Wildfire Assessment and Web Application in São Paulo

Figure 1: Relativized Burn Ratio in Color

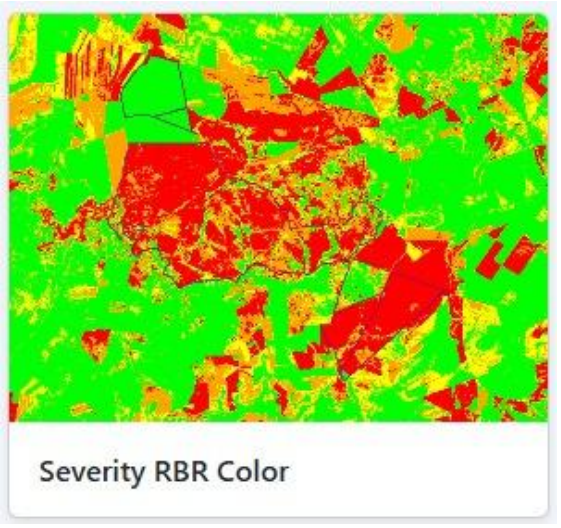

Figure 2: Severity Relativised Burn Ration Color

Figure 3: RGB PRE Fire

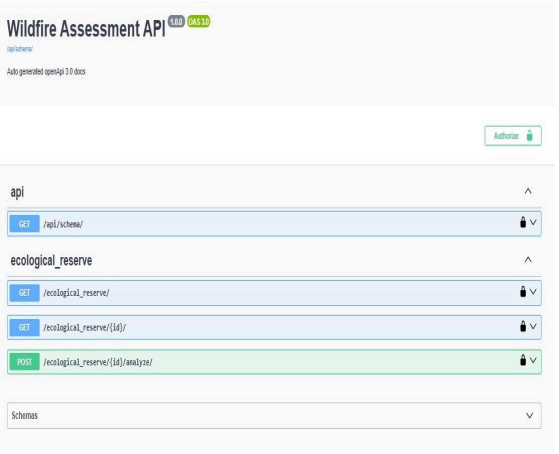

Figure 4: Screenshot of the API's graphical interface

OVERVIEW	
Flying Labs	Brazil flying Labs
Geographic area	São Paulo - Brazil
Date range	September, 2024
Sector program	Climate Action
Main SDGs	GOAL 13: Climate Action GOAL 15: Life on Land GOAL 17: Partnerships to achieve the Goal

SCOPE	
Project stakeholders	The primary stakeholder is the Forest Foundation (FF) — a public entity under the Government of the State of São Paulo, Brazil, responsible for the management, conservation, and expansion of regional forests designated for both production and permanent preservation. The areas analyzed by the system fall under FF's administration. Another key stakeholder is Tech To The Rescue (TTTR), the organization that coordinated the 2024 AI Bootcamp (supported by Lenovo and AWS), where Brazil Flying Labs presented and further developed the Wildfire Assessment project.
People impacted	The primary beneficiaries of the proposed solution include conservation area managers, directors, and decision-makers, as well as government and private organizations responsible for forest monitoring and protection. The system also supports non-governmental organizations (NGOs) focused on forest conservation and restoration initiatives. Additionally, local communities living within or around conservation areas benefit indirectly through improved ecosystem management, reduced wildfire impacts, and enhanced environmental resilience.
Number of people impacted	The exact number of people directly impacted by this solution is difficult to quantify, as Web Application can assess wildfire damage across all natural conservation areas in the state of São Paulo. The conservation and restoration of these areas play a crucial role in maintaining the water supply for much of the state and in preserving biodiversity and wildlife habitats. While the broader environmental and societal benefits extend to millions of residents indirectly, the direct users and primary beneficiaries of the proposed solution include Forest Foundation (FF) directors, managers, and unit supervisors, who can use the system to support decision-making, resource allocation, and rapid response actions following wildfire events.
Problem statement	Wildfires cause severe environmental, social, and economic impacts, particularly in conservation areas where they threaten biodiversity, water resources, and ecosystem services. However, the monitoring and assessment of wildfire damage remain major challenges due to the lack of automated, data-driven tools capable of providing timely and actionable insights. The Wildfire Assessment project addresses this gap by offering environmental intelligence and decision-support capabilities for

	wildfire prevention, response, and recovery. It delivers satellite data– an AI-based monitoring service that analyzes and reports the extent of affected areas, especially in conservation regions of the State of São Paulo. The core product is an Environmental Intelligence SaaS platform, providing ready-to-use wildfire data accessible through both an API and a web-based application.
Project objectives	Its main objectives are to: 1. Enable rapid and accurate wildfire damage assessment through the automated processing of satellite imagery (Sentinel-2A). 2. Support decision-making for environmental management and restoration by providing ready-to-use data via API and web-based dashboards. 3. Reduce costs and response time compared to traditional field inspections by offering updated information. 4. Promote transparency and scientific reliability through the use of standardized indices such as Normalized Vegetation Index (NDVI), Normalized Burning Rate (NBR), and Relativized Burn Ratio (RBR) based in scientific literature (the work is based in the paper https://doi.org/10.1007/s10661-024-13474-5). 5. Strengthen ecosystem resilience and biodiversity conservation by enabling continuous monitoring and data-driven recovery strategies. 6. Facilitate collaboration between government agencies, research institutions, NGOs, and private organizations through open data and interoperable systems. 7. Contribute to climate change mitigation by improving wildfire recovery and prevention strategies and supporting sustainable land management policies.
Scope	The Wildfire Assessment project encompasses the development and implementation of an Environmental Intelligence System — composed of an API and a web-based frontend application — designed to monitor, analyze, and report wildfire impacts in natural conservation areas. The scope includes: 1. *Data Acquisition and Processing* ○ Automated retrieval of Sentinel-2A satellite imagery from the Google Earth Engine API for specified geographic areas and time intervals. ○ Preprocessing and analysis of spectral bands (NIR, RED and SWIR) to calculate vegetation and burn indices, such as the Normalized Vegetation Index

	(NDVI), Normalized Burning Rate (NBR), and Relativized Burn Ratio (RBR) 2. *System Development* ○ Implementation of a SaaS platform (API + frontend) providing access to processed wildfire data. ○ Deployment on a scalable cloud infrastructure (AWS). 3. *User Interaction and Reporting* ○ Development of an interactive web interface for visualization, polygon and time interval selection, and report generation. ○ Delivery of downloadable maps of burned areas and severity levels. 4. *Stakeholder Engagement and Pilots* ○ Execution of pilot programs with the Forest Foundation (FF) and other stakeholders to validate and refine the system. ○ Partnerships with universities, NGOs, and private organizations for research, adoption, and expansion. 5. *Geographic and Thematic Coverage* ○ Initial focus on conservation areas in the State of São Paulo, with potential scalability to other regions in Brazil. ○ Coverage of wildfire damage monitoring, prevention, and ecological recovery planning.
Outcome	The Wildfire Assessment project resulted in the development and deployment of an Environmental Intelligence System — a combination of an API and a web-based platform — that enables automated monitoring and assessment of wildfire damage using Sentinel-2A satellite imagery. *Direct Achievements and Deliverables:* ● Development of a SaaS platform providing access to processed wildfire data through both API and web interfaces. ● Integration of automated workflows for retrieving, analyzing, and visualizing satellite images across multiple spectral bands. ● Generation of analytical outputs, including burn severity maps, pre- and post-fire comparisons, and summary reports. ● Creation of API technical documentation (OpenAPI 3.0)

	• Pilot implementation with conservation units under the Forest Foundation (FF) to validate data accuracy and decision-support capabilities. *Changes and Impacts expected:* • Improved decision-making processes for wildfire assessment and ecological recovery through environmental intelligence. • Reduced operational costs and response times by replacing manual field inspections with automated remote assessments. • Enhanced data accessibility and transparency, enabling researchers, public managers, and NGOs to base decisions on reliable, standardized information. • Integration of new tools into the workflow of FF managers and environmental agencies, supporting resource allocation and restoration planning.
Impact	In the medium and long term, the Wildfire Assessment project is expected to generate significant environmental, social, and institutional impacts by improving how conservation areas are monitored, managed, and restored after wildfires. 1. *Environmental Impact* a. Improved ecosystem resilience: The continuous monitoring of burned areas enables faster ecological recovery and better prioritization of restoration efforts. b. Biodiversity conservation: By protecting habitats from recurring fire events, the project contributes to the preservation of endangered species and ecosystem integrity. c. Climate change mitigation: Reducing the extent and recurrence of wildfires helps decrease carbon emissions and maintain forest carbon stocks. 2. *Social and Community Impact* a. Protection of water resources: Many conservation areas that could be monitored by the system are essential for the water supply of São Paulo State; their preservation ensures long-term water security for millions of residents. b. Improved safety and quality of life: Enhanced wildfire response and prevention reduce risks to nearby communities, protecting livelihoods, infrastructure, and local economies. c. Inclusive environmental governance: The system empowers local communities, NGOs, and

	decision-makers with transparent, data-driven tools for environmental monitoring and advocacy. 3. *Institutional and Technological Impact* a. Strengthened decision-making capacity: Public agencies and conservation managers gain access to reliable, up-to-date data, improving policy design and resource allocation. b. Innovation and knowledge transfer: The use of AI and satellite data fosters technological capacity within environmental institutions and universities, promoting applied research and innovation. c. Scalability and replication: The success of the São Paulo implementation establishes a replicable model for wildfire monitoring in other regions of Brazil and Latin America.
Challenges	During the implementation of the Wildfire Assessment project, several technical and operational challenges were encountered. These challenges were addressed through collaboration, innovation, and adaptive planning with TTTR, the donors and the Brazil Flying labs team. 1. *Data Availability and Cloud Coverage* a. Challenge: Frequent cloud cover in satellite imagery (especially during the rainy season) limited the availability of usable images for certain periods and areas. b. Mitigation: The team used prefiltered images, integrating multiple Sentinel-2A acquisitions to minimize cloud interference and ensure consistent data coverage for the area and the time interval provided. 2. *Integration and Processing of Large Datasets* a. Challenge: Handling and processing high-resolution satellite data required substantial computational resources and efficient data pipelines. b. Mitigation: The project leveraged cloud-based infrastructure (AWS) and the high-performance computing capabilities of Google Earth Engine (GEE) to automate image retrieval, processing, and storage. The use of scalable and distributed architecture enabled efficient analysis of large datasets without local infrastructure limitations. 3. *Algorithm Validation and Accuracy* a. Challenge: Ensuring the reliability of burn severity indices (e.g., RBR) required validation against

	ground-truth data, which was limited in some conservation areas. b. Mitigation: The team is collaborating with academic partners (UFABC) and Forest Foundation (FF) to validate results using historical fire records, field observations, and cross-referenced datasets, the process is still ongoing since the project is in the final stage. 4. *Stakeholder Engagement and Adoption* a. Challenge: Encouraging institutions to adopt a new digital tool required overcoming traditional workflows and data-sharing barriers. b. Mitigation: Conducted demonstration workshops and pilot programs with key stakeholders (such as FF and Civil Defense) to showcase practical benefits, build trust, and refine the platform based on user feedback. This action is still in progress. 5. *Funding and Sustainability* a. Challenge: Securing long-term funding to maintain and scale the service beyond the pilot phase is a key concern. b. Mitigation: The team is working on a sustainability model based on licensing (SaaS) and ESG partnerships, creating opportunities for continued operation and impact expansion. 6. *Drone Imagery Integration* a. Challenge: Incorporating drone-based imagery into the analysis pipeline proved to be a significant challenge due to the project's limited timeframe and the substantial development effort required to integrate aerial data with satellite-based workflows. b. Mitigation: The team prioritized optimizing the satellite data pipeline. The integration of drone imagery was therefore deferred to a future project, where it will enhance spatial resolution and support finer-scale validation of fire severity assessments.
Next steps	Building on the successful development and pilot phase, the next steps of the Wildfire Assessment project will focus on scaling implementation, deepening institutional integration, and advancing technological capabilities to maximize both impact and long-term sustainability. 1. *Institutional Integration and Scaling* a. Integrate the platform into the daily operations of the Forest Foundation (FF) and other

	environmental agencies, enabling wildfire monitoring and post-fire recovery planning as part of their standard workflows. b. Expand the service coverage from São Paulo to other Brazilian states, prioritizing regions with high wildfire risk and critical conservation areas. 2. *Integration of Drone and Field Data* a. Combine satellite and drone imagery to enhance spatial resolution and validation of burn severity assessments, especially in small or cloud-covered areas. b. Develop automated field data upload tools to allow managers and researchers to contribute georeferenced photos and validation datasets directly to the system. 3. *Enhanced Analytics and Predictive Capabilities* a. Integrate machine learning models for fire risk prediction and ecosystem recovery analysis, using environmental variables such as temperature, vegetation type, and past burn frequency. b. Develop custom dashboards and alert systems for early detection and prevention of wildfire events. 4. *Strategic Partnerships and Open Data Expansion* a. Formalize long-term collaborations with government agencies, NGOs, and research institutions to expand data access and joint research opportunities. b. Launch the Open Environmental Data Portal for academia and civil society, fostering transparency and scientific collaboration. 5. *Sustainability and Replication* a. Secure ESG partnerships and institutional licenses to ensure financial sustainability. b. Prepare replication roadmaps for scaling the model to other regions in Latin America with similar environmental challenges.

COMMUNITY ENGAGEMENT AND STAKEHOLDER SUPPORT	
Consent for data acquisition	The project utilizes satellite imagery from the Sentinel-2A constellation, part of the Copernicus Earth Observation Programme of the European Space Agency (ESA). These images are freely available for download and use, ensuring open access to high-quality environmental data.
Community engagement activities	A presentation of the Wildfire Assessment project is scheduled for October 16 at the AeroVision 2025 event AEROVISION – Brazil

	Flying Labs, co-organized by Brazil Flying Labs. During the event, the API, frontend platform, and overall project results will be showcased to the academic community and the general public.
Community groups engaged with	Academic community, Community in General.
Community attendance	We expect the launch event to reach over 400 participants, including members of the academic community, industry professionals, and the general public.
Community feedback	Recommendations and feedback will be collected during the event.
Stakeholder support	We plan to engage with key stakeholders in the weeks following the launch event to strengthen collaboration and gather feedback on the system's implementation.

DATA ACQUISITION	
Size of area	1725 ha
Satellite	Sentinel 2A
Bands	NIR, RED, SWIR
Orbit	Sun-synchronous orbit
Altitude	786 Km
Temporal resolution	10 days
Spatial resolution	10 m (visible and NIR bands), 20 m (red-edge and SWIR bands)

DATA PROCESSING & ANALYSIS	
Processing software	Google Earth Engine API (GEE)
Processing time	In minutes for a selected area
Data products	Thematic map showing burned areas by severity and calculation of affected area (in hectares) by severity level, with download options for pre- and post-fire imagery and high-resolution RBR GeoTIFF files for integration with QGIS.
Analysis tools	Google Earth Engine API (GEE) pipeline and QGIS for external analysis. This API graphical interface used can be integrated with any other system in the organization.
Analysis outputs	Burned areas by severity in a georeferenced data image.
Final outputs shared with stakeholders	Web application and API links, source code on GitHub, final presentation in PDF format, and training materials.
Data sharing	The user can download images from the web application directly to their computer.