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| **Institution:** University of Leicester | | |
| **Unit of Assessment:** 8 | | |
| **Title of case study:** The future of air quality: shaping environmental strategy | | |
| **Period when the underpinning research was undertaken:** 2000–2014 | | |
| **Details of staff conducting the underpinning research from the submitting unit:** | | |
| **Name(s):** Prof. Paul Monks | **Role(s) (e.g. job title):** Head of College Science and Engineering | **Period(s) employed by submitting HEI:** 2000–2021 |
| **Period when the claimed impact occurred:** 2014–2021 | | |
| **Is this case study continued from a case study submitted in 2014?** N | | |

## 1. Summary of the impact

Air pollution is thought to cause 40,000 premature deaths in the UK annually and 400,000 across Europe. The estimated health and social care costs of such deaths are expected to reach GBP5.3billion by 2035, in England alone. Research undertaken by the University of Leicester, led by Professor Paul Monks, has directly influenced the formulation of the UK Government Clean Air Strategy and the subsequent draft Environment Bill (2020), designed to protect the nation's health and environment. In particular, the work described in this case has informed policy positions in respect of domestic solid fuel burning and the mitigation of air pollution with green infrastructure, demonstrating **public policy, environmental and economic impact.**

## 2. Underpinning research

Development of cost-effective abatement strategies for air pollution requires a quantitative understanding of both the sources and the effectiveness of any abatement or mitigation strategy. Research on air quality at the University of Leicester (UoL) has directly impacted the UK government's Air Quality Strategy 2019 in two distinct areas: the impact of wood-burning, and the effect of trees (green infrastructure) on air pollution. The Air Quality Strategy 2019 sets the Air Quality Agenda in the UK for the next 10 years.

With respect to wood burning, atmospheric particulate pollution is a significant problem across the EU. There is concern about an increasing contribution from biomass burning, driven by rising fuel prices and an increased interest in the use of renewable energy sources. UoL research developed an improved gas chromatography–mass spectrometry assay to quantify atmospheric levels of wood burning products: the first to be fully validated to US FDA industry standard **[R2]**. The FDA Data *Standards* Council coordinates the evaluation, development, maintenance, and adoption of health and regulatory data *standards* to ensure that common data *standards* are used throughout the agency. The UoL assay was deployed in a landmark study, carried out between 2013–2015, that obtained the first long-term daily measurements of biomass burning markers across five sites in NW Europe over a period exceeding 24 months **[R1]**.

With respect to trees (green infrastructure), UoL research was the first to model and investigate the effect of green infrastructure in suppressing air pollution at both a local- and at a city-scale **[R3, R4, R5, R6]**. The unusually large Computational Fluid Dynamical (CFD) model was

developed by the UoL as a test case. The model was populated with the 3D infrastructures of buildings, grass and trees **[R3, R6]**, derived from lidar datasets for Leicester buildings and the National Tree Map, allowing city-scale (2 x 2 km) CFD simulations. For small particulate matter (PM2.5) the research illustrated that trees play a larger role in dispersion than in deposition (loss). The work is novel both in its methodology and subsequent results, highlighting the importance of combining local and regional scale models for assessing the impact of green infrastructure on the mitigation of air pollution in urban planning. Hallmarks of the Leicester work were calculations for a "real-world" city with trees, which was a major step forward at that time.

The studies showed that trees in deep urban street canyons could amplify pollutant concentrations **[R4, R5],** whilst in open spaces the dispersive capability of trees was significantly greater than the deposition (loss) of particles, resulting in improved air quality. Crucially, detailed calculations revealed that effects on PM2.5 could be parameterised to estimate improvements. These were of the order of 10% citywide in Leicester in the summertime **[R3],** hence relatable to direct vehicle emission reductions.

This work is built on the strong international record of accomplishment over the last 20 years in atmospheric chemistry at the UoL, including that of Professor Paul Monks. His recognised expertise in the chemistry of air quality has led to national and international recognition, with his appointment as Chair of the Air Quality Expert Group (2010–2020) and the WMO (World Meteorological Organisation) Environmental Pollution and Atmospheric Chemistry Steering Group (2014–2020).

## 3. References to the research

**R1**. Cordell, R. L., Mazet, M., Dechoux, C., Hama, S. M. L., Staelens, J., Hofman, J., Stroobants, C., Roekens, E., Kos, G. P. A., Weijers, E. P., Frumau, K. F. A., Panteliadis, P., Delaunay, T., Wyche, K. P., and **Monks, P. S**.: Evaluation of biomass burning across North West Europe and its impact on air quality, *Atmos Environ*, 141, 276-286,10.1016/j.atmosenv.2016.06.065, 2016.

**R2**. Cordell, R. L., White, I. R., and **Monks, P. S**.: Validation of an assay for the determination of levoglucosan and associated monosaccharide anhydrides for the quantification of wood smoke in atmospheric aerosol, *Analytical and Bioanalytical Chemistry*, 406, 5283-5292, 10.1007/s00216-014-7962-x, 2014.

**R3**. Jeanjean, A. P. R., **Monks, P. S.,** and Leigh, R. J.: Modelling the effectiveness of urban trees and grass on PM2.5 reduction via dispersion and deposition at a city scale, *Atmos Environ,* 147, 1-10, 10.1016/j.atmosenv.2016.09.033, 2016.

**R4**. Jeanjean, A., Buccolieri, R., Eddy, J., **Monks, P.,** and Leigh, R.: Air quality affected by trees in real street canyons: The case of Marylebone neighbourhood in central London, *Urban Forestry and Urban Greening*, 22, 41-53, 10.1016/j.ufug.2017.01.009, 2017.

**R5**. Jeanjean, A. P. R., Hinchliffe, G., McMullan, W. A., **Monks, P. S.**, and Leigh, R**.** J.: A CFD study on the effectiveness of trees to disperse road traffic emissions at a city scale, *Atmos Environ*, 120, 1-14,10.1016/j.atmosenv.2015.08.003, 2015.

**R6**. Hofman, J., Staelens, J., Cordell, R., Stroobants, C., Zikova, N., Hama, S. M. L.,

Wyche, K. P., Kos, G. P. A., Van Der Zee, S., Smallbone, K. L., Weijers, E. P., **Monks, P. S.**, and Roekens, E.: Ultrafine particles in four European urban environments: Results from a new continuous long-term monitoring network, Atmos Environ, 136, 68-81, 10.1016/j.atmosenv.2016.04.010, 2016.

**Research Grants**

**G1**. **PI: Prof. Paul S. Monks**. Title: *Joint Air Quality Initiative (JOAQUIN)*, Sponsor: EU INTERREG IVB NWE program, Period: 01/5/2011-30/9/2015. Total Awarded GBP462,000.

## 4. Details of the impact

The 2019 Clean Air Strategy, published by Defra, has been praised by the World Health Organisation as "*an example for the rest of the world to follow*" **[E6]**. UoL research **[R1–R6]** has informed this strategy. "*Under Professor Paul Monk's chairmanship, the Defra Air Quality Expert Group (AQEG) has had significant and constructive input into developing the scientific evidence base that has underpinned a wide range of the Government's activities*" **[E5]**.

**Policy Impact:**

UoL research has directly informed UK government policy in respect of domestic burning. The Clean Air Strategy **[E1]** states: "*Not all forms of domestic burning are equally polluting. The appliance (for example, stove or fireplace), how well it is used and maintained, and what fuels are burnt in it, all make a big difference to how much pollution is produced. Significant air quality benefits can be realised through a new efficient appliance as compared with an old stove or open fire*." The AQEG report **[E3]** "The potential air quality impacts from biomass burning" reviewed the evidence base detailing primary research **[R1, R2]** from UoL on the measured impact of wood burning on the UK urban atmosphere. In February 2020, the UK government announced that sales of wet wood will be phased out by February 2021 **[E6]** to support the goals embodied in Schedule 12 of the Environment Bill **[E2]**. There is an evidenced link from the primary research **[R1, R2]**, through the evidence translation to AQEG and policy impact: "*Short term measurements suggest a significant contribution of biomass burning to PM during winter in urban areas*" **[E3, E5]**; "*Government takes bold action to cut pollution from household burning*" **[E2, E6]**.

**Environmental Impact:**

The Clean Air Strategy **[E1]** states: "*Whilst urban vegetation can have significant other benefits such as for noise pollution, the government's independent scientific advisory body on air pollution, the Air Quality Expert Group (AQEG) have found that urban vegetation is not a solution to the air quality problems at a city scale*". The AQEG report **[E4]** "Impacts of Vegetation on Urban Air Pollution" draws on the UoL research **[R3, R4, R5]**, which demonstrates the relatively small effects that trees have in reducing particulate air pollution on a city scale. "*A modelling study of the effectiveness of urban vegetation in reducing* $PM_{2.5}$ [fine particulate matter of 2.5 microns or less] *concentrations by Jeanjean et al (2017), using CFD approaches over a 2km x 2km area of central Leicester showed that the dispersive effect of trees reduced* $PM_{2.5}$ *concentrations by 9% while dry deposition to the trees reduced concentrations by 2.8%. Thus modelling and measurement approaches provide broadly consistent reductions in concentrations of particulate matter*" **[E4]**. " *… the University of Leicester work on green infrastructure, highlighted in AQEG reports, directly influenced the shape of policies and commitments set out in the Strategy and the Environment Bill*" **[E5]**. The beneficiaries of such advice are local councils and UK (and EU)

bodies responsible for air quality mitigation.

**Economic Impact:**
The overall actions detailed in the Clean Air Strategy **[E1]** aim to cut the costs of air pollution to society by GBP1,700,000,000 per year by 2020, rising to GBP5,300,000,000 every year from 2030, mainly driven by reducing health and social care costs. Particulate matter, arising from pollution sources such as wood burning, is directly implicated in deleterious health outcomes. The research **[R1, R2]**, evidence **[E3]**, and policy link **[E1, E2]**, as embodied in Schedule 12 of the Environment Bill **[E2],** are driven by the derived health and associated economic benefits for the UK public (and EU): reducing particulate matter pollution from wood burning **[R1]** will directly benefit health **[E1, E2]**. In addition, the advice on urban green infrastructure **[E1, E3, E4, E5]**, underpinned by UoL research, drives significant avoided costs (in the order of GBPMs) for the implementation of ineffective air quality mitigation.

In summary, as stated by Defra **[E5]**: "*the research output[s] delivered by the University of Leicester have played a relevant and directly influential role in shaping Government policy to reduce emissions of air pollution*".

Prof. Monks's recognised expertise in translation of scientific information to policy impact has led to his appointment as Chief Scientific Advisor for the Department of Energy and Industrial Strategy (BEIS) from October 1st 2020, where he continues to advise and influence the Government on matters across science and policy.

**5. Sources to corroborate the impact**

**E1**. Clean Air Strategy 2019 (2019), Defra, H.M. Government. The strategy set out the Government plans for dealing with all sources of air pollution.
**E2**. Environment Bill (2020) – introduces measures to reduce PM emissions for domestic solid fuel burning.
**E3**. AQEG (2017), The potential air quality impacts from biomass burning, Defra, HMG, 2017.
**E4**. AQEG (2018), Impacts of vegetation on Urban Air Pollution, Defra, HMG, 2018.
**E5**. Letter from Defra - Head of Evidence team.
**E6**. Government takes bold action to cut pollution from household burning – Defra media blog (Feb 2020) https://deframedia.blog.gov.uk/2020/02/21/government-takes-bold-action-to-cut-pollution-from-household-burning/ [Accessed 4th June 2020]
**E7**. Environment Bill – https://publications.parliament.uk/pa/bills/cbill/58-01/0220/200220.pdf