

Institution: University of Portsmouth		
Unit of Assessment: UoA7 - Earth Systems and Environmental Sciences		
Title of case study: Changing perceptions and policy to better manage radioactively contaminated land at Chernobyl		
Period when the underpinning research was undertaken: 2008 - 2019		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s): Jim Smith Alex Ford Mo Hoque	Role(s) (e.g. job title): Professor of Environmental Sciences Professor of Biology Senior Lecturer Hydrogeology	Period(s) employed by HEI: 01/08/2007 - date 01/07/2008 - date 01/08/2016 - date
Period when the claimed impact occurred: 2015 - 2020		
Is this case study continued from a case study submitted in 2014? N		
1. Summary of the impact <p>The University of Portsmouth's (UoP) world-leading research and high-profile media engagement on radioactively contaminated lands in Ukraine has led to two key policy changes in the management of the Chernobyl Exclusion Zone (CEZ) and the Compulsory Relocation Zone (combined area: 4,600km²). This has led to a major change in the strategy for managing surface waters in the CEZ and to the signing of an agreement, for the first time since 1991, to begin the legal process of re-zoning four settlements and surrounding land. It has led to the development of ATOMIK spirits, the first consumer product from Chernobyl, now in production.</p>		
2. Underpinning research <p>This impact case study is based on Professor Jim Smith's 30 years' research on environmental radioactivity and on his decades-long collaborations with key Ukrainian and Belarussian researchers and with the State Agency of Ukraine for Exclusion Zone Management (SAUEZM).</p> <p>From 2013 to 2019, Smith worked with ecotoxicologist, Professor Alex Ford, to lead UoP research in the NERC-funded Radioactivity in the Environment (RATE) programme "TREE" consortium, the largest coordinated study on radiation exposure and effects undertaken at Chernobyl (G1). RATE was part funded by the Environment Agency (EA) and Radioactive Waste Management (RWM) to support world-leading research relevant to radioactive waste disposal and environmental risk assessment for nuclear decommissioning and new-build. UoP-led research focused on the effects of radiation on wildlife and the long-term transfer of ¹³⁷Cs into crops. In particular, research led by Smith presented (in 2015), for the first time, evidence that long-term chronic radiation exposures had no observable effect on mammal abundance at Chernobyl (R1). This work further compared mammal densities in the CEZ with those in protected conservation areas in the region, finding no differences for non-predatory species, but a much larger wolf population in the CEZ due to different hunting pressures (R1). This was the first robust evidence of the remarkable recovery of wildlife after a major nuclear accident, subsequently corroborated by independent camera-trap studies at Chernobyl (Webster et al., 2016) and Fukushima. As part of the TREE project, UoP (Smith, Ford) also led the largest study of radiation effects on aquatic ecosystems around Chernobyl to date. For the first time, evidence was found of subtle impacts of radiation on fish reproduction (R2) but no evidence of significant population-level impacts on fish or aquatic invertebrates (R2-4).</p> <p>In 2017, Smith was awarded a NERC Innovation Follow On grant ("iCLEAR") to undertake a programme of underpinning science and stakeholder consultation on future management of surface water systems and abandoned agricultural land at Chernobyl (G2). Smith's research with Japan's National Institute for Radiological Sciences studied transfers of radioactivity to crops after the 1950s and '60s atmospheric nuclear weapons testing. This used a unique database of >4000 measurements of ¹³⁷Cs to develop a model which could predict long-term uptake post Chernobyl and Fukushima incidents (R4). Research by Smith and Dr Mohammed Hoque into current transfers of radioactivity to crops and groundwaters in the CEZ evaluated the transfer of key radionuclides (¹³⁷Cs, ⁹⁰Sr, ²⁴¹Am and Pu isotopes) to ethanol produced from distilled grain, demonstrating that, although crops were contaminated, distillate alcohol (and the Chernobyl groundwater used to dilute it) was free from radioactivity (R5).</p>		

Smith's extensive research (with partners in Ukraine, Belarus and Japan) on transfers of radionuclides to and in water systems has elucidated the key mechanisms of long term contamination of surface waters (e.g. **R6**). This has provided supporting evidence for a change in water management priority away from (primarily) radionuclide runoff reduction. Together with the new scientific and public understanding of the role of the CEZ as a wildlife reserve (**R1**), this has reprioritised water management within the CEZ to focus on conservation, in particular development and preservation of wetlands.

3. References to the research

3.1. Research outputs

R1. Deryabina, T. G., Kuchmel, S. V., Nagorskaya, L. L., Hinton, T. G., Beasley, J. C., Lerebours, A., & **Smith, J. T.** (2015). Long-term census data reveal abundant wildlife populations at Chernobyl. *Current Biology*, 25(19), R824-R826.
<https://doi.org/10.1016/j.cub.2015.08.017>

R2. Lerebours, A., Gudkov, D., Nagorskaya, L., Kaglyan, A., Rizewski, V., Leshchenko, A., Bailey, E. H., Bakir, A., Ovsyanikova, S., Laptev, G. & **Smith, J. T.** (2018). Impact of environmental radiation on the health and reproductive status of fish from Chernobyl. *Environmental Science & Technology*, 52(16), 9442-9450.
<https://doi.org/10.1021/acs.est.8b02378>

R3. Fuller, N., **Ford, A.**, Nagorskaya, L. L., Gudkov, D. I., & **Smith, J. T.** (2018) Reproduction in the freshwater crustacean *Asellus aquaticus* along a gradient of radionuclide contamination at Chernobyl. *Science of the Total Environment*, 628-629, 11-17.
<https://doi.org/10.1016/j.scitotenv.2018.01.309>

R4. **Smith, J. T.**, Tagami, K., & Uchida, S. (2017). Time trends in radiocaesium in the Japanese diet following nuclear weapons testing and Chernobyl: Implications for long term contamination post-Fukushima. *Science of The Total Environment*, 601-602, 1466-1475.
<https://doi.org/10.1016/j.scitotenv.2017.05.240>

R5. **Smith J. T.**, Laptev G., Korychenskyi, K., Kireev, S., Obrizan, S., **Hoque, M. A.**, Kashparov V., Levchuk, S., Bugai, D. A., & Warwick P. E. (2019) *Distillate ethanol production for re-use of abandoned lands - an analysis and risk assessment*. iCLEAR.
https://researchportal.port.ac.uk/portal/files/15561808/Distillate_ethanol_production.pdf

R6. Igarashi, Y., Onda, Y., **Smith, J. T.**, Obrizan, S., Kirieiev, S., Demianovych, V., Laptev, G., Bugai, D., Lisovyi, H., Konoplev, A. Zheleznyak, M., Wakiyama, Y., & Nanba, K. (2020) Simulating dissolved ⁹⁰Sr concentrations within a small catchment in the Chernobyl Exclusion Zone using a parametric hydrochemical model. *Scientific reports*, 10(1), [9818].
<https://doi.org/10.1038/s41598-020-66623-4>

3.2. Evidence of the quality of the research

All references should be used to assess the quality of research: R1-4 and R6 are published in subject leading journals; R5 is a high quality technical report (>3000 ResearchGate reads). R1 and R2 are returned in REF2 with Output IDs 7101750 and 12186210, respectively.

3.3. Related grants

G1. **Smith, J.T.**, Thorpe, K.L. & **Ford, A.** *TRansfer - Exposure - Effects (TREE): integrating the science needed to underpin radioactivity assessments for humans and wildlife*. Funded by the Natural Environment Research Council, 10/2013 - 03/2019 (GBP484,668)

G2. **Smith, J.T.**, **Hoque, M.A.**, Wood, M.D., & Beresford, N. *Innovating the Chernobyl Landscape: Environmental Assessment for Rehabilitation and Management (iCLEAR)*. Funded by the Natural Environment Research Council, 11/2017 - 07/2021 (GBP100,616)

G3. Ford, A. & Smith, J.T. *Metabolomic profiling and biomarker development in radiation exposed crustaceans*. Funded by the Natural Environment Research Council. 30/11/2016 - 30/11/2018 (GBP33,100; In-kind facilities)

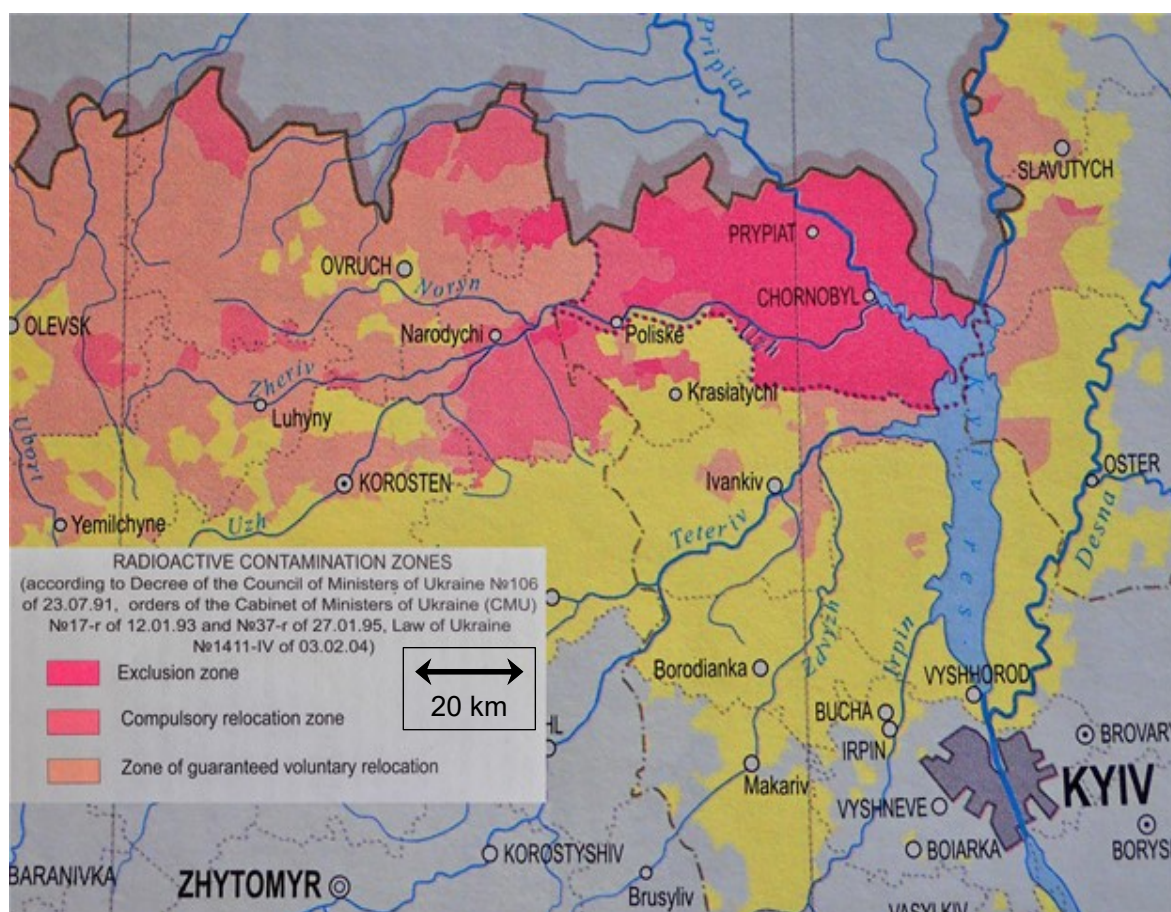
G4. Smith, J.T. & Lerebours, A. *Method development for analysis of cataract formation from chronic exposure from Chernobyl and Fukushima using Synchrotron X Rays*. Funded by the Science and Technology Facilities Council, 1/10/2016 - 31/03/2018 (GBP19,760)

G5. Smith, J.T. & Lerebours, A. *Using SAXs to measure radiation induced cataract in fish at Chernobyl and Fukushima*. Science and Technology Facilities Council, 11/2016 - 04/2018 (GBP57,564; In-kind facilities).

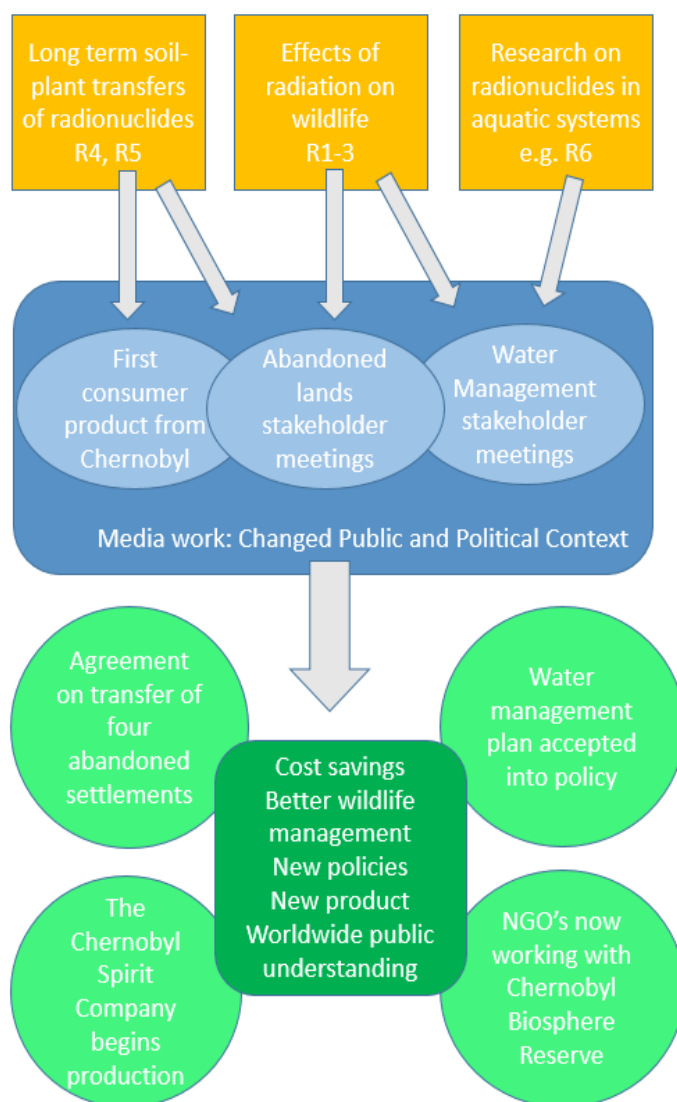
4. Details of the impact

The 1986 Chernobyl accident led to the immediate and permanent evacuation of more than 100,000 people from a huge area of land, creating the Chernobyl Exclusion Zone (CEZ), as well as the semi-abandoned "Compulsory Relocation Zone". For Ukraine, areas previously lost to agriculture still represent radiation risks, but now also represent a unique and important potential resource for agriculture, wildlife conservation and radioactive waste disposal. Due to the highly charged political and emotional context, it is essential that management strategies for the CEZ are based on the best available scientific evidence and open stakeholder consultation.

UoP research, and leadership of the iCLEAR Innovation Project, has '*had a transformative effect on [key state agency SAUEZM's] management of contaminated lands and on policy work on this issue in Ukraine*' (**S1**) and directly led to major policy changes (**S1**) supporting the management of approximately 4,600km² of abandoned lands in the Exclusion and Compulsory Relocation Zones.



Zoning of contaminated land showing the Exclusion Zone (CEZ) and the - still inhabited - Narodychi District within the Compulsory Relocation Zone (Atlas of Radioactive Contamination in Ukraine, 2008).



Management of abandoned lands

Smith's iCLEAR work on developing the scientific evidence base for re-use of radioactively contaminated lands (subject of an award-winning BBC "Our World" documentary and online story which was in the [top 100 most engaging stories](#) worldwide in 2019 out of 54 million articles (**S2**)) has changed policy on the complex issue of re-zoning of abandoned lands. Three stakeholder consultations, coordinated by **Smith** and SAUEZM, in the Narodychi District brought together local people, community leaders, local politicians, scientists and key state agencies. These, with field research in the CEZ (**R5**) and in Narodychi, 'have given a new impetus to the decades-old issue of re-zoning in Ukraine, of key importance to the future of the Narodychi community' (**S3**) by demonstrating that most abandoned areas in the Compulsory Relocation Zone can produce crops which meet Ukrainian regulations. They have led to the signing of an agreement (iCLEAR meeting 16/04/2019; **S1**) between Narodychi District and SAUEZM to begin, for the first time since 1991, the complex legal process of transfer of four abandoned settlements and associated lands back to the District.

Flow chart illustrating **research**, **impact pathways** and **impact**

Water management in the CEZ

UoP-led consultations with the key stakeholders for water resources in the CEZ (Chernobyl Biosphere Reserve; Chernobyl ECOCENTRE; Ukrainian Hydrometeorological Institute; conservation organisations, including WWF) identified the need for the first new evaluation of water management in the CEZ since 1991. The new water management strategy (**Smith** is a co-author), informed by three UoP-led iCLEAR stakeholder consultations and by **Smith's** research (e.g. **R1**, **R6**), details the current state of hundreds of dykes, drainage canals and weirs as well as, for the first time, prioritising wildlife conservation, in particular key wetland resources, in future management. The strategy (adopted by SAUEZM, **S1**; **S4**) is guiding internal investment to maintain key infrastructure, and will reduce costs (estimated savings USD500,000/year (**S4**)) by reducing the need for monitoring and maintenance of structures which have been identified as no longer serving a useful function in drainage or reduction of radionuclide runoff. By maintaining and where possible extending wetland areas, the new strategy will also support wildlife conservation (**S4**, **S5**).

Wildlife conservation

The CEZ now represents the third largest nature reserve in mainland Europe and is of global conservation importance. UoP-led work to include, for the first time, wildlife conservation as a key factor in the CEZ water management strategy will support the transition of the CEZ to a fully functioning Biosphere Reserve by maintaining and enhancing valuable wetland ecosystems (**S5**).

iCLEAR initiated and supported the first World Wildlife Fund visit to Chernobyl, leading to a signed MoU to include the Reserve in the WWF European Lynx project (S5). It has initiated the process of RAMSAR accreditation of two wetland areas in the CEZ which will give them protected status as wetlands of international importance (S5).

Scientific evidence in the media and enhanced public understanding



The 2015 UoP-led study on wildlife in the CEZ gained huge worldwide media attention (Altmetric media impact: top 0.01% of all research articles), trended no. 1 on Facebook science and had a media reach of over 100,000,000 (S6). It inspired the visit of Sir David Attenborough to Chernobyl in the final scene of *Our Planet* (Netflix's most successful documentary series), in which Sir David quoted the findings of the paper (S7). It has made 'an outstanding contribution to science communication and to a better understanding of the risks and benefits of radiation and nuclear power' (S8). UoP research supported Radioactive Waste Management and the Environment Agency in making 'a significant contribution to changing public understanding of radioactivity and its impacts' and providing evidence-based responses to challenges to the Geological Disposal programme (one of the UK's largest infrastructure projects), which were

based on an over-estimation of risks of radiation to wildlife (S9).

The UoP-led (Smith, Hoque) ATOMIK grain spirit project (www.atomikvodka.com and R5) had major worldwide media impact, with a media reach (based on circulation / tv channel viewers / website monthly views) of billions (S6), including BBC National News, CNN, Times of India, Xinhua (China) (S6) and 63 media outlets in Ukraine (S10). This 'excellent example' of science communication has 'changed and informed people's perceptions of the Exclusion Zone and contamination' (S2). These messages are essential to the ongoing recovery of affected communities (S1, S4) and to a wider understanding of risk from nuclear power and waste disposal (S2, S8, S9). Smith's spin out social enterprise "The Chernobyl Spirit Company" (Company Number 12112459) has produced an initial batch of 1,730 bottles of ATOMIK using crops from Narodychi. First year turnover is expected to be GBP60,000; 75% of profits will be re-invested in community projects to improve lives and conservation in the Chernobyl affected zones.

5. Sources to corroborate the impact

- S1. Letter from [text removed for publication], State Agency of Ukraine on Exclusion Zone Management (SAUEZM) (2017 - 2019) providing evidence of management and policy impact (28/01/2021)
- S2. Email communication from BBC [text removed for publication] providing evidence for the importance of Smith's work to BBC coverage and to public communication on radiation risk (10/2020)
- S3. Letter from [text removed for publication] the Narodychi Community providing evidence for the impact of the iCLEAR project on the community (28/01/2021)
- S4. Letter from Director-General of the Chernobyl ECOCENTRE (an arm of SAUEZM) detailing the impact of iCLEAR on future management of the CEZ (28/10/2020)
- S5. Letter from former Director of WWF, Ukraine, and a leading Ukrainian conservationist on iCLEAR support for Chernobyl Biosphere Reserve (26/10/2020)
- S6. Media coverage of Wildlife and ATOMIK (Smith), 05/10/2015 - 19/12/2019, UoP Press office
- S7. Letter from [text removed for publication], Silverback Films, on contribution to Netflix's *Our Planet*
- S8. Letter from [text removed for publication], Science Media Centre, detailing impact of Smith's media activities (22/06/2020)
- S9. Letter from the [text removed for publication], Radioactive Substances Regulation, Environment Agency and [text removed for publication], Radioactive Waste Management detailing impact of the TREE project in the UK (16/05/2018)
- S10. Summary of ATOMIK Ukrainian media coverage, Press Office, SAUEZM (08/08/2019).