Leverhulme Doctoral Scholarships Programme for Interdisciplinary Resilience Studies (PIRS)

University of Southampton

RECRUITMENT CYCLE for studentships starting: October 2025 (Cohort 2)
SUPERVISORY TEAM

Primary Supervisor	Songyan Zhu
School & Faculty:	School of Geography and Environmental Science, Faculty of Environmental and Life Sciences
Email:	Songyan.Zhu@soton.ac.uk
Co-Supervisor	Rebecca Collins
School & Faculty:	School of Geography and Environmental Science, Faculty of Environmental and Life Sciences
Email:	r.collins@soton.ac.uk
Additional Co-Supervisor(s):	Dianna Smith
School & Faculty:	School of Geography and Environmental Science, Faculty of Environmental and Life Sciences
Email:	d.m.smith@soton.ac.uk

STUDENTSHIP PROJECT TITLE

Resilience of Urban Socio-ecological System to Air Pollution (RUSSAP) in the UK

OVERVIEW

Greenspace benefits human health but is it still true when plant emissions worsen air pollution, impacting both people and ecosystems? The RUSSAP project will examine socio-ecological resilience to air pollution – i.e., greenspace health under pollution exposure and its effects on human well-being by using satellite imagery, machine learning, and modelling.

SUMMARY

This project investigates the complex relationship between urban green spaces, air pollution, and health outcomes, with a focus on the impacts of ozone – a pollutant that can harm both human health and vegetation. Recent studies have highlighted the mental health benefits of urban greening, yet certain greening initiatives may inadvertently contribute to

higher ozone levels, as air pollution is linked to 43,000 premature deaths in the UK. By studying this interplay, the project aims to provide a holistic understanding of how air quality, greenspace access, and ecosystem health interact to affect the wellbeing of urban populations.
To achieve this, the project will utilise geospatial data analysis, ecosystem modelling, and machine learning. Working with established datasets from the UFLUX, along with satellite imagery, the student will track changes in vegetation health, biodiversity, and pollution levels. This will be coupled with social data to assess how exposure to these environments impacts human health, providing insights into trade-offs between urban greening and pollution mitigation.
The project is supervised by leading researchers in ecology and environmental health, with access to advanced data analysis tools and networks within Sustainability and Resilience Institute (SRI), Southampton and potential external collaborations including Edinburgh and Exeter, offering an exceptional opportunity for those interested in applying science for sustainable urban design. The findings will guide policymakers in creating greener, healthier cities resilient to pollution and climate stressors. This research is critical for advancing urban sustainability and promoting resilient socio-ecological systems in cities facing rapid environmental change.

PROJECT CONCEPT

There is increasing evidence that urban green spaces contribute to improved human health and wellbeing outcomes [1]. Yet vegetation within these spaces is under increased stress by air pollution [2]. Whilst there has been an overall reduction in traditional pollutants in the UK, ground-level ozone (O_3) levels have risen, especially in suburban areas, due to the photochemical reactions between NO_x (commonly from vehicle combustion) and volatile organic compounds (VOCs) like isoprene from trees and other vegetation [2]. This creates a complex and dynamic relationship, as initiatives designed to increase urban greening to improve mental health have the potential, under certain conditions, to increase ozone and ozone has known harmful impacts on human health independent of exposure to other pollutants [3]. Ozone is also considered the most detrimental pollutant in terms of its impact on vegetation and other levels of biodiversity [5]. Adding to this complexity, ozone levels are known to fluctuate temporally; they tend to be higher in the summer due to warmer temperatures, and higher on weekends. These dynamics present unique challenges in understanding the effect of greenspace on the health of urban ecosystems and the people living within them [5]. This studentship aims explore the relationship between air pollution, ecosystem health and human health to better understand via the following objectives:

1. Quantify the impact of air pollution, particularly ozone, on urban ecosystem health, focusing on vegetation health and photosynthetic activity.
2. Analyse the associations between pollution levels, greenspace access, and indicators of ecosystem health on human health and wellbeing.
3. Examine trade-offs among air pollution, ecosystem health, and human health, and develop a model-based resilience evaluation system to guide policy on urban greening, pollution management, and public health.

To achieve these objectives the following methods are suggested:

1. Geospatial Data Analysis for Ecosystem Health:
    a. Using the LESO/LAPSO (air pollution) [5, 6] and UFLUX (ecosystem carbon dynamics) [7, 8] datasets developed by the supervisory team to assess changes in ecosystem health across the UK's urban areas.
    b. Remote sensing datasets (MODIS Aqua/Terra, Landsat, Sentinel-2) to track vegetation health over time, with a focus on photosynthetic activity, biodiversity indicators, and carbon sequestration capacity.
    c. Climate reanalysis data from ERA5 to provide historical and projected climate information (temperature, precipitation, drought indices) to enable an analysis of urban vegetation responses to these stressors.
2. Air Quality and Pollution Impact Modelling:
    a. Using DEFRA's in-situ air pollution measurements with Sentinel-5/-2 to improve LESO/LAPSO urban modelling to focus on ozone and other pollutants that impact both human and plant health.
    b. Using Sentinel-5 TROPOMI and Aura OMI satellite data, along with atmospheric models (P-model and Lloyd-Taylor respiration model to evaluate the effects of air pollution on urban vegetation health and photosynthetic functioning.
3. Machine Learning and Statistical Analysis:
    a. Machine learning methods will be applied to analyse complex datasets linking vegetation health, air quality, confounding climate factors, and health (mental and physical) indicators obtained from nationally representative surveys.
    b. Data on greenspace usage (such as the People and Nature Survey) can be incorporated to improve understanding of exposure.
4. Resilience Evaluation:
    a. By integrating the findings from vegetation and air quality modelling with social and mental health data, these models can be used to develop a framework to assess how effectively urban areas can promote improved human and ecosystem health.

This project seeks to understand how air pollution affects urban socio-ecological system resilience – i.e., exploring the potential effects of pollution on vegetation health, biodiversity, and the health and wellbeing of urban residents. By assessing these factors together, and exploring potential trade-offs, this research will help improve understanding of how to design healthier cities. In turn this will give us better understanding of urban ecosystem resilience – given current and future pressures in these spaces.

References

[1] Reyes-Riveros, Rosa, et al. "Linking public urban green spaces and human well-being: A systematic review." *Urban forestry & urban greening* 61 (2021): 127105.

[2] Zhu, Songyan, et al. "Estimating near-surface concentrations of major air pollutants from space: A universal estimation framework LAPSO." *IEEE Transactions on Geoscience and Remote Sensing* 61 (2023): 1-11.

[3] Cohen, Aaron J., et al. "Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: an analysis of data from the Global Burden of Diseases Study 2015." *The lancet* 389.10082 (2017): 1907-1918.
[4] Agathokleous, Evgenios, et al. "Ozone affects plant, insect, and soil microbial communities: A threat to terrestrial ecosystems and biodiversity." *Science Advances* 6.33 (2020): eabc1176.
[5] Zhu, Songyan, et al. "Estimating near-surface concentrations of major air pollutants from space: A universal estimation framework LAPSO." *IEEE Transactions on Geoscience and Remote Sensing* 61 (2023): 1-11.
[6] Zhu, Songyan, et al. "LESO: A ten-year ensemble of satellite-derived intercontinental hourly surface ozone concentrations." *Scientific Data* 10.1 (2023): 741.
[7] Zhu, Songyan, Tristan Quaife, and Timothy Hill. "Uniform upscaling techniques for eddy covariance FLUXes (UFLUX)." *International Journal of Remote Sensing* 45.5 (2024): 1450-1476.
[8] Zhu, Songyan, et al. "UFLUX-GPP: A cost-effective framework for quantifying daily terrestrial ecosystem carbon uptake using satellite data." *IEEE Transactions on Geoscience and Remote Sensing* (2024).

Please explain how this project represents a contribution to interdisciplinary resilience studies (max 250 words).

This project contributes significantly to interdisciplinary urban resilience studies by bridging ecological, environmental, and public health research. Urban resilience depends on a city's ability to maintain healthy ecosystems and support the wellbeing of its residents amid environmental challenges. This project explores the nuanced effects of air pollution, especially ground-level ozone, on urban vegetation – a critical component of green infrastructure – and human health. By investigating the feedback loops between air quality, ecosystem vitality, and human health outcomes, the project aims to capture the trade-offs and synergies essential to designing resilient urban spaces.
The research approach combines geospatial data science, environmental modelling, and health analysis, offering insights into the dynamic interactions between urban greening, pollution, and wellbeing. It leverages interdisciplinary methodologies, including machine learning and remote sensing, to quantify ecosystem responses to pollution stressors, while using public health data to evaluate the benefits and risks of green space exposure for urban residents.
This integrated perspective advances resilience studies by illuminating the dual roles of green infrastructure as both a resource for mental health and a potential source of pollution under certain conditions. The findings will support the development of resilience frameworks for urban planning that balance environmental, social, and health objectives. Ultimately, this work will guide policies to enhance urban resilience by promoting green spaces that are both ecologically sustainable and conducive to

human health, positioning it as a critical contribution to sustainable and resilient urban systems.

Please list and describe any specific/additional technical training or support to undertake and successfully deliver this project. *Note that students recruited into this programme will undertake a bespoke training curriculum. Students and their supervisory teams will also identify generic skills gaps to address through training courses offered by the University's Doctoral College.*

The student will need training (or to be self-trained by using free online courses like Python 101) to understand computer programming to process geospatial data. National Centre for Research Methods training courses will support the student in the handling on the nationally representative surveys the choose; for example “Finding and accessing data from the UK Data Service” this will support a student with limited experience with handling social data.
