Institution: University of Worcester

Unit of Assessment: UoA14 Geography and Environmental Studies

Title of case study: Mapping and mitigating harmful invasive species

Period when the underpinning research was undertaken: 2007-2020

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:
Professor Carsten A. Skjøth	Professor of Atmospheric Science	2013-present
Dr Matthew Smith	Research Fellow	2004-2011, 2015-present

Period when the claimed impact occurred: 2014-2020

Is this case study continued from a case study submitted in 2014? No

1. Summary of the impact

*Ambrosia artemisiifolia (*ragweed) is an invasive species impacting human health, agriculture and nature systems. The health impacts alone are estimated to cost €9 billion per year across Europe. Research has made it possible to quantify and map the distribution of ragweed and carry out efficient mitigation. Mapping of ragweed has fed into forecasting models, allowing effective management of hay fever. Identification of ragweed source areas informed EU directives which have led to subsequent reductions in its spread. Further, the research has identified the cost-effectiveness of biological control using the ragweed beetle *Ophraella communa* which would reduce health costs in Europe by €1.7 billion/year.

2. Underpinning research

Researchers at Worcester (Smith) were involved in an EU-COST network, EUPOL, from 2007-11 (Grant 1). The network was focused on the production, atmospheric distribution, and health impacts of the 12 most important aero-allergenic pollens, as well as the means of monitoring and forecasting these phenomena. A key output of the network was the identification of European source regions for ragweed (*Ambrosia artemisiifolia*) pollen, one of the 12 most important aero-allergenic pollens, demonstrating how the species can be mapped using airborne pollen data (Reference 2).

The network further explored the mechanism by which the pollen and the seeds of ragweed were spread. The identification of source areas using pollen data (Reference 1) was key to this exploration and provided the argument for looking into the role of bird seed as a primary mechanism for the spread. It was found that bird seed packages produced in the main source areas were heavily infested with ragweed seed, thereby providing a route of infection to other European countries. The research thus helped inform a 2012 European Directive (EU n° 744/2012) which set the maximum levels of ragweed seeds in products intended for animal feed, in particular, birds.

The research on ragweed was extended through a second EU-COST network, SMARTER (Grant 2), which ran from 2013-17, of which Skjoth (now at Worcester) was Vice-Chair and Scientific Coordinator. Common ragweed is one of the most prominent invasive alien species in Europe. Its pollen grains are carriers of noxious allergens that may induce severe symptoms in sensitised people. It is also a significant agricultural weed with a range that is likely to increase under climate change. This network set out to explore long-term management and monitoring options and the development of new innovative management solutions, such as a synergy between biological, physical and chemical control measures and vegetation management, and assess their cost-effectiveness in mitigating the effects of invasive alien species (Reference 5).

The mapping approach for ragweed developed in EUPOL was refined in SMARTER (with the additional support of a Marie Curie Career Integration Grant (Grant 3). The final synthesis of the mapping covered all relevant regions in Europe and parts of Asia in high detail, providing a new method and a valuable tool for mitigating ragweed and the impact of its highly allergenic pollen (Reference 3).

Another key aspect of SMARTER was to explore the applicability of biological control of ragweed using natural enemies. The network identified that the ragweed beetle (*Ophraella communa*), accidentally released in the Po Valley, Italy, was the likely cause of the significant decrease in atmospheric concentrations of ragweed pollen in the region (Reference 4). Further studies, exploring the effect of the ragweed beetle alongside European-wide mapping of the plant and pollen exposure, demonstrated that the observed reduction in pollen exposure can be replicated throughout Europe (Reference 6).

3. References to the research

1. Smith, M. , Skjøth, C. , Myszkowska, D., Uruska, A., Puc, M., Stach, Alicja, Balwierz, Z., Chlopek, K., Piotrowska, K., Kasprzyk, I. and Brandt, J. (2008) Long-range Transport of Ambrosia Pollen to Poland. Agricultural and Forest Meteorology, 148 (10). pp. 1402-1411. https://doi.org/10.1016/j.agrformet.2008.04.005
2. Skjøth, C. , Smith, Matt , Sikoparija, B., Stach, Alicja, Myszkowska, D., Kasprzyk, I., Radišić, P., Stjepanović, B., Hrga, I., Apatini, D., Magyar, D., Páldy, A. and Ianovici, N. (2010) A Method For Producing Airborne Pollen Source Inventories: An Example of Ambrosia (Ragweed) on the Pannonian Plain. Agricultural and Forest Meteorology, 150 (9). pp. 1203-1210. https://doi.org/10.1016/j.agrformet.2010.05.002
3. Sikoparija, B., Skjøth, C., Celenk, S., Testoni, C., Abramidze, T., Alm Kübler, K., Belmonte, J., Berger, U., Bonini, M., Charalampopoulos, A., Damialis, A., Clot, B., Dahl, Å., de Weger, L.A., Gehrig, R., Hendrickx, M., Hoebeke, L., Ianovici, N., Kofol Seliger, A., Magyar, D., Mányoki, G., Milkovska, S., Myszkowska, D., Páldy, A., Pashley, C.H., Rasmussen, K., Ritenberga, O., Rodinkova, V., Rybníček, O., Shalaboda, V., Šaulienė, I., Ščevková, J., Stjepanović, B., Thibaudon, M., Verstraeten, C., Vokou, D., Yankova, R., Smith, M. (2017) Spatial and Temporal Variations in Airborne Ambrosia Pollen in Europe. Aerobiologia, 33 (2). pp. 181-189. https://doi.org/10.1007/s10453-016-9463-1
4. Müller-Schärer, H., Sun, Y., Chauvel, B., Karrer, G., Kazinczi, G., Kudsk, P., Oude Lansink, A.G., Schaffner, U., Skjøth, C., Smith, M., Vurro, M., de Weger, L.A. and Lommen, S.T. (2018) Cross-fertilizing Weed Science and Plant Invasion Science to Improve Efficient Management: a European Challenge. Basic and Applied Ecology, 33. pp. 1-13. https://doi.org/10.1016/j.baae.2018.08.003
5. Skjøth, C., Sun, Y., Karrer, G., Sikoparija, B., Smith, Matt , Schaffner, U. and Müller-Schärer, H. (2019) Predicting Abundances of Invasive Ragweed Across Europe Using a “Top-down” Approach. Science of the Total Environment, 686. pp. 212-222. https://doi.org/10.1016/j.scitotenv.2019.05.215
6. Schaffner, U., Steinbach, S., Sun, Y., Skjøth, C. , de Weger, L., Lommen, S., Augustinus, B., Bonini, M., Karrer, G, Sikoparija, B., Thibaudon, M. and Müller-Schärer, H. (2020) Biological weed control to relieve millions from ambrosia allergies in Europe. Nature Communications, 11. Article no. 1745. https://doi.org/10.1038/s41467-020-15586-1

Grants

1. Smith, “Assessment of production, release, distribution and health impact of allergenic pollen in Europe” (EUPOL), EU-COST Network, (2007-11).
2. Skjoth, “Sustainable management of Ambrosia artemisiifolia in Europe” (SMARTER), EU-COST Network, (2013-16).

3. Skjoth (PI), SUPREME, Marie Curie Career Integration Grant, EU Framework Programme, (07/2014-06/2018), £88,047.

References 3, 5 and 6 are included in the unit's REF2021 output submission. References 1 and 2 were included in the University's UoA5 submission to REF2014.

4. Details of the impact

As has been emphasised above, ragweed is a major source of allergenic pollen across Europe which has negative impacts on human health (severe allergic rhinitis, conjunctivitis and asthma) and costs the European economy billions of euros every year in direct health costs and lost work days. Fundamentally, the research has brough positive benefits for public health across Europe (with the cost savings associated with that) through:

- enhanced public awareness of the health risks associated with ragweed pollen but also of the positive role of the ragweed beetle in controlling its spread
- the development of mechanisms to forecast ragweed pollen concentrations and spread which enable allergy sufferers and clinicians to plan medication regimes to reflect high pollen concentrations but also activities such as exercise and travel to avoid peak periods
- reductions in the spread of ragweed through European legislation on bird seed

More recently, the research has highlighted the benefits of using biological control to contain the spread of ragweed, providing a clear rationale for this approach. This impact is very early stage but has the potential to underpin substantial economic, health and environmental benefits across Europe.

Enhanced awareness of a public health risk

The *SMARTER* network adopted a very clear public engagement strategy not least through its connections with the International Ragweed Society, an international organisation with the primary aim of promoting knowledge and understanding of ragweed and its health and environmental impacts. A core component of this engagement has been International Ragweed Day which is held in June of each year. The purpose of this initiative is not only to help people identify ragweed and to highlight its negative health impacts but also to identify strategies individuals can adopt to limit its spread (Source A).

The network was also identified as one of ten "success stories" in the COST Action Report for 2016 (Source B). The report articulated, in particular, how SMARTER "spread knowledge of the [ragweed] beetle's great usefulness in reducing pollen production and limiting growth of ragweed populations, but also that risks for other plants, like sunflowers, are small".

Ragweed pollen forecasting

One of the key input parameters for pollen forecasts is the distribution of pollen sources. The approach developed by Skjoth of combining land use data with annual pollen counts has been shown to be the most effective approach in predicting ragweed pollen concentrations (Source C). Consequently, since 2019, the University has been contracted to provide pollen data for the Copernicus Atmosphere Monitoring Service (CAMS) (Source D). CAMS is a European Commission initiative delivered through the European Centre for Medium-Range Weather Forecasts (ECMWF) which provides information related to air pollution and health, solar energy, greenhouse gases and climate forcing. It provides its own European wide weather and pollen forecasts (Source E) but also provides data for a range of other organisations including the World Health Organisation and the European Environment Agency, whilst its data also underpins pollen forecasts provided through various national media across Europe (e.g. Euronews). It introduced a ragweed forecast for the first time in 2019 (Source F). As emphasised in this CAMS press release, pollen forecasts "allow allergy sufferers to take preventive measures

days before exposure", thus limiting the health impacts of their allergies. It is important to note that these forecasts can also aid clinicians in diagnosis and treatment of allergies (e.g. by enabling them to provide more targeted advice for patients on medication regimes) and education (Source G).

Reductions in the spread of ragweed

As noted above, the research of EUPOL laid the groundwork for a European Commission directive in 2012 limiting the volume of ragweed seed in bird feed. The impact of this legislation has been felt during this REF assessment period. Research undertaken as part of SMARTER (Reference 3) showed that local pollen sources are the primary cause of ragweed pollen concentration in any given region. In Northern Europe, where these local sources are primarily a function of ragweed seed dispersion, ragweed pollen concentration has fallen since the directive, strongly suggesting the directive has taken effect in these areas.

5. Sources to corroborate the impact

A. International Ragweed Day June 2020: http://internationalragweedsociety.org/wp-content/uploads/2020/06/Int-Ragw-Day_2020.pdf
B. COST Annual Report 2016: https://issuu.com/costprogramme/docs/cost_annual_report_2016_digital
C. Zink, K. et al, (2017) Numerical ragweed pollen forecasts using different source maps: a comparison for France, International Journal of Biometeorology. 61, pp.22-33. https://doi.org/10.1007/s00484-016-1188-x
D. Contracts to deliver ragweed pollen data for CAMS, 2019, 2020, 2021.
E. CAMS Hourly Forecast and Analyses: http://macc-raq-op.meteo.fr/index.php?category=ensemble&subensemble=hourly_ensemble&date=LAST&calculation-model=ENSEMBLE&species=o3&level=SFC&offset=000
F. News story from Copernicus website announcing the introduction of a ragweed forecast for 2019: https://atmosphere.copernicus.eu/cams-helping-allergy-sufferers
G. Letter from Consultant Respiratory Physician, NHS Worcestershire Acute Hospitals, outlining the benefits of pollen forecasts to their practice