Impact case study (REF3b)

Institution:	University of York
Unit of Assessment:	5, Biological Sciences
Title of case study:	The control of invasive alien species

1. Summary of the impact

York research developed the essential common ground of our understanding of invasive alien species, highlighting their effects on biodiversity and their economic costs. The conceptual frameworks developed at York underpin all subsequent policies and practical strategies in 2008-2013, including the Convention on Biological Diversity (CBD), whose 193 signatory countries are legally bound to "*prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species*". UK and international policies and strategies to prevent new introductions and control established aliens stem directly from York research.

2. Underpinning research

Mark Williamson, Professor of Biology at York (now *Emeritus*), OBE for services to environmental protection, and his collaborators at York transformed research on Invasive Alien Species (IAS) and created a framework that has since formed the basis for rational policy. Williamson's (1996) classic book "*Biological Invasions*" established the conceptual framework that helped determine the direction of future research and its applications. This is the most heavily-cited work on biological invasions published in the 1990s. Williamson collaborated with Professors Alastair Fitter FRS CBE (York, 1972-present) and Charles Perrings (York, 1993-2005), publishing 49 papers and 1 book, and co-editing 4 more books on IAS from 1993-2013. "*Mark Williamson has made a seminal contribution to the field of biological invasions. He was at the vanguard of the discipline and helped shape it from a descriptive subject to a quantitative ecological science with testable hypotheses and a rigorous modelling framework*" according to Philip Hulme, Professor of Plant Biosecurity at Lincoln University in New Zealand (section 5). Key conclusions from the York research are:

- **Biological invasions are often characterized by a lag phase followed by a rapid expansion** (Williamson 1996), revealing that early eradication is the most effective control.
- **The best predictor that a species will become invasive is that it has already invaded elsewhere.** This discovery (Williamson & Fitter 1996) remains robust to the present day.
- **There are stages of invasion (introduction, establishment, pest) with low probabilities (~10%) of transition from one to the next** (the 'tens' rule). Williamson's defining analyses showed that only *ca* 1% of introduced species become invasive pests (Williamson 1993).
- **Propagule pressure is an important determinant of invasion success.** Williamson (1999) showed that the chance of invasion of a particular species increases with the numbers released, such that strong controls on releases (customs controls) will minimise risks.
- **The economic costs of IAS are extremely high.** "*The Economics of Biological Invasions*" (Perrings *et al.* 2000) was the first book on the subject and spawned a rush of further studies. This led to understanding of the cost-effectiveness of initial prevention, and/or early control.
- **Internalising the economic costs of invasions ('polluter pays') is likely to be effective for prevention, containment and mitigation.** York collaborated internationally to develop this idea and to model cost responsibilities (e.g. Perrings *et al.* 2002).
- **Invasive species controls are 'weakest-link' public goods and hence the effective management of IAS requires coordination.** For example, importation control can be undermined by the least secure entry point (Perrings *et al.* 2000), and coordinating institutions with improved data-sharing and collaboration are needed to support weak links in the global spread and control of invasive species (e.g. Perrings *et al.* 2002, 2010).

3. References to the research. York PIs in **bold**, York-associated PDRAs underlined. The research has been published in peer-reviewed journals and books with respected publishers. Citation counts taken from Google Scholar September 2013.

Perrings C., **Williamson M.** & Dalmazzone S. (2000) *The Economics of Biological Invasions*. Edward Elgar, Cheltenham. [Google Scholar citations 245] On request

Perrings C., **Williamson M.**, *et al.* (2002) Biological invasion risks and the public good: an economic perspective. *Conserv Ecol* **6**, 1, URL: http://www.consecol.org/vol6/iss1/art1 [GS 235]

Williamson, M. (1996) *Biological Invasions*. Chapman & Hall , London [GS 2330] On request.

Parker, I.M.,…**Williamson M.H.** *et al.* (1999) Impact: toward a framework for understanding the

ecological effects of invaders. *Biological Invasions* **1**, 3-19 DOI:10.1023/A:1010034312781 [GS 1050]

Williamson, M. & **Fitter A.** (1996) The varying success of invaders. *Ecology* **77**, 1661-6. DOI: 10.2307/2265769 [GS 865]

Williamson M. (1999) Invasions. *Ecography* 22, 5-12 http://www.jstor.org/stable/3683202 [GS 425]

4. Details of the impact

Invasive Alien Species (IAS) are among the greatest threats to global biodiversity and appear to have been the most significant cause of documented extinctions. Global damage from IAS is estimated to cost US$1.4 trillion annually, and the threat is increasing with the continued growth of global trade and tourism. York research has provided:

A. Widespread recognition of the enormity of the problem caused by alien species for biodiversity and economies – generating political motivation to act. This has led to over 45 currently-operational international instruments to control non-native species. The Convention on Biological Diversity (CBD) legally binds its 193 signatory countries to "*prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species.*" Williamson took a leading part in the international process leading to this, working with the UK Health and Safety Executive, the UK Dept of the Environment, European Directorates, and the Organisation for Economic Co-operation and Development. He was on the SCOPE (Scientific Committee on Problems of the Environment) Biological Invasions programme, and he and Perrings formed the economic section of the Global Invasive Species Programme (GISP).

B. The conceptual framework for understanding invasions that underpins present-day national and global policies and strategies. "*Research at the University of York*" … "*influence*[s] *policies throughout the world and* [is] *central to the practical assessment of the risks, prevention and management of invasive alien species*" (IUCN 2013).

Impacts on UK policies. The UK Department for Environment, Food and Rural Affairs (Defra) policies stem directly from the York research. Defra produced a "*Review of non-native species policy*" in 2003 which assessed the UK legislative framework concerning non-native species and its ability to meet our international obligations. Williamson contributed heavily and his work is cited more than anyone else. The report draws on his 'tens' rule, on the York-developed thesis that it is difficult to predict which species will invade, that the best predictor is invasiveness elsewhere, on the Perrings and Williamson analysis of the relative costs of dealing with different IAS, and on Williamson's work on invasive plants in Britain. The recommendations of this review have been implemented and underpin all policy, strategy and action on IAS in the UK in 2008-2013. Key are:

- **Coordinated organisation.** Recommendation 1 of the 2003 Review is: *'The Government should designate or create a single lead co-ordinating organisation* [for] *non-native species policies across Government'*, adopting Perrings and Williamson's recognition of the importance of coordination. In response, the Non-Native Species Secretariat (NNSS, at York) was set up, responsible to governments and agencies in England, Scotland and Wales. NNSS launched "*The Invasive Non-native Species Framework Strategy for GB*" with an implementation plan in 2008. This Strategy aims to prevent and deal rapidly with new arrivals, as suggested by York researchers, resulting in the formation of The Rapid Response Working Group in 2008. The NNSS Strategy is the current framework for coordinating the actions of government departments, related bodies and key stakeholders.

- **Risk assessment. Recommendation 2 of the 2003 Review is to:** "*Develop comprehensive risk assessment procedures to assess the risks posed by non-native species*", using criteria based on Williamson's three stages of invasion. They underpin subsequent animal and plant reports and the Non-Native Species Audit conducted by English Nature in 2005. The audit (citing York work) identified 2721 species and hybrids *already* occurring in England, and their impacts, and has been used as the baseline for defining and prioritising work during 2008-2013. Natural England undertook horizon scanning in 2008 to identify non-native species likely to become invasive: reports on animals (2009) and plants (2011) draw on the York framework, and the 2012 report of the GB Non-Native Species Secretariat (Defra, Scot Govt, Welsh Govt) cites 7 Williamson/York publications. The reports inform GB prioritisation and targeting of resources.

- **Control releases into the wild.** Section 14 of The Wildlife & Countryside Act (1981) is the UK's main legislation covering release into the wild of non-native species. Species listed in schedule 9 '*cannot legally be released, allowed to escape, planted or otherwise caused to grow in the*

wild except under licence'. The 2003 Review recommended '*regular review and updating of this schedule...if it is to be effective'.* As a result, in 2010, 36 additional plant and 24 mammal species were added. The criteria for selection included species *'that have become invasive or damaging in other countries'* (Defra 2007 consultation); i.e., based on Williamson and Fitter's key conclusion. In 2011 The Non-Native Species Information Portal (NNSIP) was launched, providing further coordination. The Wildlife & Natural Environment (Scotland) Act 2011 (Commencement 4, Savings & Trans Provisions) came into force in July 2012, the invasive species orders aiming to provide controls associated with Williamson's three stages of invasion.

- **Economics of invasive species.** "*The three-stage hierarchical approach sets out that measures to prevent introduction of invasive non-native species are generally far more cost-effective and environmentally desirable than measures taken following introduction and establishment*" (Defra 2003), and Recommendation 5.2 states: "*Consideration should be given to identifying.. where responsibility for management or.. costs should lie with those responsible for the illegal introduction of the non-native species* [and to provide] *a legal basis for imposing fines on the 'polluter pays' principle"*. Both statements directly follow from York research**.** Hence, Scottish Government, Defra and Welsh Assembly together sponsored CABI (2010) to analyse the economic costs of IAS. The report concludes that IAS cost the British economy £1.7 billion/yr, citing 5 York papers, using Williamson's estimates of the economic impact of alien plants in Britain, and accepting his and Perrings' conclusion that costs of invasives "*are not generally incorporated... (Perrings et al. 2005), meaning that the true economic costs of [IAS] are not reflected in the economy.*" The policy-relevant CABI conclusions (cost-effectiveness of prevention, early control or eradication) reflect conclusions from York papers.

Overall, York research is central to all UK strategies for IAS, successes including near-eradication of American Mink in the Western Isles, resulting in the dramatic recovery of waterbird populations.

Global impacts. Williamson's "*insight has had wide impact in terms of biosecurity strategies around the world*" according to Philip Hulme, Professor of Plant Biosecurity in New Zealand. Piero Genovesi (Chair of the International Union for the Conservation of Nature Invasive Species Specialist Group; IUCN 2013) states "*Williamson's .. stages of invasion* [are] *incorporated within almost all risk assessment strategies carried out by national governments across the world and international structures, including the European Union and the Convention on Biological Diversity*".

- **The global Convention on Biological Diversity** (CBD) adopted twenty 'Aichi' Biodiversity Targets in October 2010 at its 10th Conference of Parties (CoP10). Target 9 is: *"By 2020, invasive alien species and pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment."* According to Genovesi (IUCN 2013), "*This target was directly informed by a 2012 CBD report, which drew heavily on Williamson's biological research (stages of invasion and need to prioritize control of recognised pests) and on his economics work with Perrings*". The support documents for the CBD (2012) report cite Williamson (1998) and Perrings *et al.* (2000, 2002). CoP11 (2012) launched the Global IAS Information Partnership to facilitate this.

- **Impacts on European policies.** In 2011, the EU adopted a 2020 Biodiversity Strategy, directly adopting the York-influenced Aichi Target wording for IAS (EC 2011). The technical support for the development of the Strategy was provided by IEEP (Institute for European Environmental Policy) whose 2009 report cites Williamson. The Strategy recognises the York-based conclusion that prevention and early-control are most cost-effective; specifically that IAS cause €12.5 *billion* annual damage in the EU, whereas the estimated annual implementation costs of the EU Strategy are €40 to 190 *million*. To achieve these strategic goals, the EC proposed a *Regulation of the European Parliament and of the Council on the prevention and management of the introduction and spread of invasive alien species* in 2013.

- **National and regional programmes.** The CBD, SCOPE and GISP programmes have fed into numerous international, regional and national programmes, many of which pre-date 2008 but are still in use. For example, Hulme states that Williamson's "*finding that previous history of invasion was an important explanatory variable in deciding whether a species would become problematic … is one of the key components in the Australian Weed Risk Assessment Scheme which remains the main screening tool in Australia for new introductions*". Other programmes were established during 2008-2013. Since CoP10, there has been a surge in the number of countries (e.g. Finnish Strategy and Action Plan, 2012), intergovernmental groupings and NGOs

developing IAS legislation and strategies, reflecting principles originally developed in York. For example, the underlying principles of the "*Guidelines for Invasive Species Management in the Pacific*" (Pacific Community & Regional Env Prog Secretariat, 2009) state: *"Not all introduced species are invasive, and action should be prioritised to deal first with those currently causing, or with potential to cause, the most harm...to maximise effectiveness and value for money, invasive species risk assessment, prioritisation and management must be based on good science"*, which is York-derived rationale. In Sept 2012, the EU announced backing for the BirdLife Pacific Partnership for a four-year €1.5 million regional programme to address the threats posed by invasive species, to improve the livelihoods of over ten million people in Pacific communities. Another example is the World Organisation for Animal Health's "*Guidelines for assessing the risk of non-native animals becoming invasive*" (OIE 2011). Fig. 2 of their risk assessment stems directly from Williamson's stages of invasion, and additional text strongly reflects York research: "*What are the features … that may affect the probability of establishment and spread of the animals? Examples of the kind of inputs that may be required are: 1) history of invasiveness elsewhere; 2) number and size of releases or escapes (propagule pressure)*".

- **Internalisation of economic costs.** Perrings and Williamson's call to transfer true economic costs of IAS to those responsible is being heeded; in some countries prevention costs are transferred to the private sector by legislation on imports and safety precautions. In New Zealand, the private sector spends ~ $407 million *pa* controlling pests, compared to $299.6 by Government. The Government imposes levies to support IAS control on those (a) likely to benefit from the control and (b) who create or exacerbate IAS problems (e.g. through trade).

Overall, a succession of steps in the fight against invasive species have stemmed from York work. First, awareness of the problem of IAS was recognised. Second, understanding the processes of invasions led to strategies and legislation to minimise arrivals and control those that do. And most recently, understanding of the economic drivers of invasion (trade) is leading to economic and legislative levers to disincentivize those who might accidentally bring about new invasions.

5. Sources to corroborate the impact

CABI (2010) The economic cost of invasive non-native species on Great Britain, by Williams F. *et al.* CABI, Wallingford. http://b3.net.nz/gerda/refs/429.pdf

CBD (2012) Target 9 – Invasive Alien Species. Turpie, J. *et al.*, *Input .. high level panel on global assessment of resources for .. biodiversity 2011-2020* (UNEP/CBD/COP/11/INF/20) http://www.cbd.int/doc/meetings/fin/hlpgar-sp-01/official/hlpgar-sp-01-07-en.pdf

Defra (2003) Review of non-native species policy. Defra, London. http://jncc.defra.gov.uk/pdf/BRAG_NNC_DefraReviewofNon-NativeSpeciesPolicy.pdf based on: Fasham M. & Trumper K. (2001) http://archive.defra.gov.uk/wildlife-pets/wildlife/management/non-native/documents/review-report.pdf with Williamson the most cited author.

Defra (2007) *Consultation on: (1) The Review of Schedule 9 to the Wildlife & Countryside Act 1981 and (2) The Ban on Sale of Certain Non-native Species*. Defra, Lond. http://archive.defra.gov.uk/wildlife-pets/wildlife/management/non-native/documents/consultation.pdf

Defra (2008) The invasive non-native species framework strategy for Great Britain. GB Non-Native Species Secretariat, Defra, London.

EC (2011) Our life insurance, our natural capital: an EU biodiversity strategy to 2020. COM(2011) 244 final), EC. http://ec.europa.eu/environment/nature/biodiversity/comm2006/pdf/2020/1_EN_ACT_part1_v7[1].pdf (Cites IEEP 2010; but actually the IEEP 2008 report citing Williamson).

GB Non-Native Species Secretariat (2012) Non-Native Species in Great Britain: establishment, detection and reporting to inform effective decision making; H.E.Roy *et al.* Rpt to Defra, CEH, Wallingford. https://secure.fera.defra.gov.uk/nonnativespecies/downloadDocument.cfm?id=753

Hulme, P (2013). Writing to C D Thomas, 7 March 2013.

IEEP (2008) Assessment of the impacts of IAS in Europe and the EU. Kettunen, M. *et al.* Report to EC, Tech. support to EU strategy on IAS. Inst. for European Env. Policy, Brussels, Belgium. http://ec.europa.eu/environment/nature/invasivealien/docs/Kettunen2009_IAS_Task%201.pdf

IUCN (2013) Letter from IUCN Invasive Species Specialist Group Chair, Piero Genovesi. Rome.

OIE (2011) Guidelines for assessing the risk of non-native animals becoming invasive. OIE, Paris. http://www.oie.int/fileadmin/Home/eng/Our_scientific_expertise/docs/pdf/OIEGuidelines_NonNativeAnimals_2012.pdf

SPREP (2009) Guidelines for invasive species management in the Pacific. Compiled by Alan Tye. Apia, Samoa: http://www.sprep.org/att/publication/000699_RISSFinalLR.pdf