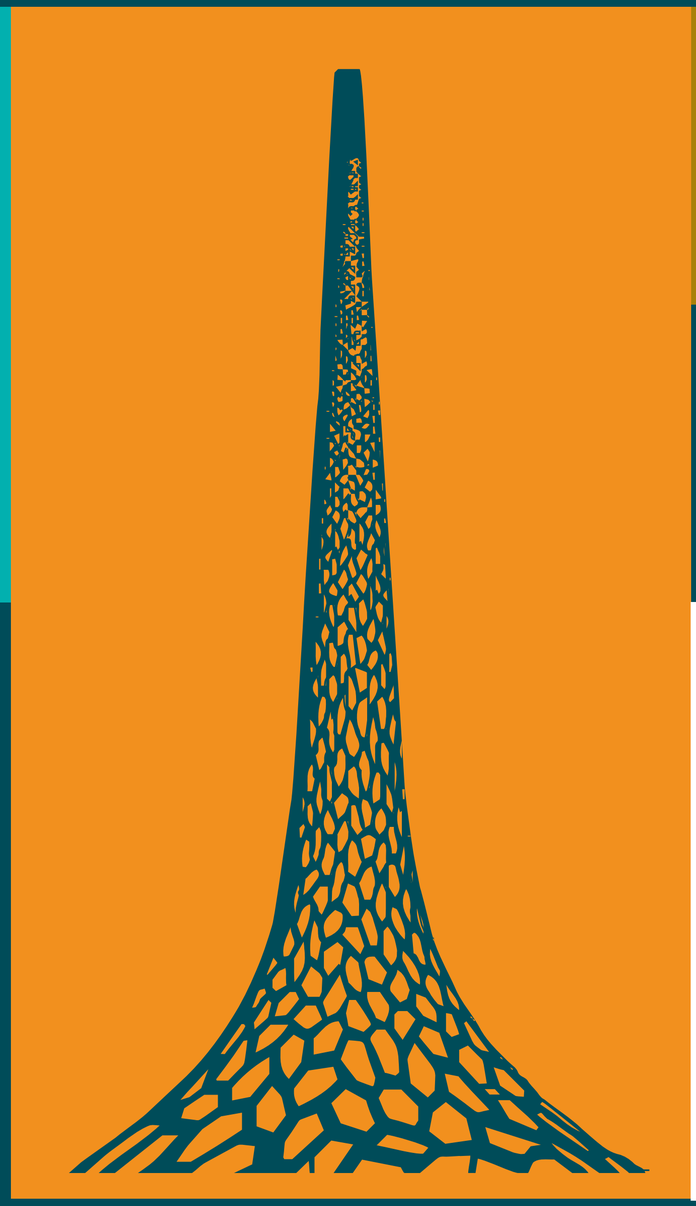
2025



ANNUAL REPORT

جامعة الملك عبدالله
للعلوم والتقنية
King Abdullah University of
Science and Technology

DRYLAND ECOLOGY AND GLOBAL CHANGE LAB

PRESENTATION

Welcome to the 2025 Annual Report of the Dryland Ecology and Global Change Lab at King Abdullah University of Science and Technology (KAUST).

This year has been one of growth, consolidation, and remarkable progress for our lab, following my incorporation to KAUST in 2024. It has been both intense and highly fruitful: we launched our first experiments and field surveys, established our laboratory facilities, delivered my first courses as a Professor at KAUST, celebrated hallmark publications, and initiated key strategic partnerships such as SaudiNET, a program designed to position KAUST and the Kingdom at the forefront of dryland monitoring, environmental forecasting, and ecological research.

Throughout this dynamic period, our work has been shaped by the core values of the lab—a healthy, collaborative, and people-centered environment where talent can thrive—and firmly aligned with the priorities of KAUST's Strategy and Vision 2030. Our mission is clear: to contribute to Saudi Arabia's scientific leadership by training the next generation of dryland ecologists and environmental scientists, and by generating research that informs sustainable management of the Kingdom's natural resources while addressing global environmental challenges.

Fernando T. Maestre, Head of the Dryland Ecology and Global Change Lab
Professor of Environmental Science and Engineering.

LAB MEMBERS

Fernando T. Maestre
Professor of Environmental Science and Engineering

Research scientist
Emilio Guirado

Research specialist
Antonio García Moreno

Postdoctoral researchers
Chukwuebuka C. Okolo
Corey Nelson
Fangli Wei
Jiayuan Liao
Lucio Biancari
Mario Corrochano Monsalve
Qi Liu

PhD students
Khulud Alghannam
Norah Alghamdi
Zubaydah Alahmadi
Baqer Al Mousa
Amaal Alharbi
Zahra Alhawsa

MsC students
Sara Abdallah

Research assistants
Shimaa Hassan
Yanjie Zhu
Micaela Calvani A

Visiting students and scientists
David J. Eldridge
Ji Chen
José Luis Molina Pardo
Kaarina N. Shilula
Víctor Maull
Víctor Valenzuela Polo
Fengyu Fu

PARTNERSHIPS

The launch of SAUDINet in 2025 marks an important milestone for the lab.

Created through a partnership between the National Center for Vegetation Cover Development and Combating Desertification (NCVC) and KAUST, the SAUDINet initiative aims to advance terrestrial ecology research across the Kingdom, with particular emphasis on arid and hyper-arid ecosystems — regions critically underrepresented in global biodiversity and soil datasets.

Led by Professor Fernando Maestre, SAUDINet will help close major ecological data gaps that currently limit accurate climate modelling and satellite-based assessments. The program includes specialized training for NCVC personnel in biodiversity monitoring and ecological sampling, with samples analyzed in KAUST's state-of-the-art laboratories.

By generating high-quality field data to inform land restoration, carbon-sequestration strategies, and biodiversity conservation, SAUDINet will strengthen the scientific foundation for sustainable land management in the Kingdom and will position Saudi Arabia as a regional leader in dryland research.

CAPACITY BUILDING

In early November, we delivered a multi-day training workshop at the Imam Abdulaziz bin Mohammed Royal Reserve Development Authority (IARDA), engaging professionals from IARDA, NEOM, Red Sea Global, University of Jeddah, and King Abdulaziz University. As part of the KAUST-funded project **"Assessing livestock grazing impacts and carrying capacity in Saudi Arabia's terrestrial ecosystems"**, participants received hands-on instruction in the standardized vegetation and soil monitoring protocols developed by our group. This workshop strengthened national capacity in ecological assessment and advanced a unified approach to monitoring terrestrial ecosystems.

Supporting Saudi talent is a core pillar of our lab's mission.

This workshop reflects our commitment to empowering local expertise in environmental monitoring and sustainable land management, fully aligned with KAUST's strategy and Saudi Vision 2030.

RESEARCH

The Dryland Ecology and Global Change Lab investigates how natural and human pressures shape the biodiversity, functioning, and resilience of dryland ecosystems, integrating fieldwork, experiments, modelling, and advanced remote sensing to deliver knowledge and solutions for sustainable dryland management.

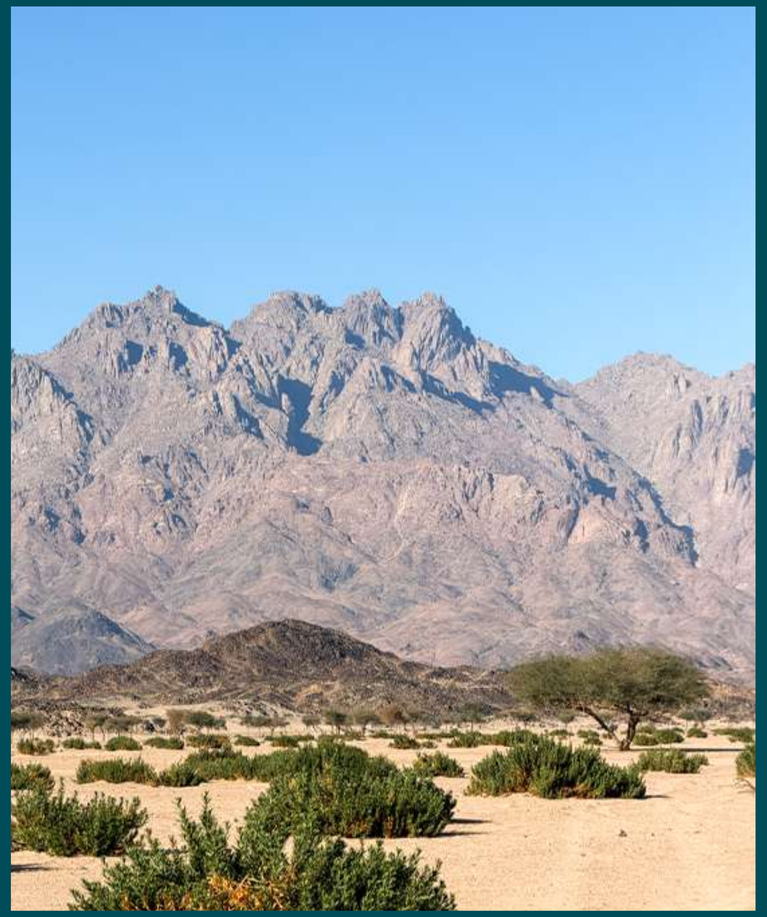
1 **Global change impacts on dryland ecosystems.**
We examine how warming, shifting rainfall, and land-use intensification alter the biodiversity, structure, and functioning of dryland ecosystems worldwide.

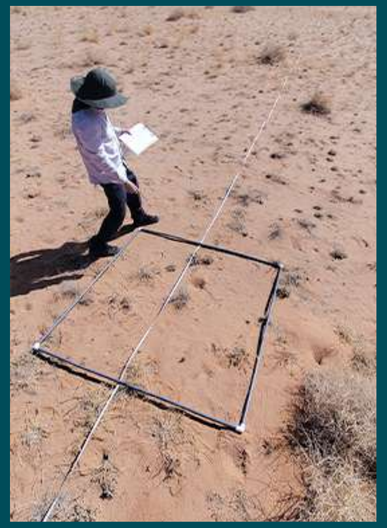
2 **Biocrusts for soil health and ecosystem restoration.**
We develop biocrust-based technologies and cultivation methods to restore degraded soils and enhance ecosystem recovery in drylands.

3 **Artificial intelligence and remote sensing for natural resource management.**
We apply AI, machine learning, and multi-scale remote sensing to map, monitor, and predict changes in dryland environments for evidence-based decision-making.

4 **Nature-based solutions for climate change mitigation and land restoration.**
We design and evaluate scalable ecological interventions—such as soil and vegetation restoration—to enhance carbon sequestration and reduce land degradation.

5 **Sustainable grazing management in arid and hyper-arid ecosystems.**
We assess how grazing practices shape soils, vegetation, and microbial communities to inform sustainable rangeland management strategies.





RESEARCH

During 2025, we initiated fieldwork for the project "Assessing livestock grazing impacts and carrying capacity in Saudi Arabia's terrestrial ecosystems", funded by KAUST. Using a standardized protocol tested across global drylands, we are surveying major Saudi rangelands to assess how climate, soil properties, and livestock grazing affect biodiversity and the capacity of ecosystems to deliver key services. Field surveys were completed in areas near Yanbu and within the King Salman Royal Reserve, as a first step toward broad coverage across the Kingdom in the coming years.

At each ecosystem surveyed, we combine detailed measurements of vegetation and soil to better understand ecosystem health, carrying capacity, and how Saudi terrestrial ecosystems may respond to future climate change and increases in grazing pressure

RESEARCH

Biological soil crusts, or biocrusts, are living layers of microbes on the soil surface that play a key role in maintaining soil health in dryland environments. These communities are easily damaged by human activities such as grazing and can take decades to recover naturally.

Although recent research shows that adding biocrust material to degraded soils can speed up recovery, producing enough material remains costly and difficult to scale.

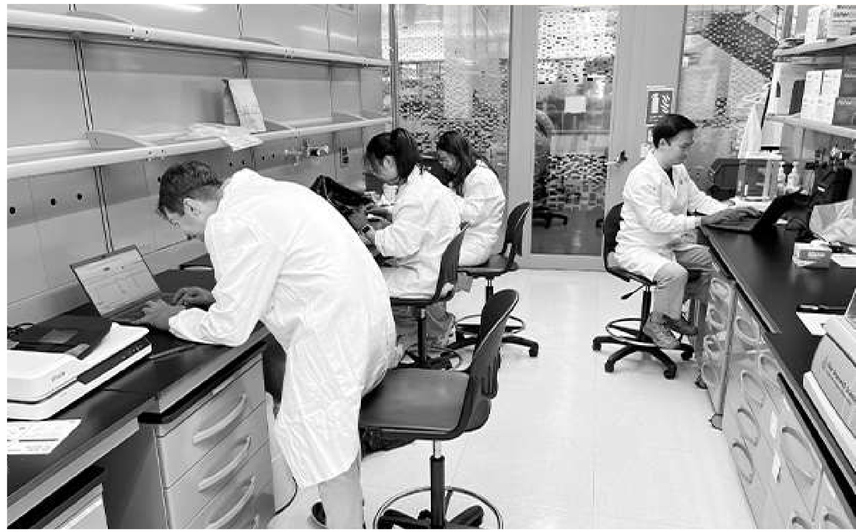
During 2025 we started experiments to produce biocrust inoculum at scale, track its effects on soil biodiversity, and integrate its benefits into sustainable land management in Saudi Arabia and beyond.

We also conducted a **greenhouse experiment** to evaluate nature-based solutions for improving nitrogen use efficiency in agriculture. Specifically, we examined whether biostimulants enhance nitrogen uptake efficiency and drought tolerance in sorghum, while simultaneously reducing nitrogen losses and greenhouse gas emissions.

PUBLICATIONS

In 2025, our lab contributed to an exceptional body of scientific work, publishing 28 articles across international peer-reviewed journals including *Nature, Science, Nature Plants, Nature Food and Nature Communications*. These studies advanced our understanding of land degradation, drought, grazing impacts, soil biodiversity, biocrust ecology, and ecosystem functioning across drylands and beyond. Our team played leading roles in major international collaborations, produced high-impact syntheses and global datasets, and delivered new insights directly relevant to biodiversity conservation, climate adaptation, and sustainable land management.

This diverse and influential publication portfolio reflects the lab's growing leadership in dryland ecology and global change research, and helps position KAUST as a global hub for dryland research.



HIGHLIGHTED PUBLICATION

Bending the curve of land degradation to achieve global environmental goals.

This landmark review led by our lab provides a comprehensive, science-based roadmap to reverse global land degradation and align the objectives of the three Rio Conventions. Drawing on global datasets and scenario analyses, the paper identifies four transformative levers—reducing food waste by 75%, restoring 50% of degraded agricultural and natural lands, and adopting more sustainable, ocean-based diets—that together could cut land degradation by more than half and dramatically shrink the land footprint of food systems. The article emphasizes that healthy land is foundational for tackling climate change, biodiversity loss and food insecurity, and calls for integrated policy action that embeds food systems into international environmental agreements. Beyond its scientific contributions, this Review positions KAUST at the forefront of global land sustainability efforts, demonstrating our leadership in shaping the research and policy agenda on one of the century's most pressing environmental challenges

Maestre, F. T. et al. 2025.
Nature 644: 347–355.
doi: 10.1038/s41586-025-09365-5

Read more

HIGHLIGHTED PUBLICATION

Drought intensity and duration interact to magnify losses in primary productivity.

This major paper, an outcome of the global International Drought Experiment Collaboration, reveals how drought intensity and duration interact to shape ecosystem functioning in grasslands and shrublands worldwide. By synthesizing data from a globally distributed experiment (74 sites across six continents), we show that while ecosystems often acclimate to multi-year moderate drought, consecutive years of extreme drought trigger rapidly escalating losses in primary productivity—up to a 2.5-fold greater decline by the fourth year. These findings provide s ome o f t he strongest experimental evidence to date that the stability of dryland and grassland ecosystems is at serious risk under future climate extremes, advancing our understanding of ecosystem resilience under intensifying drought regimes.

Ohlert, T, et al. 2025.
Science 390:284–289.
doi: 10.1126/science.ads8144

Read more

HIGHLIGHTED PUBLICATION

Dung predicts the global distribution of herbivore grazing pressure in drylands.

This article presents the first high-resolution global maps of livestock and wild herbivore grazing pressure across drylands, using dung mass as a standardized, field-based proxy of herbivore abundance. Drawing on surveys from 760 sites across six continents, including those from the BIODESERT global survey led by Prof. Maestre, the study reveals striking spatial disconnects between livestock and wild herbivores and identifies major grazing hotspots in Africa, the Eurasian grasslands, India, Australia, and the western United States. The results from this study indicate that dung-based indicators offer a powerful and cost-effective tool to refine grazing assessments, improve herbivore density models, and support more sustainable rangeland management. This work provides an important resource for supporting rangeland management and land stewardship efforts worldwide, while showcasing our lab's leadership in advancing dryland monitoring methods.

Eldridge, D. et al. 2025.
Nature Food 6: 253–259.
doi: 10.1038/s43016-024-01112-9

Read more

TEACHING

Scientific Writing and Publishing (EnSE 394C)

This graduate-level course provides a holistic and comprehensive training in scientific writing and publishing, guiding students through the entire process from structuring a manuscript to navigating peer review and publication ethics. Designed as a highly interactive experience, students develop a full scientific article based on their own research data, engaging in iterative writing, peer review, and in-class discussions that mirror real-world publishing practices. By integrating theoretical foundations with hands-on writing, expert guest lectures, and critical feedback, the course equips students with the skills, confidence, and ethical awareness needed to publish high-quality research in international journals

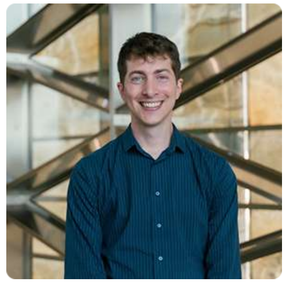
Plant and Ecosystem Stress Biology (BESE 394B)

This course, co-taught with Profs. Monika Chodasiewicz and Brande Wulff, offers an integrative perspective on how plants and ecosystems respond to biotic and abiotic stressors, spanning molecular, physiological, ecological, and ecosystem-level processes. Through a team-taught structure and an interactive format that combines lectures, laboratory practicals, literature analysis, and student presentations, the course encourages active learning and cross-scale thinking. The ecosystem stress module taught by Prof. Maestre explicitly connects fundamental plant biology with global change drivers such as aridity, drought, and grazing, fostering a holistic understanding of stress responses that is directly relevant to contemporary environmental challenges

Professor and assistants (EnSE 394C)

PROFESSOR
Fernando T. Maestre

ASSISTANT
Emilio Guirado



ASSISTANT
Lucio Biancari

IN THE PRESS

NCVC and KAUST launch SAUDINet to advance terrestrial ecology in Saudi Arabia

KAUST Press release, 12/03/2025, **link.**

KAUST authors new study on land degradation

Arab News, 14/08/2025, **link.**

The world's food waste would already cover the surface of Russia (In spanish)

El Mundo, 13/08/2025, **link.**

The future of the planet is decided at the table (In spanish)

El País, 14/08/2025, **link.**

Why Gulf researchers have beef with global meat consumption

The National, 27/08/2025, **link.**

AWARDS AND RECOGNITIONS

Fernando T. Maestre recognized as a "Highly Cited Researcher" in the Environment & Ecology category by Clarivate.

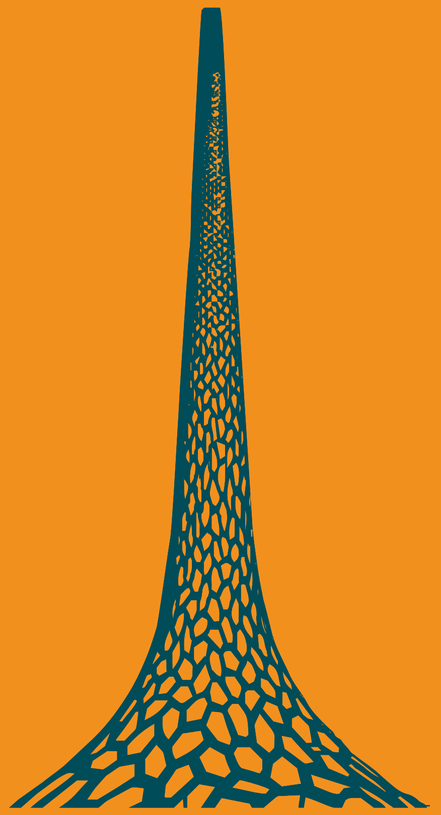
Follow this **link** to access the KAUST press release.

Emilio Guirado received a "Ramón y Cajal" research fellowship from the Spanish Ministry of Science and Universities

Lucio Biancari recognized with an Honorable Mention of the Enrique Chaneton Award by the Argentine Association of Ecology for his paper **"Drivers of woody dominance across global drylands"**, published in Science Advances.

THANK YOU

2025



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For more information about our work, please visit our website at *https://maestrelab.kaust.edu.sa/* or scan the QR code below.

drylandecology.lab@kaust.edu.sa