Institution: Newcastle University		
Unit of Assessment: 7		
Title of case study: Prioritising and Managing the Global Challenge of Invasive Alien Species		
Period when the underpinning research was undertaken: 2000 - 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 Pete Robertson	Prof of Practice - Wildlife Management	2014 – present
Prof Stephen Rushton	Prof of Biological Modelling	1981 – present
Dr Aileen Mill	Senior Lecturer in Vertebrate Ecology and Biodiversity	2013 – present
Dr Olaf Booy	PhD and Associate Member of Staff	2015 – 2019 (PhD) 2019 – present (Associate)
Period when the claimed impact occurred: Aug 2013 - 2020		
Is this case study continued from a case study submitted in 2014? N		

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

Newcastle University research on the prioritisation and management of invasive alien species (IAS) has impacted on national, European and global actions to achieve Aichi Global Biodiversity Target 9 and guided over £30m of national and international programmes to protect threatened native species from the consequences of IAS. Newcastle's risk management methodology is incorporated into GB policy, and has guided management in Europe, USA, the Caribbean and Australia. Newcastle research now forms part of recommended global best practice, supports species listing under EU Regulations which place management responsibilities on Member States, and informs UK government enquiries on national IAS policy.

2. Underpinning research (indicative maximum 500 words)

IAS are recognised as one of the five main drivers of declines in global biodiversity. Managing the effects of these species is a great societal challenge for the 21st century, reflected in the UN Convention on Biological Diversity's (CBD) Aichi Global Biodiversity Target 9, the UN Sustainable Development Goal 15, together with associated EU legislation (Regulation EU1143/2014). Together, these commit signatories to prevent further introductions and significantly reduce the impacts of IAS, and control or eradicate priority species. The delivery of these commitments carries significant economic and social costs at a global scale.

The scale of the challenge is large. For example, over 60,000 species have become established within the EU with taxa spanning terrestrial, freshwater and marine environments. A further 40-60 species establish in the EU each year, meaning that the scale of the challenge greatly outweighs the resources available to manage their impacts. The prioritisation of management action is key, but the framework necessary to effectively balance benefits, costs and feasibility has been lacking. We developed a novel multi-criteria methodology to evaluate the feasibility of IAS management that can be applied across multiple taxa and environments (**R1**) and which directly addresses this need for prioritisation. This methodology combines the use of published evidence and expert elicitation to consider the effectiveness, practicality, cost, acceptability, and wider impact of management in a structured framework to produce an overall ranked assessment of feasibility. When used in combination with existing risk assessment approaches, the cost-effective prioritisation of species for management is greatly improved. Newcastle have worked with government policy officials to apply this methodology at both national (**R1**) and continental scales (**R2**) to prioritise IAS management.

IAS impact on the ecosystems they enter and interact with the native species therein. Managing these impacts requires an understanding of species interactions, together with how the IAS may

be influenced by human intervention. Key original papers by Newcastle researchers demonstrated the interactive effects of IAS on threatened native species, using the first ecological applications of individual based modelling in real landscapes to describe the effects of predation (**R3**) and disease mediated competition (**R4, G1**). Newcastle research has also described how the cost and effectiveness of management are influenced by the scale of these programmes (**R5)**. By combining ecological modelling with the dynamics of management, these methods have been applied in collaboration with practitioners to provide the ecological understanding to guide many current IAS impact management programmes, including the first global programme aiming to remove an IAS at a continental scale (**R6, G2**)

Newcastle directly engages, advises and partners with the key bodies involved in IAS policy and management at national (GB Non-native Species Secretariat, Animal and Plant Health Agency, Scottish Natural Heritage, UK Environmental Audit Committee), continental (European Commission; **G3**) and global levels (International Union for the Conservation of Nature, Convention on Biological Diversity). Through partnerships, advice, committee membership and scientific evidence this work contributes to global activities to deliver Aichi Global Biodiversity Target 9 and UN Sustainable Development Goals.

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

Peer-reviewed publications:
(All citations taken from Web of Science on 11/2/21, unless otherwise stated)

R1 Booy, O., **Mill, A.C**., Roy, H.E., Hiley, A., Moore, N., **Robertson, P**., Baker, S., Brazier, M., Bue, M., Bullock, R. and Campbell, S., Eyre, D., Foster, J., Hatton-Ellis, M., Long, J., Macadam, C., Morrison-Bell, C., Mumford, J., Newman, J., Parrott, D., Payne, R., Renals, T., Rodgers, E., Spencer, M., Stebbing, P., Sutton-Croft, M., Walker, KJ., 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), pp.2401-2417. https://doi.org/10.1007/s10530-017-1451-z Citations: 45.
This paper proposes a new method using risk management to assess the feasibility and cost of invasive species management scenarios. When used in combination with risk assessment data, this allows the effective prioritisation of management actions.

R2 Booy, O., **Robertson, PA**., Moore, N., Ward, J., Roy, HE., Adriaens, T., Shaw, R., Van Valkenburg, J., Wyn, G., Bertolino, S., Blight, O., Branquart, E., Brundu, G., Caffrey, J., Capizzi, D., Casaer, J., De Clerck, O., Coughlan, NE., Davis, E., Dick, JTA., Essl, F., Fried, G., Genovesi, P., González-Moreno, P., Huysentruyt, F., Jenkins, SR., Kerckhof, F., Lucy, FE., Nentwig, W., Newman, J., Rabitsch, W., Roy, S., Starfinger, U., Stebbing, P., Stuyck, J., Sutton-Croft, M., Tricarico, E., Vanderhoeven, S., Verreycken, H., **Mill, AC.** 2020. Using structured eradication feasibility assessment to prioritise the management of new and emerging invasive alien species in Europe. Global Change Biology. 26:6235-6250. https://doi.org/10.1111/gcb.15280
The application of the Booy et al (2017) method to the prioritisation of invasive species management in Europe.

R3 Rushton, S.P., Barreto, G.W., Cormack, R.M., Macdonald, D.W. and Fuller, R., 2000. Modelling the effects of mink and habitat fragmentation on the water vole. Journal of Applied Ecology, 37(3), pp.475-490. https://doi.org/10.1046/j.1365-2664.2000.00504.x Citations: 71.
The first paper to apply individual based modelling in real landscapes to invasive species impacts on threatened native species, demonstrating the impacts of predation.

R4 Rushton, S.P., Lurz, P.W.W., Gurnell, J., Nettleton, P., Bruemmer, C., Shirley, M.D.F. and Sainsbury, A.W., 2006. Disease threats posed by alien species: the role of a poxvirus in the decline of the native red squirrel in Britain. Epidemiology & Infection, 134(3), pp.521-533. https://dx.doi.org/10.1017%2FS0950268805005303 Citations: 100

This paper applies individual based modelling in real landscapes to invasive species impacts on threatened native species, demonstrating the impact of disease mediated competition.

R5 Robertson, P.A., Adriaens, T., Lambin, X., **Mill, A**., Roy, S., Shuttleworth, C.M. and Sutton-Croft, M., 2017. The large-scale removal of mammalian invasive alien species in Northern Europe. Pest Management Science, 73(2), pp.273-279. https://doi.org/10.1002/ps.4224 Citations: 26.
An analysis of the success and costs of large scale mammalian removal programmes.

R6 Robertson, P.A., Adriaens, T., Caizergues, A., Cranswick, P.A., Devos, K., Gutiérrez-Expósito, C., Henderson, I., Hughes, B., **Mill, A.C.** and Smith, G.C., 2015. Towards the European eradication of the North American ruddy duck. Biological Invasions, 17, pp.9-12. https://doi.org/10.1007/s10530-014-0704-3 Citations: 17.
An account of progress on the first continental scale programme aiming to eradicate an invasive species.

Example Grants:

G1: Evolving grey squirrel management techniques in the UK and Ireland. 2014 – 2019 EU LIFE and Heritage Lottery Fund (EU-LIFE 14 NAT/UK/000467). Consortium led by the UK Wildlife Trusts. £3m total project value; Newcastle split to **Mill** and **Rushton £191k**

G2: Spatially Explicit Model for Guiding Ruddy Duck Control. Defra; **Rushton PI £135k**, 2006-2008

G3: Development of risk assessments to tackle priority species and enhance prevention. DG Environment, European Commission ENV.B2.ETU/2016/0013. Consortium led by CEH and Univ Vienna. £2m total project value; Newcastle split to **Robertson £60k** 2016-2021

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

Newcastle research has provided the method used by many nations for prioritising IAS management, and which has been proposed as best practice by the Convention on Biological Diversity. Aichi Global Biodiversity Target 9 requires signatory nations to control or eradicate priority IAS. While methods exist to describe the scale of the problem posed by a species (Risk Assessment), prioritisation also needs to include whether management is feasible (Risk Management), considering whether it will be effective, acceptable, affordable, practical, and its wider environmental impacts. However, an effective tool to deliver risk management for IAS that can be used across different taxa and environments has been lacking. This issue was recognised in The GB Non-Native Species Strategy (2015) which included a target to 'Further develop the risk analysis mechanism to support strategic prioritisation of resources, in particular through developing a risk management tool (which incorporates cost/benefit analysis)'. This target was met by the publication of Booy et al (2017), which describes a method that has now been adopted by government as the GB Non-native Risk Management (NNRM) scheme. The value of this process is described in a supporting letter from The GB Chief Non-Native Species Officer, who notes that it has "directly contributed to policy and practical management decision making in GB and Europe" (**S1**).

The Aichi Target commitments, reflected in national legislation, have produced a global need for an effective IAS risk management tool which is met by the Booy et al (2017) method. The method has subsequently been applied by nations around the world. The Belgian government authorities who have used it describe the research as "instrumental to shaping policy decisions and on the ground management of IAS" in Belgium and the EU, with the approach described as "exemplary and inspirational from a science policy perspective" (**S2**) The Newcastle method was effective in informing Belgian policy: it identified the "necessary budget for eradication (minimally €86m) and spread limitation (€11-96m) for the set of IAS of the Regulation in Flanders."(**S2**). The method was also applied at a continental scale, via a Newcastle-led European workshop to

inform the European Commission's selection of Species of Union Concern (**R2**). Newcastle staff co-ordinate the management content of the existing European Commission IAS Risk Assessment process which underpins the listing of Species of Union Concern under EU Regulation 1143/2014 (**S3, G3**). Since its establishment in 2014, the EU list now contains 66 species and places management responsibilities on all Member States. Beyond Europe, the Newcastle method has been applied by Biosecurity Queensland in Australia to prioritise management of more than 300 pest plants and animals in the ~2 million km^2 area of the State of Queensland, and who describe the Newcastle research as "ground-breaking" (**S4**). It has been applied in the UK Overseas Territories in Anguilla and The Turks and Caicos Islands to identify species for priority eradication to protect local endemic species (**S5).** This identified a total of 99 species from these territories which were assessed for eradication, with 22 identified as having a high or very high feasibility of success, and three eradication plans subsequently produced (**S5**). The US Geological Survey has applied the Newcastle method for IAS management in California, describing how it "effectively resolves" many existing problems, resulting in "immediate strategic planning to remove introduced beaver" and the ability to "allocate funds and prioritise management of non-native species within …. the Natural Communities Conservation Planning (NCCP) program" (**S6**).

This risk management approach is also being recommended as global best practice through the Convention on Biological Diversity. In 2017, the CBD Secretariat formed a Technical Expert Group on the development of IAS management tools and guidance. Newcastle staff (**Robertson**) convened the preparatory on-line forum on the costs and effectiveness of IAS management and presented our approach to risk management in Montreal in 2019. The Technical Expert Group then proposed the use of the Booy et al (2017) multi-criteria approach as best practice for risk-based IAS prioritisation (**S7**).

Subsequently, CBD published their Global Biodiversity Outlook 2020 which reported progress to achieve Aichi Global Biodiversity Target 9. The summary highlighted 'the progress in prioritising IAS species in terms of the risk they present, as well as in the feasibility of managing them (Booy et al 2017), directly contributing to progress towards this global target.' (**S8**).

As well as producing a framework to prioritise management, Newcastle research also supports and guides individual large-scale IAS management programmes, influencing several major international eradication programmes. Since 2000 at least 35 Newcastle publications have dealt directly with the large-scale management of IAS (**S9**, **R5**). These include the largest global IAS eradication yet attempted; the management of the invasive ruddy duck across Europe. This programme aims to protect the white-headed duck, which, when the programme started, was the most threatened breeding bird species in Europe. This programme was highlighted as a successful case study in the CBD Global Biodiversity Outlook 2020 (**S8**), based on our research (**R6**). This process of combining ecological modelling with the dynamics of intervention has also been applied to other large scale programmes such as the management of grey squirrels to protect the native red squirrels, including grey squirrel eradication from Anglesey and subsequent recolonization by the threatened native red squirrel. A further example is the protection of ground nesting birds in the Hebrides from the effects of the invasive American mink **(R5)**. Newcastle staff currently have advisory roles in major projects managing invasive species in Orkney (PAR) and the Uists (AM). Together these IAS management projects have an estimated value in excess of £30m (**S9**).

Newcastle expertise and experience also contributes to UK national policy on IAS. Evidence presented by Newcastle staff to the House of Commons Environmental Audit Committee Enquiry on Invasive Species (2019) proposed increased resources, an increased focus on preventative actions, and new capabilities such as an IAS Inspectorate, recommendations supported by the Committee who appreciated the "quality" of the input (**S1 and 10**).

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

Source 1 - Newcastle's role in the Prioritisation and Management of Invasive Non-Native Species in Great Britain. Letter of support from the GB Non-Native Species Secretariat with supporting documents, which describes the impact of Newcastle Research on policy and prioritisation, its international role and its support for large scale management programmes.

Source 2 - Letter of support from Institute for Nature and Forest Research, Belgium. This describes the use of the Booy et al (2017) method and collaboration with Newcastle staff to prioritise and guide IAS management in Belgium, with reference to their report on this topic.

Source 3 - EU Process to List Species of Union Concern. This provides details of the process by which the EU lists Species of Union Concern, an example risk assessment on which these decisions are based, and the role of Newcastle in the production of these.

Source 4 - Letter of support from Biodiversity Queensland, Australia. This describes their use of the Booy et al (2017) method to prioritise species of invasive species for research and management.

Source 5 - Prioritisation of IAS management in The British Overseas Territories of Anguilla and The Turks and Caicos Islands. This describes how the Booy et al (2017) methodology has been used by a number of the UK Overseas Territories (Anguilla and The Turks and Caicos Islands). Newcastle staff and associates (OB, PAR and AM) contributed to workshops held in these territories in January / February 2020 which prioritised established invasive species for eradication or for control to reduce the risk of in-territory spread.

Source 6 - Letter of support from United States Geological Survey. This describes their assessment and subsequent use of the Booy et al (2017) methodology to prioritise IAS management in reserved areas in California.

Source 7 - The Development of Invasive Alien Species Management Tools and Best Practice Guidance for the UN Convention on Biological Diversity. Letter of Support from the Secretariat of the CBD thanking Newcastle for their role in the 2019 Technical Expert Group on *Methods for cost-benefit and cost-effectiveness analysis which best apply to the management of invasive alien species,* and a copy of the group report. The report proposed the use of our multi-criteria approach as best practice for risk-based IAS prioritisation (**R1**).

Source 8 - Newcastle's contribution to the delivery of Aichi Global Biodiversity Target 9 on Invasive Alien Species. CBD's publication Global Biodiversity Outlook 2020 reviewed progress to achieve the Aichi Global Biodiversity Targets over the period 2010-2020. Their assessment of the partial achievement of Target 9 directly refers to three Newcastle publications. The summary of global progress identifies '*the progress in prioritising IAS species in terms of the risk they present, as well as in the feasibility of managing them*' **R1,** together with presenting Newcastle research as best practice case studies of IAS management **(R5, R6)**

Source 9 - Modelling the Impact, Spread and Control of IAS. A compendium of Newcastle papers, reports and grants related to the assessment and management of IAS to illustrate the breadth of work on this topic, including details of over £30m of UK and European management programmes supported by our staff and research.

Source 10 - House of Commons Environmental Audit Committee – Invasive Species Enquiry 2019. A letter from the Committee thanking Newcastle staff for their written and oral evidence. The enquiry report describes their evidence on the creation of an IAS inspectorate function (para 44) and greater resources with a focus on prevention and early response (para 101, 103). These are supported by the Committee's recommendations (paras 107,108) which are currently being considered in the 2020 Government Spending Review.