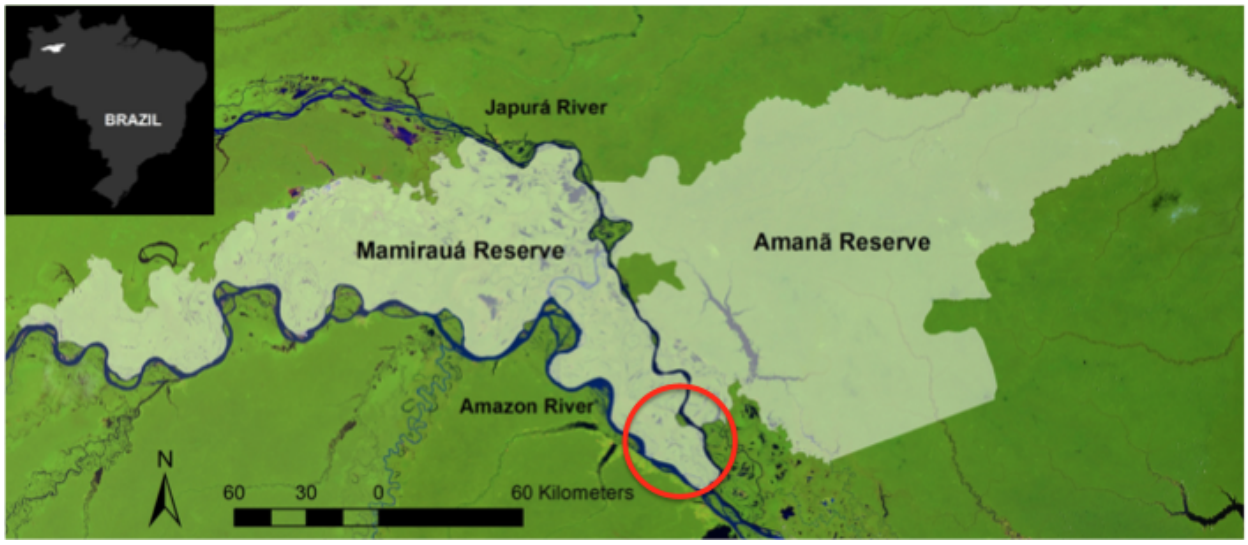

Figure 1 - Mamirauá and Amanã Sustainable Development Reserves in Central Amazon. Red circle represents the region where tests will be conducted.

Phase 2

Lessons learned in the Phase 1 will be used in the design and development of second-generation systems. Work will be done on significantly lowering the cost per sensor node, extend the range and bandwidth of the communications channels, expand the database of visual and acoustic species signatures, and develop web interfaces that can be accessed by scientists, educational institutions, government agencies, and the general public.

Phase 3

The system will be developed and matured further, and deployed at a regional scale in the Amazon.

Phase 1 Objectives (Goals and Outcomes)

1. Real-time detection and identification of key species combining acoustic and visual cues.
2. Obtaining a baseline level of Amazon wildlife activity during the day and night.
3. Detecting changes in species distribution and behaviour due to environmental pressures.
4. Design and development of the overall architecture of the Providence system.
5. Design and development of the Providence sensor nodes, including onboard processing, multi-modal sensor suite, in situ energy harvesting system, and long-range communications channel to a base station.
6. Monitoring the status of traps to capture wildlife for scientific studies in Central Amazonia.
7. Development of multimodal species recognition methods.
8. Extensive field testing of Providence prototypes in the Mamirauá Reserve in the Central Amazon.

Time Horizon (Phase 1)

18 months
Start: September 2016
End: March 2018

Project Schedule (Phase 1)

The planned start date for Phase 1 of Providence is 01/January/2017, with an end date of March/2018.

Partners

The R&D partners in Project Providence are:

Mamirauá Sustainable Development Institute (Mamirauá Institute)

Mamirauá Institute is responsible for introducing a new paradigm in the conservation of biodiversity and the sustainable development of traditional communities in Amazonia, having proposed, implemented and managed the first sustainable development reserve of Brazil. The Institute is renowned for its work in the conservation of biodiversity in Amazonia through solid biological and social research, technological innovation and community based

management of flora and fauna. It currently runs 65 research projects distributed in over 10 sites in a variety of ecosystems in Amazonia, involving over 50 researchers and 20 partner institutions.

Federal University of Amazonas (UFAM) - Institute of Computing

One of the youngest academic unities of UFAM, the Institute of Computing hosts the second best countrywide undergraduate program of computer science and a top 10 graduate program. The Institute has a solid expertize on system engineering, embedded software development, sensor network, information retrieval, big data and analytics, machine/deep learning, pattern recognition and autonomous outdoor vehicles. Located in the city of Manaus, the largest city in the Amazon, the Institute is strongly committed with conservationist programs and it is actively involved in promoting sustainable development in various spheres, from conducting correlated research and development projects to influencing governments policies. The Institute has a long term experience of tracking wildlife by RF devices (monkeys) and sound (frogs), with pilots run in the Campus forest (the third largest native urban segment in the world), and with partners (including Mamirauá and INPA-National Institute of Amazonian Research). The partnership with Mamirauá started on 2012 with the co-development of an environmental monitoring platform based on lighter-than-air equipments (tethered aerostats and airships); a concept proposed by Alberto Elfes back in the 90's. Furthermore, due to its proximity with Manaus Industrial Pole, the Institute of Computing has a strong expertize on system engineering and a mixing of academics and industrial profiles.

The Sense of Silence Foundation (TSOSF)

TSOSF is a public institution of over 5,000 staff, dedicated to higher education and research, specialized in the fields of engineering and technology**.** In a highly creative context, the TSOSF's research, teaching and management projects are based on the principles of freedom, justice, democracy, solidarity, cooperation, sustainability, efficiency, transparency and social responsibility. This also reflects the University's commitment to the environment and changes in society. The LAB holds expertise in: signal modeling and processing; real-time automatic identification, classification and localization of biological and anthropogenic sound sources; tracking of animals with passive acoustic techniques; 3D numerical simulations; control of marine noise pollution; measurement and monitoring of anthropogenic sound sources; development of passive techniques to explore remote regions; ethical and legal aspects of wildlife research; cross-disciplinary approach to help creating policies towards wildlife conservation. *The Sense of Silence Foundation* is managing the LIDO programme in the Amazon and has a long-term research agreement with the Mamirauá Institute to develop and deploy technological solutions for wildlife conservation.

Commonwealth Scientific and Industrial Research Organization (CSIRO) - Autonomous Systems Lab

The CSIRO Autonomous Systems Lab, Brisbane, conducts leading research in applied robotics, sensor networks, and autonomous system. It develops foundational and applied research in robotic, sensor networks, and autonomous systems for a broad range of

domains, including agriculture, mining, biodiversity and biosecurity, environmental research and monitoring, advanced manufacturing, cultural heritage and online learning, as well as other science and application domains. The lab has over 80 researchers and technical staff, a large number of students, and an extensive research infrastructure. The Commonwealth Scientific and Industrial Research Organization (CSIRO) is Australia's national science agency, and is one of the largest and most diverse research organizations in the world. It has over 5,500 staff, and is classed in the top 1% of research organizations worldwide. CSIRO conducts research and development across five broad areas: digital technologies; manufacturing, materials and minerals; energy; environment; and food, health and life sciences industries. It has extensive international collaborations with academic organizations, government agencies, NGOs and industry partners.