

# Adam Kleczkowski

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Mathematics and Statistics  
University of Strathclyde,  
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## Current duties and research interests

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- Google Scholar h-index 24, 1625 citations (March 2018).
- Research: Mathematical modelling and statistical analysis of systems at the interface of epidemiology, socio-economics and policy. Main current areas of application:
  - Spread and control of tree, plant and animal diseases, including trade;
  - Prediction of outbreaks, social impact and human behaviour during influenza epidemics;
  - Impact of intensification on food security in shrimp and fish production;
  - Control of Norovirus dynamics in shellfish;
  - Delivery of ecosystem services, including pollination and impact of neonicotinoids on bee population.
- Development of stochastic, spatially extended, network- and agent-based models;
- Development of bioeconomic models, including stochastic game theory;
- Design and use of computer games in epidemiology and health protection.
- Parameter estimation for epidemiological data (classical and Bayesian, including particle filtering and MCMC).
- Interaction with policy makers, including design and co-design of decision support systems (Defra/Forestry Commission project).
- Preparation of scientific papers; securing external funding and running project, including supervision of 3 PDRAs; supervision of PhD projects.
- Teaching (ca. 200h contact hours per year): Lectures, tutorials and assessment for mathematical courses across all levels (UG and TPG), including algebra, calculus, advanced calculus, real and complex analysis, probability, statistics and numerical methods. Supervision of honours projects and RPGs. Designing new courses, tutorial and exam questions.
- Administration:

## Employment

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2018-present: Global Talent Chair in Mathematics, Department of Mathematics and Statistics, University of Strathclyde, Glasgow;

2014-2018: Chair in Mathematics, Computing Sciences and Mathematics, Faculty of Natural Sciences University of Stirling, Stirling; Head of Biological Modelling Research Group (2017-2018); Head of Mathematics and Statistics Group (2008-2017); Deputy Head of Computing Science and Mathematics (2014-2017).

2007-2014: Senior Lecturer (2007-2013) and Reader (2013-2014) in Applied Mathematics, University of Stirling; duties as above; additionally, Research Director for the Department of Computing Science and Mathematics (2009/10).

2005-2007: Lecturer in Mathematical Biology, Department of Plant Sciences and College Lecturer in Mathematics for Natural Sciences, Selwyn College, Cambridge;

2003 (concurrent with below): joint project with Univ. of York, Development of Soil Ecosystem Model for the NERC Soil Biodiversity Thematic Programme (developing models for soil microbial diversity);

2002-2005: Research Associate, Department of Plant Sciences, Cambridge; *A strategic model to evaluate control strategies and disease risk of Rhizoctonia in field vegetables*; DEFRA-funded project (developing models for spread of plant pathogens; risk analysis; parameter estimation);

2000-2002 Research Associate, King's College Research Centre and Dept. Plant Sciences, Cambridge (model development and fitting for plant pathogens, particularly cereal pathogens);

1996-2000 Senior Research Fellow in Mathematical Biology, King's College, Cambridge (model development and fitting for plant pathogens; data analysis and models of plant-climate interactions);

1993-1996 Research Associate, Department of Plant Sciences, University of Cambridge (deterministic and spatial models of plant pathogens and model fitting, particularly soil-borne diseases of brassicas);

1992-1993 Visiting Research Fellowship, Department of Zoology, University of Cambridge (models of childhood diseases, particularly measles);

1989-1991 (concurrent with below) Wissenschaftler (Research Associate), Arbeitsgruppe Theoretische Ökologie, Forschungszentrum Jülich, Germany (deterministic and stochastic models in ecology);

1984-1993 Research Assistant, Institute of Physics, Jagiellonian University, Kraków (deterministic and stochastic models in physical systems). 1989-1991 and 1992-1993 on secondments, as above.

## Education

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1984-1989 PhD, Jagiellonian University, Kraków, Poland;  
1979-1984 MSc, Jagiellonian University, Kraków, Poland;  
1975-1979 Secondary school, A-levels with distinction.

## Awards and grants

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### Ongoing:

2018-2020 Centre of Expertise in Plant Health (Scottish Government, total £600k yearly over 5+ years, Co-I; Stirling component £100k pa);

2016-2021 *Disease management options: Insights from comparing forestry and agriculture* (Scottish Government Strategic Research Programme, £300k; PI of the HEI component);

2017-2019 *The epidemiology of novel PdRI resistant grapevines: epidemic and vector movement models to support integrated disease management* (USDA, led by Univ. of California at Berkeley, cooperator);

2017-2018 'AgriFood at York' funded project on *Biosecurity and food security: The role of Private-Public Partnerships and Assurance Schemes* (£14k, CoI);

### Finished:

2016-2017 Defra ITT FEE/0365 *Developing a Plant Health Outbreak Decision Support Framework* (£120k, CoI);

2014-2017 *Modelling economic impact and strategies to increase resilience against tree disease outbreaks* (BBSRC, £1.1m, PI);

2014-2017 *Risks of Animal and Plant Infectious Diseases Through Trade* (NSF-BBSRC, USD1.5m USA component, £600k UK component, Co-I).

2016 BSPP summer student project, collaboration with Scientific Advice for Scottish Agriculture, £2500;

2013, 2014, 2015, 2016 NERC Graduate Course in Modelling for Environmental Science (£30k, CoI);

2014-2015 *Gamification: scoping the use of games to engage and learn* (DEFRA; £4k, CoI);

2013-2017 CASE studentship (CEFAS/University of Stirling) on *An epidemiological and economic framework for designing and evaluating control strategies for water- and food-borne pathogens: A Norovirus case study*. (£50k, PI)

2011 Department for International Development grant on *Characterising livestock system "zoonoses hotspots"* (£19k; PI)

2010 Medical Research Council Catalyst grant, *EPISYSTEM: Designing biological, social and economic environments to enhance resistance to zoonotic outbreaks* (£50k, PI) (selected for the second stage; ultimately unsuccessful)

2010 European Investment Bank grant, *Designing Markets for Ecosystem Services Delivery* (€300k, Co-I)

2009 IMA and BSPP travel grants (total £800)

2008 Leverhulme Trust, *Integrative Ecology* (CoI, selected for the second stage as the only application from Scotland; ultimately unsuccessful).

2003 NERC Soil Biodiversity Programme, travel (overseas) grant;

2003 STOCHDYN - *Stochastic Dynamics: fundamentals and applications*, ESF project, as a part of the European consortium.

2002 British Council/KBN British-Polish Young Scientist Research Collaboration Programme, travel grant for a PhD student, jointly with Jagiellonian University, Poland, *Plant and animal disease on lattices and networks – dissemination and prevention*;

1999 British Council/KBN British-Polish Joint Research Collaboration Programme, travel grant jointly with Jagiellonian University, Poland, *Spatial and temporal heterogeneities in nonlinear models of biological systems*;

1997 BBSRC/EPSRC 3-year grant *Scaling up from individual to population behaviour in stochastic, spatially-extended systems* as a second principal investigator;

1997 BBSRC 3 years PhD studentship *Analysis and prediction of nonlinear dynamics in biological control of plant pathogens*, as a second supervisor and a joint applicant; PhD awarded in 2001;

1990 Polish Ministry for Higher Education prize for scientific research;

1987, 1988 Jagiellonian University internal prize for scientific research;

1984 MSc with distinction;

1979-1983 (every year) Jagiellonian University prize for an outstanding student;

Pending as of March 2018:

2019-2022 *Brexit and pollination* (CoI, BBSRC).

2018-2021 *Plant biosecurity implications of changes in trade* (PhD, Defra, deadline October 2018, in prep.).

Planned as of March 2018:

2018-2021 *Bioeconomic modelling of potato diseases* (PhD, James Hutton Institute/AHDB, deadline October 2018, in prep.);

## **PhD supervision**

Currently one student as second supervisor (students finished in 2016 and 2017); application pending for funding for 2 students from 2018. 3 students as first supervisor (Stirling) and 3 students as second supervisor fully engaged with research (Cambridge), all successfully finished. Internal and external PhD Examiner (Edinburgh, York, Sussex, Heriot-Watt, Glasgow);

## **Teaching**

**Lectures and practicals:** *Stirling:* lectures and tutorials for various mathematical courses across all years of studies, including calculus, advanced calculus, variational calculus, algebra, probability, statistics, numerical methods, stochastic processes; coaching students for an international Mathematical Contest in Modelling; *Cambridge:* Lectures and practicals for Quantitative Biology Part IA; Part IB Plant and Microbial Sciences lectures and practicals; lectures and supervisions in Frontiers in Plant-Microbe Interactions, Part II; Cambridge Infectious Disease Consortium: Graduate course in modelling; College supervisions. *Kraków:* Classes in physics and mathematics for year 1 and 4 physics students;

**Project supervisions:** Honours projects at Stirling; Part II and Part III Physics projects at Cambridge (with application to biological systems); 11 summer projects with funding from MIT, Carnegie, BSPP and NERC;

**Other teaching duties:** *Stirling:* Personal Tutor (since introduction in 2014); *Cambridge:* Tutor and Personal Tutor, Selwyn College and King's College (Cambridge); Director of Studies in Mathematics for Natural Sciences Tripos, Selwyn College; interviews of candidates for admission to study physical sciences, computer sciences and biology (King's College, Selwyn College); *Kraków:* Supervisor of a student computer laboratory; computing classes.

## **Skills and relevant experience**

**Basic skills and experience:** Practical and theoretical knowledge of biology, ecology, soil science, economics, mathematics, statistics and computing; ability to develop and analyse mathematical models of a wide range of biological and socio-economic phenomena; experienced in experimental design and in statistical analysis of experimental data, including classical and Bayesian statistics, time series analysis, spatial statistics and modelling, MCMC and likelihood parameter estimation; excellent knowledge of C, R, Shiny, Mathematica; good knowledge of Python; experience in design and maintenance of (non-profit and scientific) Web pages and internet domain handling. Organiser and co-organiser of eight international conferences (1987-1990, 2003, 2010, 2017); member of an International Scientific Committee, Symposium on Statistical Physics, 2007 and 2017. Participant and invited lecturer at scientific conferences (a list on request).

**Internet consultancy:** Founder of an internet consultancy, [askstatistician.com](http://askstatistician.com) (online since 2005).

**Languages:** Polish – mother language; fluent English; conversational German; basic Russian. Experienced English-Polish translator (including simultaneous oral translation).

**Professional organisations:** Fellow of the Institute for Mathematics and its Applications (from 2010), Fellow of the Royal Statistical Society (from 2006), Member of the Edinburgh Mathematical Society (from 2014), the British Society for Plant Pathology (from 2003) and the British Ecological Society (from 2000);

**Other relevant experience:** Member of the Plant Health Expert Group, Scottish Government (2014-2015). FP7/HORIZON 2020 expert evaluator (2013, 2014, 2015, 2016): MSCA and RISE. Regular grant (BBSRC, NERC, MRC, ISF) and journal paper reviewer. External examiner, University of Aberdeen (2014-present).

**Other interests:** Bible and Christianity; history, particularly Central European; classical music; hiking; woodworking, gardening.

**Scientific publications****Published or in print**

1. P. McMenemy, A. Kleczkowski, D. Lees, J. Lowther, N. Taylor. 2017. *A Model for Estimating Pathogen Variability in Shellfish and Predicting Minimum Depuration Times*. PLoS One, 13(3): e0193865 [IF: 2.806]
2. A. Bate, A. Kleczkowski, G. Jones, R. Naylor, J. Timmis, P. White and J. Touza. 2017. *Cross-Border Biosecurity Conflicts in Infectious Disease Management*. EcoHealth, DOI: 10.1007/s10393-018-1312-y [IF: 2.489]
3. A. Kleczkowski, C. Ellis, N. Hanley, D. Goulson. 2017. *Pesticides and Bees: ecological-economic modelling of bee populations on farmland*. Ecological Modelling, 360, 53–62
4. M.F. Macpherson, A. Kleczkowski, J. Healey, C. Quine and N. Hanley. 2017. *The effects of invasive pests and diseases on strategies for forest diversification*. Ecological Modelling, 350, 87-99
5. M.F. Macpherson, A. Kleczkowski, J. Healey and N. Hanley. 2017. *Payment for multiple forest benefits alters the effect of tree disease on optimal forest rotation length*. Ecological Economics, 134 82-94
6. M.F. Macpherson, A. Kleczkowski, J. Healey and N. Hanley. 2016. *The Effects of Disease on Optimal Forest Rotation: A Generalisable Analytical Framework*. Environmental and Resource Economics DOI: 10.1007/s10640-016-0077-4
7. A. Bate, G. Jones, A. Kleczkowski, A. MacLeod, R. Naylor, J. Timmis, J. Touza, P. White. 2016. *Modelling the Impact and Control of an Infectious Disease in a Plant Nursery with Infected Plant Material Inputs*. Ecological Modelling, 334:27-43.
8. L. Williams, S. Rasmussen, A. Kleczkowski, S. Maharaj, and N. Cairns. 2015. *Protection motivation theory and social distancing behaviour in response to a simulated infectious disease epidemic*. Psychology, Health & Medicine, DOI: 10.1080/13548506.2015.1028946.
9. A. Kleczkowski, S. Maharaj, S. Rasmussen, L. Williams and N. Cairns. 2015. *Spontaneous social distancing in response to a simulated epidemic: a virtual experiment*. BMC Public Health, 15:973.
10. V. Marmara, A. Cook and A. Kleczkowski. 2014. *Estimation of force of infection based on different epidemiological proxies: 2009/2010 Influenza epidemic in Malta*. Epidemics 9:52-61.
11. P. Karp, B. Dybiec and A. Kleczkowski. 2014. *Improving epidemic control strategies by extended detection*. Int. J. Mod. Phys. C25, 1350106.
12. K. Oleś, E. Gudowska-Nowak and A. Kleczkowski. 2013. *Efficient Control of Epidemics Spreading on Networks: Balance between Treatment and Recovery*. PLoS One 8, e63813.
13. K. Oleś, E. Gudowska-Nowak and A. Kleczkowski. 2012. *Understanding disease control: influence of epidemiological and economic factors*. PLoS One 7, e36026
14. S. Maharaj and A. Kleczkowski. 2012. *Controlling epidemic spread by social distancing: Do it well or not at all*. BMC Public Health 12 679.
15. K. Oleś, E. Gudowska-Nowak and A. Kleczkowski. 2011. *Understanding disease control: influence of epidemiological and economic factors*. PLoS 7 e36026.
16. A. Kleczkowski, K. Sławińska, E. Gudowska-Nowak and C.A. Gilligan. 2012. *Searching for the most cost-effective strategy for controlling epidemics*. Journal of the Royal Society Interface 9 pp. 158-169.
17. H. Ziebell, A.M. Murphy, S.C. Groen, T. Tungadi, J.H. Westwood, M.G. Lewsey, M. Moulin, A. Kleczkowski, A.G. Smith, M. Stevens, G. Powell and J.P. Carr, 2011. *Cucumber mosaic virus and its 2b RNA silencing suppressor modify plant-aphid interactions in tobacco*. Nature Scientific Reports 1:187.
18. B. Dybiec, A. Kleczkowski and C.A. Gilligan, 2009. *Control of epidemics spreading by Lévy fliers*. Journal of the Royal Society Interface 6 pp. 941-950.
19. A. Kleczkowski and C.A. Gilligan, 2007. *Parameter estimation and prediction for the course of a single epidemic outbreak of a plant disease*, Journal of the Royal Society Interface 4 pp. 865-877.
20. Willis KJ, Kleczkowski A, New M, Whittaker RJ, 2007. *Testing the impact of climate variability on European plant diversity: 320 000 years of water–energy dynamics and its long-term influence on plant taxonomic richness*, Ecology Letters 10 pp. 673-679.
21. L. Irvine, A. Kleczkowski, A. Lane, J. Pitchford, D. Caffrey and P. Chamberlain, 2006. *An integrated data resource for modelling the soil ecosystem*, Applied Soil Ecology 33 pp. 208-219.
22. A. Kleczkowski, B. Dybiec and C.A. Gilligan 2006. *Influence of economic and social factors on disease control strategies for epidemics on local, global and small-world networks*. Acta Physica Polonica B37 pp. 3017-3026.

23. Bailey DJ, Kleczkowski A and Gilligan CA., 2006. *The role of disease resistance in the response of winter wheat to take-all*. *Phytopathology* 96 pp. 510-516.
24. A.H. Fitter, C.A. Gilligan, K. Hollingworth, A. Kleczkowski, R. Twyman, J.W. Pitchford, 2005. *Biodiversity and ecosystem function in soil*, *Functional Ecology* 19 pp. 369-377.
25. E. Gudowska-Nowak, A.Kleczkowski, E. Nasonova, M. Scholz and S. Ritter, 2005. *Correlation between mitotic delay and aberration burden, and their role for the analysis of chromosomal damage*. *Int. Journal Radiation Biology* 81 (1) pp. 23-32.
26. A. Kleczkowski, 2005. *Predictability in simple population models*. *Acta Physica Polonica* 36 (5) pp. 1623-1634.
27. B. Dybiec, A. Kleczkowski and C.A. Gilligan, 2005. *Optimizing control of disease spread on networks with incomplete knowledge*. *Acta Physica Polonica* 36 (5) pp. 1509-1526
28. B. Dybiec, A. Kleczkowski and C.A. Gilligan. 2004. *Controlling disease outbreaks on networks with incomplete knowledge*. *Physical Review E* 70 pp. 066145-1-5.
29. G.J. Gibson, A. Kleczkowski and C.A. Gilligan. 2004 *Bayesian analysis of botanical epidemics using stochastic compartmental models*. *Proc. National Academy Sciences USA* 101 pp. 12120-12124.
30. Bailey DJ, Kleczkowski A, and Gilligan CA. 2004. *Epidemiological dynamics and the efficiency of biological control of soil-borne disease during consecutive epidemics in a controlled environment*. *New Phytologist* 161 pp. 569-575.
31. A. Kleczkowski and P.F. Góra. 2003. *Quenched disorder and long-tail distributions*. *Physica A* 327 (3-4) pp. 378-398.
32. E. Gudowska-Nowak, A.Kleczkowski, G. Kraft, E. Nasonova, S. Ritter and M. Scholz. 2001. *Mathematical Models of Radiation-Induced Mitotic Delay: Time-Course Analysis and Statistics of Lesions*, *Physica Medica* 17 pp. 161-163;
33. S. Gubbins, C.A. Gilligan and A. Kleczkowski. 2001. *Population dynamics of plant-parasite interaction: thresholds for invasion*, *Theor. Pop. Biol.*, 57 (3) pp. 219-234;
34. A. Kleczkowski and B.T. Grenfell. 1999. *Mean-field-type equations for spread of epidemics: the 'small-world model'*. *Physica A* 274 pp. 355-360; also published in A. Gadomski, J. Kertész, H.E. Stanley and N. Vandewalle (eds.), *Applications of Statistical Physics*, Elsevier, 1999.
35. G.J. Gibson, C.A. Gilligan, A. Kleczkowski. 1999. *Predicting variability in biological control of a plant-pathogen system using stochastic models*. *Proc. Roy. Soc.* 266 pp. 1743-1753;
36. L. Heusser, C. Heusser, A. Kleczkowski and S.J. Crowhurst. 1999. *A 50,000 yr record of South American millennial-scale climate instability during the last glaciation from Chile*. *Quaternary Research* 52 pp. 154-158;
37. K.J. Willis, A. Kleczkowski, K.M. Briggs and C.A. Gilligan. 1999. *The role of sub-Milankovitch Climatic Forcing in Initiation of the Northern Hemisphere Glaciation*. *Science* 285 pp. 568-571.
38. K.J. Willis, A. Kleczkowski and S.J. Crowhurst, 1999, *124,000-year periodicity in terrestrial vegetation change during the late Pliocene epoch*. *Nature* 397 pp. 685-688;
39. A. Kleczkowski, 1998, *Statistical properties of dynamical systems with disturbances: variation in parameters*. *Acta Physica Polonica B* 29, pp. 1717-1735;
40. A. Kleczkowski, C.A. Gilligan and D.J. Bailey. 1997. *Scaling and spatial dynamics in plant-pathogen systems: from individuals to populations*, *Proc. Royal Soc. B* 264, pp. 979-984;
41. C.A. Gilligan and A. Kleczkowski. 1997. *Population dynamics of botanical epidemics involving primary and secondary infections*. *Phil. Trans. Royal Soc. B* 352, pp. 591-608;
42. A. Kleczkowski, D.J. Bailey and C.A. Gilligan. 1996. *Dynamically generated variability in plant-pathogen systems with biological control*. *Proc. Royal Soc. B* 263, pp. 777-783;
43. B.T. Grenfell, A. Kleczkowski, C.A. Gilligan and B.M. Bolker. 1995. *Spatial heterogeneity, nonlinear dynamics and chaos in infectious diseases*. *Statistical Methods in Medical Research* 4, pp. 160-183;
44. B.T. Grenfell, B. Bolker, and A. Kleczkowski. 1995. *Seasonality, Demography, and Dynamics of Measles in Developed Countries*, in D. Mollison (ed.) *Epidemic Models*, Publications of the Isaac Newton Institute for Mathematical Sciences, Cambridge Univ. Press, Cambridge, pp. 248-268;
45. B.T. Grenfell, B. Bolker, and A. Kleczkowski. 1995. *Seasonality and extinction in chaotic metapopulations*. *Proc. Roy. Soc. B* 259, pp. 97-103;
46. B.T. Grenfell, A. Kleczkowski, S.P. Ellner and B.M. Bolker. 1994. *Nonlinear forecasting and chaos in ecology and epidemiology: measles as a case study*. In: *Forecasting and chaos*, (ed. Tong, H.), Singapore, New Jersey, London, Hongkong: World Scientific, pp. 321-345;
47. B.T. Grenfell, A. Kleczkowski, S.P. Ellner and B.M. Bolker. 1994. *Measles as a case study in nonlinear forecasting and chaos*. *Phil. Trans. Roy. Soc. A* 348, pp. 515-530;

48. A. Kleczkowski. 1993. *Stochastic versus chaotic dynamics for genetic model – revisited*. Acta Physica Polonica B 24 pp. 1445-1473;
49. A. Kleczkowski. 1993. *Dynamical systems with impulses: stroboscopic maps approach*. Acta Physica Polonica B 24 , pp. 1061-1071;
50. E. Gudowska-Nowak, G.O. Williams and A. Kleczkowski. 1989. *Stochastic vs. chaotic dynamics in a deterministic system*. J. Stat. Phys. 54 , pp. 539-548;
51. A. Kleczkowski. 1989. *On the different forms of master equations: dynamical Ising model*. Acta Physica Polonica, A75 , pp. 365-376;
52. A. Kleczkowski. 1988. *Some formal properties of the time-symmetry breaking operator*. Acta Physica Polonica A73 , pp. 19-24;
53. A. Kleczkowski and A. Fuliński. 1987. *Nonlinear maps with time delay*. Physica Scripta, 35 , pp. 119-122;

#### **Selected refereed conference publications**

1. S. Maharaj, T. McCaldin, and A. Kleczkowski, *A Participatory Simulation Model for Studying Attitudes to Infection Risk*, Proceedings of the Summer Computer Simulation Conference, 2011.
2. A. Kleczkowski and S. Maharaj, *Stay at Home, Wash Your Hands: Epidemic Dynamics with Awareness of Infection*, Proceedings of the Summer Computer Simulation Conference, 2010.
3. A. Kleczkowski, D.J. Bailey, W. Otten, M. Grose and C.A. Gilligan, *Implications of root spatial relationship in young wheat obtained from CT-scanning for an invasion by fungal pathogens*, IOBC Conference on Multitrophic Interactions in Soil, 2007, published in IOBC Bulletin **42** pp. 109-112, 2009.
4. P. Kleczkowski and A. Kleczkowski, *Advanced Methods for Shaping Time-Frequency Areas for the Selective Mixing of Sounds*, 120<sup>th</sup> Convention of Audio-Engineering Society, Paris, France, 2006;
5. A. Kleczkowski, J. McGlade and N. Leader-Williams, *Mathematical Models of Rhino Poaching in Africa*; Proceedings of the European Simulation Multiconference, Nuremberg, Germany, 1990;

#### **Other publications**

1. A. Kleczkowski, *Polish agriculture in the 21<sup>st</sup> Century: a strategy for sustainable farming*. A report for Chancellerie diplomatique, République de Pologne, Bruxelles, 1999;
2. A. Kleczkowski, A. Breed, L. Matthews, D. Thronicker and F. de Vries, *Characterising livestock system ‘zoonoses hotspots’*, report, Department for International Development, 2011.

#### **Publications under review or in advanced preparation**

1. A. Kleczkowski, D.C. Little, F. Murray, A. Shinn and B. White. 2018. *Riding the tiger: a bioeconomic model of disease-induced booms and busts in the SE Asian farmed shrimp market*. PNAS, to be submitted shortly. [IF: 9.661]
2. M.F. Macpherson, A. Kleczkowski, J. Healey, C. Quine, N. Hanley, C.A. Gilligan and B. White. 2018. *Optimal management of an emerging pathogen*. In prep.
3. A. Bate, M. Redenti, N. Hanley and A. Kleczkowski. 2018. *Coordination of control of plant pathogens on trading networks: Game-theoretical approach*. In prep.
4. A. Kleczkowski and N. Hanley. 2018. *Spatial coordination in optimal forest management*. In prep.
5. A. Kleczkowski, D. Goulson and N. Hanley. 2018. *Ecological-economic modelling of interactions between wild and commercial bees and pesticide use*. In prep.