Institution: Imperial College London

Unit of Assessment: 14 – Geography and Environmental Studies

Title of case study: C14-3 Improving understanding of the risks of pests leads to better international management

Period when the underpinning research was undertaken: 1 August 2013 – 31 July 2020

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Prof John Mumford	Professor of Natural Resource Management	Sept 1979 - Present
Prof Clive Potter	Professor of Environmental Policy	Nov 1984 - Present

Period when the claimed impact occurred: 1 August 2013 – 31 July 2020

Is this case study continued from a case study submitted in 2014? N

1. Summary of the impact (indicative maximum 100 words)

Invasive species and introduced agricultural pests cause losses estimated at around $1.4tn/yr worldwide and control measures impose major constraints on trade. Mumford, Potter and colleagues developed new methods for quantifying risks in trade and natural pathways for insects and pathogens, provided risk managers with model decision tools to target responses, and demonstrated how understanding social attitudes can improve risk communication for greater public and industry acceptance. These frameworks and approaches are now adopted by the International Plant Protection Convention, the governing trade body of the Food and Agriculture Organisation (FAO) to which almost all countries belong, and by the European Food Safety Authority (EFSA), the world's largest fresh produce importer.

2. Underpinning research (indicative maximum 500 words)

Analysis and effective communication of risks from invasive species to trade and the natural environment has been hampered for decades by the absence of scientifically credible and transparent risk analysis frameworks, limited area-wide management tools and by a lack of understanding of how risk can best be communicated to complex stakeholder groupings. Regulators and risk managers have relied on biosecurity risk analyses that are largely qualitative, subjective and focused on individual species.

Path breaking research by Imperial Professors John Mumford, Clive Potter and colleagues on pest risks, management and governance has included work on trade network analysis, market influences, indicators of control and surveillance performance, international standards and regulations, ecological drivers, bioterrorism and bio-crime risk, and stakeholder and public perception of pest risks. Mumford has modelled pest pathways to enable more precise assignment of conditional probabilities and comparative analysis of risks from multiple pests and pathways **[1]**. For invasive species, Mumford has demonstrated a quantitative framework for prioritising responses combining consistent risk assessment and management processes **[2]**.

Their approach involves integration of quantitative (modelling) and qualitative (expert judgement) methods to estimate probability of invasive species entry and impacts of establishment on horticulture, agriculture and the wider environment **[3]**. They used Bayes nets to assimilate data from different sources and points on a trade pathway, including records of pest entry and establishment, combined with data from quarantine, efficacy of treatments, and expert judgements of parameters too difficult to estimate directly. With end users in mind, Mumford and colleagues developed consistent parametric assumptions and graphical tools to make the problem of

parameter estimation tractable and accessible to industry and regulatory stakeholders **[2, 3]**. This fundamental research has provided evidence for new approaches to pathway risk analysis and has been instrumental in their adoption in line with international standards.

Risk messaging has been analysed by Potter and colleagues. His work on perception and communication of biosecurity risk analysed within a Social Amplification of Risk Framework (SARF) has explained how expert risk messaging is amplified or attenuated over time through traditional and social media **[4]**. Potter has analysed the impact that different risk messaging strategies have on the public and how messages are crafted and targeted at different groups to maximise effectiveness in changing behaviour.

The resulting approach to risk analysis, combining technical improvements to pest risk analysis to provide a more consistent quantification of risk with improved risk messaging in real world contexts, has been widely adopted. A fundamental issue resolved by Mumford was to link the four principal pest risk components in international standards (entry, establishment, spread and impact) into a mathematically coherent risk expression that could be simulated, along with inherent uncertainties **[5]**.

Safer and more valuable trade has also been facilitated by improved field-based area-wide management schemes, such as Mumford's initiative with Indian colleagues to reduce mango fruit flies at their source through a combination of technical inputs (attractive baits and traps) and social mobilisation (local grower groups taking effective area-wide actions) **[6]**.

3. References to the research (indicative maximum of six references)

Research publications

[1] Holt, J., Leach, A.W., Mumford, J.D., MacLeod, A., Tomlinson, D., Baker, R., Christodoulou, M., Russo, L., Marechal, A. (2016) Development of probabilistic models for quantitative pathway analysis of plant pest introduction for the EU territory. EFSA supporting publication 2016:EN-1062. 372pp. DOI: 10.2903/sp.efsa.2016.EN-1062.

[2] Booy, B., Mill, A.C., Roy, H.E., Hiley, A., Moore, N., Robertson, P., Baker, S., Brazier, M., Bue, M., Bullock, R., Campbell, S., Eyre, D., Foster, J., Hatton-Ellis, M., Long, J., Macadam, C., Morrison-Bell, C., Mumford, J., Newman, J., Parrot, D., Payne, R., Renals, T., Rodgers, E., Spencer, M., Stebbing, P., Sutton-Croft, M., Walker, K.J., Ward, A., Whittaker, S., Wyn, G. (2017) Risk management to prioritise the eradication of new and emerging invasive non-native species. *Biological Invasions*, 19(8):2401-2417. doi:10.1007/s10530-017-1451-z

[3] Holt, J., Leach, A.W., Johnson, S., Tu, D.M., Nhu, D.T., Anh, N.T., Quinlan, M.M., Whittle, P.J.L., Mengersen, K., Mumford, J.D. (2017) Bayesian networks to compare pest control interventions on commodities along agricultural production chains. *Risk Analysis*, 38:297-310. DOI: 10.1111/risa.12852. http://onlinelibrary.wiley.com/doi/10.1111/risa.12477/full

[4] Urquhart, J., Potter, C., Barnett, J., Fellenor, J., Mumford, J., Quine, C.P. (2017) Expert risk perceptions and the social amplification of risk: a case study in invasive tree pests and diseases. *Environmental Science and Policy*, 77:172-178. doi:10.1016/j.envsci.2017.08.020

[5] Soliman, T., MacLeod, A., Mumford, J.D., Nghiem, T.P.L., Tan, H.T.W., Papworth, S.K., Corlett, R.T., Carrasco, L.R. (2016) A regional decision support scheme for pest risk analysis in Southeast Asia. *Risk Analysis*, DOI: 10.1111/risa.12477

[6] Verghese, A., Shivananda, T.N., Mumford, J.D. and Kamala Jayanthi, P. D. (2016) Socio-economic analyses of area-wide management of Mango Fruit Fly in South India. *Proceedings of the 9th International Symposium on Fruit Flies of Economic Importance*, Bangkok, Thailand, pp87-92. ISBN 978-616-358-207-2. https://nucleus.iaea.org/sites/naipc/twd/Documents/Proceedings_9thISFFEI.pdf

4. Details of the impact (indicative maximum 750 words)

Introduced pests and invasive species cause over $1 trillion in annual damage worldwide, are a significant barrier to trade, and are second to habitat loss as a cause of global environmental harm. Mumford, Potter and colleagues have developed a series of standards, quantitative models, decision procedures and understanding of ecology, technology and social attitudes that have been adopted by policymakers, regulators and biosecurity risk managers in UN agencies **[A, B]**, EU regulatory bodies **[C, D, E]**, and national authorities **[F, G]**. Wide engagement by the researchers with policymakers and regulators, internationally and domestically, has demonstrated the importance of pathway-based risk analysis and provided decision makers with an evidence base from which novel quantitative analytical tools and risk communication strategies could be developed and applied to manage existing and emerging biosecurity threats **[G]**. Mumford's research on pest risk assessment has informed working groups on which he served to prepare international guidance on use of genetic and radiation-based technologies for pest control (EFSA **[H]**; WHO/IAEA **[I]**).

Policy impacts

Both Mumford and Potter have been closely involved in development of UK government biosecurity policy **[G]**. As Chair of Defra's Non-native Species Risk Analysis Panel, Mumford has been directly involved in advising government on design and implementation of effective biosecurity measures **[E, G]**; more widely, the UK Minister stated that the process led by Mumford *"strongly influenced the EU's approach, including its risk methodology, when the EU invasive alien species regulation came into force in 2015*" **[E]**. Potter and Mumford were members of Defra's Tree Health and Plant Biosecurity Task Force, to advise on how to safeguard the country's trees, woods and forests from invasive pests and diseases **[G]**. The Taskforce's recommendations were implemented in full and included creation of a new Plant Health Risk Register, a methodological innovation based on Mumford's work and launched in 2014, described as *"an extremely effective policy innovation which allows the Plant Health Risk Group within Defra to undertake monthly reviews of threats"* **[G]**, together with a series of improvements to risk messaging to encourage behavioural changes in horticultural and forestry sectors.

In international standard setting, Mumford's quantitative, pathways-based modelling has been used to justify new standards and procedures for biosecurity and has been adopted by implementing agencies (EFSA) **[D, C]**, (Defra) **[G]** and by international standard setting bodies (IPPC, WTO) **[A, B]**. Mumford provided technical direction to the evaluation of the European Plant Health regime **[J]** that led to pathway risk analysis being included as a key platform for biosecurity risk management in the EU Plant Health Regulation (2016), implemented in 2019 **[B]**. Mumford led the design for a prototype quantitative pathway analysis tool for pathway risk analysis for the European Food Safety Authority **[D, C],** which oversees all fresh produce imports into the EU, worth over €20bn in 2019. With support from the Standards and Trade Development Facility (WTO), Mumford and colleagues developed a pathway-based production chain management system for South East Asian markets. It was adopted by the Philippines, Vietnam, Malaysia and Thailand, a crucial factor assisting these developing economies to negotiate trade agreements to export food commodities that satisfy international IPPC phytosanitary requirements **[K, A]**.

Specific commercial impact

Improved risk management facilitates horticultural trade, with significant and well documented economic benefits for producers in the global south, such as in India on mango **[L, M]**. For instance, Mumford's area-wide bait, trap and area-wide approach to fruit flies in India was used in a government scheme on mango fruit fly control to shift from production of low-price pulp and juice markets to higher value fresh fruit sales for mango on tens of thousands of farms **[L]**. This area-wide fruit fly control in southern India has increased mango yields three-fold and moved from $0.10/kg pulp sales to $1.00/kg fresh fruit sales. This has increased farm gate values by $700 million/year and *"transformed the incomes, and the lives, of many rural families"* as the "*total annual value of mango production in India increased in value by US$ 3.5 billion for 2013-2019"*

[M]. Area-wide fruit management using sterile insects (SIT), in a scheme built on Mumford's concepts, has "*supported export of around $200 million from Brazil in 2018"* **[B]**.

Pest risk analysis has been applied to new agricultural commodity trade pathways under the revised EU Plant Health regulations from 2019 **[B**, **following recommendation in J]**. New and changing trade pathways, particularly for €30bn/yr horticultural commodities, are subject to pest risk analysis and resulting pest management measures driven by approaches developed by Mumford, Potter and colleagues **[B, G]**.

5. Sources to corroborate the impact (indicative maximum of 10 references)

[A] STDF rolling our Systems Approach globally. (2020) https://www.ippc.int/en/core-activities/capacity-development/beyond-compliance-project/ (Archived here)

[B] Supporting letter from Former Deputy Director General of the UN International Atomic Energy Agency, Vienna, Austria and Professor of Genetics, University of Sao Paulo, Brazil

[C] EFSA. 2018. Guidance of the EFSA PLH Panel on quantitative pest risk assessment. (reference [D] cited on page 9 (1.3.3. Fit for purpose risk assessment)) http://www.efsa.europa.eu/sites/default/files/engage/180212-0.pdf (Archived here)

[D] Holt, J., Leach, A.W., Mumford, J.D., MacLeod, A., Tomlinson, D., Baker, R., Christodoulou, M., Russo, L., Marechal, D. 2016. Development of probabilistic models for quantitative pathway analysis of plant pest introduction for the EU territory. EFSA supporting publication 2016:EN-1062. 372pp. DOI: 10.2903/sp.efsa.2016.EN-1062 (Mumford was overall leader of project) https://www.efsa.europa.eu/en/supporting/pub/1062e (Archived here)

[E] Hansard. Lords debate on invasive species regulation 22/1/2019 (Mumford role cited by Minister) https://hansard.parliament.uk/Lords/2019-01-22/debates/47E62238-A793-40E7-98C7-4C1715CC162F/InvasiveNon-NativeSpecies(AmendmentEtc)(EUExit)Regulations2019 (Archived here)

[F] DEFRA. (2014) Tree Health and Plant Biosecurity Expert Taskforce: Final report. PB13878. Department for Environment, Food and Rural Affairs, London, UK. 100pp. Launched 2014. https://secure.fera.defra.gov.uk/phiw/riskRegister/Summary-of-Guidance-for-phase-1-Public-Ver2.pdf (Archived here)

[G] Supporting letter from Chief Plant Health Officer, Defra, UK.

[H] EFSA (2020). Scientific Opinion on the adequacy and sufficiency evaluation of existing EFSA guidelines for the molecular characterisation, environmental risk assessment and post-market environmental monitoring of genetically modified insects containing engineered gene drives. EFSA Journal 2020;18(11):6297, 90 pp. https://doi.org/10.2903/j.efsa.2020.6297 (Archived here)

[I] WHO/IAEA. (2020) Guidance framework for testing the sterile insect technique as a vector control tool against Aedes-borne diseases. World Health Organization, Geneva, Switzerland. 190pp. Licence: CC BY-NC-SA 3.0 IGO ISBN: 978-92-4-000237-1 (electronic version) https://www.who.int/tdr/publications/year/2020/guidance-framework-for-testing-SIT/en/ (Archived here)

[J] Evaluation of the EU's Plant Health Regime: Food Chain Evaluation Consortium (2010) Evaluation of the Community Plant Health Regime. DG SANCO, European Commission, Brussels, Belgium. Report 386pp + Annexes 314pp (Mumford role as technical adviser, Recommendation 4 relates to pathway analysis followed up in [D] and [C]) http://ec.europa.eu/food/plant/plant_health_biosafety/rules/index_en.htm (Archived here)

[K] Quinlan, M., Mengersen, K., Mumford, J., Leach, A., Holt, J. and Murphy, R. (eds) (2016) Beyond Compliance: A Production Chain Framework for Plant Health Risk Management in Trade. Chartridge Books, Oxford, UK.253pp. ISBN: 978-1-911033-10-3 Ebook: http://www.standardsfacility.org/PG-328 (Archived here)

[L] Verghese, A., Shivananda, T.N., Mumford, J.D. and Kamala Jayanthi, P. D. (2016) Socio-Economic Analyses of Area-Wide Management of Mango Fruit Fly in South India. Proceedings of the 9th International Symposium on Fruit Flies of Economic Importance, Bangkok, Thailand, pp87-92. ISBN 978-616-358-207-2. https://nucleus.iaea.org/sites/naipc/twd/Documents/Proceedings_9thISFFEI.pdf (Archived here)

[M] Supporting letter from Indian Council of Agricultural Research (ICAR)-National Bureau of Agricultural Insect Resources, Bengaluru, India.