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Smart models to protect the planet
AI Fellow Ghjulia Sialelli

Page 4

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Page 12

Funding focus

Biodiversity

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Time to act

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Cover: AI Fellow Ghjulia Sialelli is developing models for global biomass mapping (see p. 4).

EDITORIAL

Biodiversity is under pressure across the entire world. The variety of habitats, species and genetic diversity is suffering due to intensive land and water use, the depletion of natural resources, climate change and the spread of invasive species.

But biodiversity is not a luxury. It regulates the climate, protects against floods, maintains soil fertility and ensures the renewal of raw materials and food supplies – services that are vital for social and economic wellbeing.

To halt the decline in diversity, decisive action is needed. We must respect planetary boundaries and develop new methods to use ecosystems and resources in a more sustainable and regenerative way. The good news? With in-depth research, innovative start-ups and targeted philanthropic efforts, highly promising approaches at ETH are already underway.

Precision for the planet

Ghjulia Sialelli is harnessing machine learning to support environmental protection. Through her research at ETH, she aims to help preserve biodiversity and combat climate change.

"Achieving accurate estimates of forests and above-ground biomass is crucial," Ghjulia Sialelli explains, "because this is the data that enables us to measure the amount of carbon stored in vegetation and how it changes over time." Securing these estimates is the challenge behind her research as a fellow at the ETH AI Center. Her goal is to produce a high-resolution, interpretable global biomass map covering several years.

A model for greater control

Existing datasets on above-ground biomass often focus on specific regions or are only available in low resolution. This makes it difficult to assess carbon stocks with the required precision. "To meet their CO_2 targets, many companies rely on offsetting. They purchase carbon credits from providers who use the proceeds to fund climate projects such as reforestation," Ghjulia Sialelli explains. "But because we can't monitor carbon stocks correctly, it's hard to evaluate whether these measures are actually being implemented." Her model aims to make the trade less error-prone by enabling the status of the vegetation to be assessed more accurately and over a period of several years. It also provides specific insights for protecting biodiversity by estimating how much biomass would be lost if a forest were cleared.

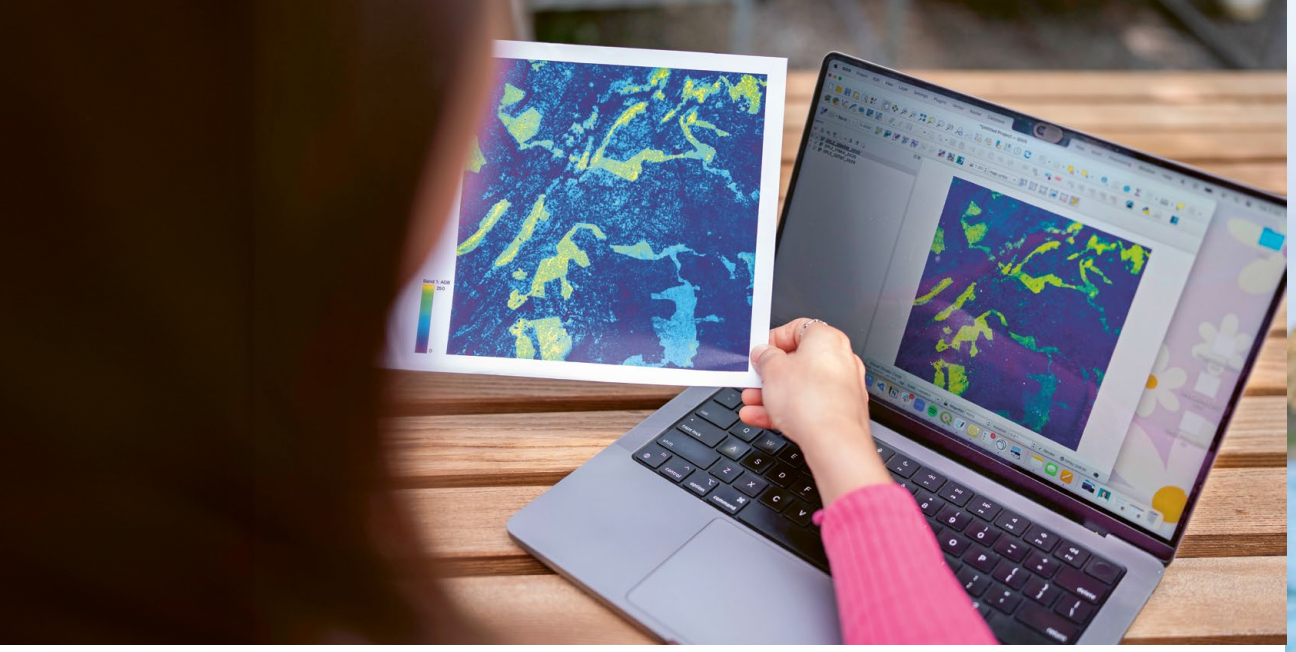
To develop her model, the doctoral student used openly accessible satellite data, including images from Sentinel-2, the Earth observation satellite operated by the European Space Agency (ESA) that regularly captures new images of every region on the planet. Ghjulia Sialelli supplemented this data with radar satellite data, global land cover maps, canopy height maps and NASA reference data. "Data quality is essential. Even the best model can't deliver reliable results if the data it's based on is flawed," she stresses. She then designed a variety of machine learning techniques and developed her first baseline models. The next step is to gradually refine them further – by improving precision in how uncertainties are depicted, for example.

Encouraging critical thinking

Originally from Corsica, Ghjulia Sialelli first came to ETH Zurich for an exchange semester during her Bachelor studies at the École polytechnique near Paris. Excited by the active community and the broad span of research conducted in sustainability, she then chose to return to Zurich for her Master's degree in computer science.

It was during the ETH interdisciplinary course "AI for Good" that she connected with UZH Professor Jan Dirk Wegner, who later

ETH Foundation / Valeriano Di Domenico



Ghjulia Sialelli works with satellite data and machine learning to create high-resolution models for global biomass mapping.

supervised her Master's thesis alongside Konrad Schindler, ETH Professor of Photogrammetry and Remote Sensing. Towards the end of her degree, Ghjulia Sialelli was offered the opportunity to continue her research as part of a doctoral programme. She applied for a fellowship at the ETH AI Center, funded by the Dieter Schwarz Foundation, and was delighted to be accepted. "The fellowship has given me access to a fantastic network that greatly benefits my work. It's also a valuable endorsement of the quality of my research," she says.

That artificial intelligence harbours great potential for addressing challenges in the environment, medicine and humanitarian aid, Ghjulia Sialelli is of no doubt. At the same time, she's convinced of the need to approach new developments with a critical eye. "AI is a very powerful tool. How we use it can also have negative consequences," she says. In her own work, she prefers to use smaller models wherever possible, as they require less computing power and are more resource-efficient.

Environmental responsibility is a key issue to the young researcher at all levels – whether as former president of the Student Sustainability Committee or as an organiser of the AI + Environment Summit. "My generation has grown up with the climate crisis. For me, living consciously is a given." Ghjulia Sialelli hopes her biomass monitoring model will also help inform political decision-making on biodiversity protection – and in doing so, contribute to long-term climate solutions.

AI Fellowship programme

The offer of research fellowships to outstanding international doctoral and postdoctoral students forms one of the core pillars of the ETH AI Center. The selected fellows work on a range of subjects, from basic research to applications in areas such as robotics, digital health, learning sciences and natural language processing. The fellowships are largely made possible through donations.

Find out more:
ethz-foundation.ch/en/eth-ai-center

Juanita Escobar

Relief for coral reefs

With the health of the oceans in acute danger, marine biologist Ulrike Pfreundt left her academic career to found a company dedicated to building and restoring tropical coral reefs.

Angela Alegria

Thanks to specially designed surface structures, coral larvae are able to settle in artificial reefs more easily. The cavities also provide hiding places, like this one for an octopus off the coast of Ecuador.

ETH spin-off rrreefs is a company with a mission to regenerate one per cent of coastal reefs by 2034. To what extent is this a personal cause for you?

ULRIKE PFREUNDT – I've always been close to nature. I started out as a microbial oceanographer and spent a lot of time researching in the tropics. The more I learned about this environment, the more I realised how badly it's doing. That really got to me. There's even a term for this: environmental grief. So I decided to leave my academic career and devote myself fully to marine conservation. Together with three co-founders, I deliberately chose the start-up path because I wanted the challenge of developing a regenerative business model.

What does that model look like?

Intact coral reefs are essential to healthy oceans: almost a third of all known organisms in the ocean depend on coral reefs, so their decline could severely impact marine ecosystems. Reefs also provide food, income and protection from coastal erosion for hundreds of millions of people. That's where we come in – for example, with our regeneration project in Pujada Bay in the Philippines, which has been running for nearly two years. We're now at the point of building our first local facility to 3D-print our reef modules. This significantly reduces production costs and creates value for the surrounding community. Thanks to support from the Fourfold Foundation, we're able to train residents living in Pujada Bay, who are highly motivated to do something for their reef: they learn to dive, learn about our modular system, and take further training in scientific monitoring. This builds strong local teams. Participatory processes and co-design are key to this. We ask fishers, for instance, where a reef structure is most urgently needed to help the fish return. We would also like to involve these people who know their reefs very well to help with monitoring and enable them to have an alternative income to fishing. In this way, we're factoring in the entire socio-ecological context and developing a model that can be adapted to other similar countries.

"Participatory processes and co-design with local communities are key to our success."

How does rrreefs plan to make money?

We're pursuing two business lines with which we've been generating revenue for two years: on the one hand, we work with companies that want to support ocean biodiversity as part of their corporate sustainability efforts or supply chain resilience. We offer a package consisting of implementation, monitoring, reporting and storytelling. On the other hand, we're attractive to the tourism and hospitality industry. For resort owners, a dying reef is bad for business. We offer reef repairs and even entire reef structures. Regenerative experiences are booming in the tourism sector right now; we are developing programmes that allow hotel guests to contribute to building the reef.

You built your first artificial reef off the Colombian island of San Andrés. How is it doing almost four years later?

Recently, we saw a shark there for the first time – that was amazing! Less anecdotally, we can say that fish diversity and biomass are now comparable to the nearby natural reef, which is a good result. The coral has been growing more slowly than we'd hoped, probably due to frequent periods of extreme heat. It grows much faster in the Philippines! What's great is that at every one of our reefs, every measuring point shows an increase in young corals, which means that there are more and more!

What do you say to the argument that fighting climate change should be our first priority if we want to stop coral reefs dying?

All of these solutions, including ours, won't save coral reefs unless we tackle climate change at the same time. At some point, everything will die if it gets too hot. Our goal is to secure coral reefs in different places around the world for long enough that they can continue to exist in the long term. But the reefs are in such bad shape, emergency aid is needed right now.

How will you achieve your goal of regenerating 700 kilometres of reef structure by 2034?

We'll get there if we manage to triple the area we regenerate each year. It's ambitious, but not impossible. We'll need local teams implementing projects in many different places at the same time. Simultaneously, we're developing a strategy for industrialised countries, based on more automated processes. Our headquarters will remain in Zurich: on the one hand, we're close to our clients, and on the other, close to the talent we need, particularly from ETH.

Your mission is a Herculean task – what keeps you optimistic?

We have an incredible community which constantly motivates us – and we celebrate small wins! I can also feel real momentum. More and more people care about the oceans and are working on solutions – we need every one of them!

Stocker Lab

rrreefs originated at the Institute of Environmental Engineering at ETH Zurich, where Ulrike Pfreundt was a postdoctoral fellow from 2016 to 2020 in the group led by Professor Roman Stocker. Here, biologists collaborate with physicists, engineers and mathematicians to study how microbes and microscopic organisms shape marine ecosystems. The Stocker Lab receives funding from donors that include the Simons Foundation and the Gordon and Betty Moore Foundation.

Protecting our natural resources

ETH Zurich generates a wide array of insights and technologies to protect biodiversity and strengthen ecosystems – from monitoring that improves sustainability in rainforest management to pollution-fighting bacteria and sensor-driven water conservation. Find a selection of projects, supported by the Ricola Foundation, ETH Escher Circle and donors of the Pioneer Fellowship Programme and Student Project House.

BiodivX
(Professor Stefano Mintchev)

As part of the BiodivX project, researchers developed autonomous robots and analytical technologies that collect and evaluate environmental DNA (eDNA), sounds and images in complex settings such as rainforest canopies. The aim is to measure and better understand biodiversity in these valuable ecosystems.

Alpine Vegetation
(Professor Alex Widmer, Professor Jake Alexander)

This project examines the ecological and evolutionary processes that shape the response of alpine plants to a changing climate, with the goal of improving the conservation of alpine plants and ecosystems.

Diversity in coral reefs
(Professor Shinichi Sunagawa)

A DNA-based approach enables the rapid creation of a catalog of reef biodiversity, integrating previously described species while resolving cryptic and newly discovered ones. This offers an efficient, scalable, and, once established, capable method of identifying and documenting reef-scale biodiversity by environmental DNA (eDNA) monitoring.

"We support projects at the intersection of science and nature, to protect the Earth's natural life-support systems for future generations."

Raphael Richterich, President of the Ricola Foundation

Caterra
Caterra's robot uses a laser-based system to remove weeds growing in close proximity to crops – enabling scalable and ecological farming that's free of chemicals.

CellX Biosolutions
Using bacteria that can break down persistent chemical pollutants, CellX offers an alternative to conventional disposal methods and plays a valuable role in reducing environmental contamination.

Digit Soil
The start-up supports farmers in understanding the value of soil biological activity through soil enzymatic activity measuring devices that assess soil fertility. In research, the devices enable lab-independent on-site measuring.

Riverkin
High-resolution freshwater monitoring using Riverkin sensors allows to track water quality, support conservation, and inform better water management.

Synature
Synature's smart microphones record biodiversity levels fully autonomously, detecting over 10,000 species via sound. The aim is to enable efficient tracking of conservation projects, regenerative agriculture and ESG reporting.

ETH Foundation / Kristina Milkovic, Adobe Stock

A school for life

His time at ETH was anything but easy for Finnish entrepreneur Jukka Helkama – and proof that he could rise to any challenge that came his way.

You began your mechanical engineering studies at ETH Zurich in 1965. How do you remember your time here?
JUKKA HELKAMA – It was the toughest period of my life (laughs). Studying at ETH had always been my father's dream. He was a gifted engineer and had secured a place in Zurich. But then World War II broke out in Finland, and he ended up studying in Sweden. So it was I who fulfilled his dream and enrolled at ETH. I wasn't particularly talented at maths and had to work extremely hard for the first two years.

What did you take away from your student years?
Not the methods for solving differential equations or integrals, but the knowledge that I can overcome almost any obstacle. This proved to be of great help in my professional life. I often used to tell myself: "You made it through ETH, so you can manage this too." And I met my wife at ETH. She was studying architecture. Luckily, we didn't meet until I was in my seventh semester and the most demanding phase of my studies was already over.

Where did your career take you?
After graduating, I completed officer training and joined our family business, Helkama, which my grandfather had founded in Tampere in 1905. Originally, it was a trading company for bicycles and sewing machines. Finland was poor at the time, and most of the population lived in rural areas. But fortunately, there were a few factories in Tampere, so people there had a bit of money. A sewing machine enabled them to make their own clothes, and a bicycle made the journey to work much quicker.

What was the state of the company when you joined in 1972?
After my grandfather's death, my father and his brothers took over the firm, which by then had moved its headquarters to Helsinki. That was after World War II. The introduction of licence fees for imports had made trading more difficult, so Helkama started producing its own goods, setting up a bicycle factory and a radio factory, which later went on to make televisions. The brothers were highly innovative and made significant expansions to the business, adding car imports, motorcycle manufacturing and cable technology. I was responsible for the bicycle and cable business.

Was your ETH education useful to you in that role?
I was chiefly a businessman and factory manager then. In 1981, I attended Stanford as a Sloan fellow and completed a Business Management programme that was valuable for my day-to-day work. But my time at ETH also proved to be very useful. For one,

"ETH was a cornerstone in my life."

ETH Foundation / Daniel Winkler

Much has changed since his days at ETH 55 years ago: Jukka Helkama in discussion with Michael Pantic from the Autonomous Systems Lab on the latest advances in flying robots.

I could hold my own in discussions with our engineers. For another, I never found it difficult to work under pressure or maintain accuracy in long-term projects and complete them on time. These are skills that ETH taught me.

In 2005, you handed over the business to your daughter, who now leads Helkama in its fourth generation. How do you occupy yourself today?
I see myself as part businessman, part engineer and part humanist. After my professional career, I became especially interested in how we can make the world a bit better. This year, Helkama sold its cable division – it had reached a critical size and the investment required for further growth would've probably been too high. We're currently investing some of the proceeds in Adwatec, now also a member company of the Helkama Group. Adwatec makes cooling systems for high-performance electrical engineering, helping to greatly improve the reliability and efficiency of power grids and electric motors used in ships or wind turbines. Some time ago, I also bought, renovated and automated an old river power station, including a diversion stream with spawning grounds for salmon. And I spend time with my eight grandchildren, out in my rowing boat, or competing in Masters Athletics events. My disciplines are triple jump, hurdles and sprint.

You've been supporting talent at ETH for 15 years. What's your motivation?
ETH was a cornerstone in my life. I'm very grateful for everything I learned here, and by supporting young students I'm glad to be able to give something back. It's interesting to see how applied the teaching is nowadays, and how much broader the curriculum has become. A welcome development – and one I'm delighted to support.

Pinpointing changes in biodiversity

The WildinSync initiative, launched at ETH Zurich, is monitoring global trends in biodiversity – using eDNA, satellite data and artificial intelligence.


Karma Sherub

“Technology alone is not enough. We need an international network that shares knowledge and takes collective responsibility.”

Professor Loïc Pellissier

The diversity of species on Earth is vast, and it underpins healthy, stable ecosystems, clean water, fertile soils and diverse food sources. But this biodiversity is under threat. The destruction of valuable habitats, overexploitation, pollution and, increasingly, climate change are the main causes of global species loss. In Switzerland alone, over a third of species and more than half of all habitat types are at risk. Governments and private actors around the world are implementing locally adapted measures to preserve biodiversity. But to assess the effectiveness of these efforts, we need robust indicators. This is precisely where WildinSync, a project led by ETH Professor Loïc Pellissier, comes in.

Following genetic traces

At the heart of the initiative is the aim to document changes in biodiversity on land and in water across the globe. The key technology is known as eDNA (environmental DNA): genetic traces that organisms leave in their environment and which can be detected over long distances. Unlike conventional methods, eDNA samples can capture the genetic fingerprint of entire ecosystems. When combined with satellite imagery and AI-powered data analysis, this enables researchers to generate highly detailed insights.

In addition to advancing the collection and analysis of eDNA, the initiative seeks to build a global network of researchers and stakeholders to measure and monitor biodiversity across a wide range of sites – in real time and across borders. “Technology alone is not enough. We need an international network that shares knowledge and takes collective responsibility,” says Loïc Pellissier, whose research group on Ecosystems and Landscape Evolution at ETH Zurich and the Swiss Federal Institute for Forest, Snow and Landscape Research WSL studies the links between landscape development and biodiversity. WildinSync already collaborates with partner institutions on four continents – from Colombia to Bhutan – and aims to expand this network to over 50 countries by 2030. The initiative is also building capacity to ensure data collection is broadly accessible and to avoid creating dependencies. Biodiversity monitoring can only function in a decentralised, long-term and equitable way if knowledge and infrastructure are shared – especially in regions that have been virtually excluded from global research networks or had insufficient say in decision-making processes.

An early warning system for biodiversity

WildinSync aims to make ETH-developed technologies – such as eDNA sampling and analysis equipment, as well as expertise in operating biobanks – available to researchers worldwide and to establish a shared database. In addition to eDNA samples from rivers, lakes and soils, satellite data provides crucial information on changes in vegetation, such as deforestation or urban sprawl. With the help of artificial intelligence, researchers can analyse the enormous data volumes from eDNA and satellite sources, detect patterns and make predictions about how biodiversity might change in the areas studied.

Standardised, high-resolution biodiversity data from thousands of monitoring sites opens up a wide range of applications: it can serve as a benchmark for species decline, the emergence of diseases or the spread of invasive species. Reliable data is crucial for making the scale of biodiversity loss visible – to the public, policymakers and the business community alike. It also reveals whether conservation measures are effective, whether international commitments are being met, and where habitats are recovering or diversity is returning. In this way, WildinSync functions as an early warning system. “Nature doesn’t change overnight. We want to detect warning signals as early as possible,” Loïc Pellissier says. “Only those who understand what’s at stake can take the right action.”

The WildinSync initiative is a powerful example of the impact that cutting-edge research, interdisciplinary thinking and committed partnerships can have on tackling the major ecological challenges of our time. Also key to the process are far-sighted donors whose donations to the ETH Foundation make global diversity monitoring possible. These include the 1wild Foundation, Fondation Valery, JAF Foundation and PostFinance.

Learn more:
ethz-foundation.ch/en/projects

“Research at ETH protects our natural resources – supported by committed donors across the world.”

Shana Sturla,
President of the Board of Directors
ETH Foundation USA,
ETH Professor of Toxicology

ETH Foundation / Daniel Winkler

With around two million specimens, ETH Zurich's Entomological Collection offers fascinating insights into the insect world.

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