Economic benefits to New Zealand from research conducted by the Allan Wilson Centre

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Executive summary

We report on a number of strategic initiatives that the Allan Wilson Centre (AWC) undertakes and consider the potential direct and indirect net economic benefits they may provide the New Zealand economy.

This comment on the value of advanced scientific research comes at the same time as the most recent the New Zealand Productivity Commission's report is released (Sept. 2013). They express their deep concern that labour productivity in New Zealand has stalled since 2000 and that new technologies that could improve economic output not being adopted quickly enough into the domestic economy. "We need to better understand the barriers to superior technologies and production techniques spreading from high to low-productivity firms within the domestic economy."

Because basic research typically occurs on the technological frontier, its economic value is difficult to identify, quantify and value, even in retrospect. Basic research rarely possesses intrinsic economic value, rather, they are critical inputs to other investment processes that yield further research findings, and sometimes, yield innovations.

The AWC contributes toward the NZ economy by providing two core services. They develop intellectual property and the technical means to enable NZ enterprises to compete in frontier technologies in domestic and international markets. They also provide goods and services that allow New Zealand to fulfill its non-competitive public good public welfare obligations. For example, clean water, protecting species and public health.

Despite the difficulties associated with valuing the contribution of research to the production of economic goods and services, in all the projects we considered, we found that they have the potential to realise direct and indirect economic net benefits for the New Zealand economy and society in general.

Introduction

The brief for this research is to assign economic benefits to some of the research conducted by Allan Wilson Centre (AWC). Economic benefits are reflected in an increase in the economic value added to the economy, i.e. a contribution to total economic output or Gross Domestic Product (GDP).

Because basic research typically occurs on the technological frontier its economic value is difficult to identify, to forecast or even to gauge accurately in retrospect. Economic payoffs from the application of new ideas or technologies may also take a long time to be realised. Often the outputs of basic research rarely possess intrinsic economic value. Rather, they are critically important inputs to other investment processes that yield further research findings, and sometimes yield innovations (Koh, Wong, 2005, pg 267).

Much of the AWC's research is basic in that it provides new knowledge and tools and techniques, the application of which can lead directly or indirectly to the production of economic goods and services. Some of the outcomes achieved through the use of this research is non-economic in terms of there being no quantifiable economic output or service; take for example preservation of biodiversity, the preservation of ecosystem processes and functions, the knowledge about sustainable populations etc. Society has determined biodiversity preservation to be important (valuable) and through legislation sets a goal to achieve this. Here the research provides means to achieve this through new knowledge and understanding and new techniques and technologies. The research in some cases leads to cost reducing ways to achieve the desired outcomes, in others is can lead to achievement of the goals set.

From an economic perspective, research centres like AWC provide NZ with two core services. First, they develop intellectual property and the technical means to enable NZ enterprises to compete in frontier technologies in international markets. In this situation, economic cost benefit analysis can be helpful to identify the projects with the greatest potential. Second, they provide goods and services that allow New Zealand to fulfil its non-competitive public good or public welfare obligations. For example, clean water, protecting species and public health. In this situation, economic efficiency analysis can be helpful to identify the least cost approach to achieve a stated objective.

The scientific output from the basic research is an important means to develop a country's innovative capacity and its international reputation.

In the recently released New Zealand Productivity Commission report (Sept. 2013) they express concern that labour productivity in New Zealand has faltered and that new technologies that could improve economic output not being adopted quickly enough. In their paper they stress that, for decades, labour output has been in decline compared with labour productivity in other OECD countries.

In trying to explain New Zealand's poor productivity record they speculate about the extent to which new technologies and work practices developed off-shore are incorporated into the New Zealand economy as well the extent to which new technologies pass from from high- to low-productivity firms in the domestic economy.

In what follows we have looked at the Strategic Initiatives and some of the projects to identify linkages to where the results of the research have or will directly or indirectly lead to economic outcomes to New Zealand.

Strategic Initiative 1: Water Quality & Public Health – *Disease Ecology & Pathogen Evolution*

NZ has an unacceptable high rate of infectious diseases caused by microbial organisms. Diseases caused by bacterial pathogens Campylobactor and Salmonella often can be traced to animal sources, and contaminated water can harbour the protozoans Cryptosporidium and Giardia. Outbreaks of these diseases can result in substantial losses to the economy, and infectious disease is also a major concern for national wildlife conservation programmes.

The tools developed by the research allow tracing the evolution and transmission of diseases in the New Zealand environment. While the tools by themselves do not create economic benefits to society, their application plays often a pivotal role in investigating diseases and identify sources and this has helped and continues to help in dealing with the issues (reducing the problem), putting in place management or restorative programmes, informing biosecurity (source attribution, in New Zealand and overseas) and putting in place monitoring and control programmes to avoid trade barriers, just to mention a few.

In all of those applications the research tools play a pivotal role. The economic benefits achieved, in terms of costs avoided, benefits gained, exports protected or reduced probabilities of future infections are very significant. The role of the research and the tools, even though pivotal, is hard to quantify and value. All that can be said is that the research has led, and is still leading, to achieving economic benefits to the NZ society.

Examples

1. NZ experienced rising annual rates of campylobacteriosis from the 1990 onwards and peaked in 2006. Source attribution techniques based on genotyping (the output of the research) of *Campylobactore jejeuni* were used to estimate the contribution of different sources and transmission pathways of campylobacteriosis in New Zealand. On the basis of the findings, public health officials advocated for more rigorous controls on foodborne pathways of campylobacteriosis. In late 2006, the New Zealand Food Safety Authority released a risk management strategy. From April 2007, poultry processors monitored and reported to the NZFSA-administered National Microbiological Database Campylobacter spp prevalence. A marked decline in campylobacteriosis occurred over the following year. Source attribution modelling was used to provide supportive evidence that the decline in human campylobacteriosis can be largely attributed to a reduction in infection arising from poultry (Sears et al., 2011).

   Over the years many studies have been conducted estimating the cost of campylobacteriosis to NZ. Duncan (2011), using the information of those studies and further information, calculated that the total cost to society, in 2007 constant dollars, was $99million (of which $6.2mill where health costs). Duncan then looked at the decline in campylobacteriosis from 2006 -2008 (a 58% decline), and the cost of the monitoring programme to Government and Industry, and conducts and economic analysis that shows that the Net Benefits to society, in $2007, was $57.4/annum (if only health costs where considered, the annual net benefits are $3.6million).

These figures represent a cost saving to New Zealand, which is not just a one-off but a yearly on-going saving. A cost saving is an economic benefit.

The research conducted by this Strategic Initiative and the tools developed played a crucial role in identifying the source of the problems which led then to an appropriate monitoring programme for which (by means of the same tools) identification of success can be demonstrated, all this leading to an economic benefit to New Zealand of an annual return (i.e. a net benefit after all implementation costs have been included) of somewhere between 3.6 and 57.4 million dollars per year, depending on how things are calculated and what is included. The results of the research have contributed to achieving this economic outcome. It is impossible to attribute a proportion of the outcome to the research input. All that can be said is that the research provided tools and knowledge that was pivotal to achieving the outcome.

The identification of campylobacter strains in NZ has helped reduce the costs of the Department of Conservation (DoC) of disease screening for translocations, and other pathogen testing, done as part of Zoe Grange's PhD which has contributed to takahe conservation and our understanding of pathogen reservoirs in conservation sites. Every test result contributes to our baseline data on pathogen hosts and distribution. This is very valuable as part of our understanding of the whole picture (Rod Hay, pers com).

The work on water quality and public health (especially DoC campgrounds), hasn't changed DoC's current management practice because they have standard warnings (signs and brochures) advising to boil water in the campgrounds. However, evidence in support of current practice is a benefit in itself. The findings are useful with regard to water quality in general. Improving water quality is a benefit to NZ society and tourism, in terms of avoidance of disease and associated health costs. A cost saving is an economic benefit.

2. Similarly, source attribution techniques play an important role in the monitoring of *E. coli* 0157. Beef and veal exports to the USA in 2009

were $724mill and represented 0.4% of GDP (Duncan, 2011). Without the strict monitoring and control this export would be a risk.

3. Kiwifruit exports are currently valued at around $1 billion per annum (Ministry of Primary Industry, 2013). In November 2010 the virulent bacterial disease, *Pseudomonas syringae pv. actinidiae* (Psa-V), was discovered in a New Zealand kiwifruit orchard. This disease, that has decimated gold kiwifruit orchards in the Latina region of Italy, is expected to result in the removal of almost all of the gold Hort 16A kiwifruit variety in New Zealand. Hort 16A now accounts for 30 percent of export kiwifruit value (Greer and Saunders, 2012). Export of Gold Kiwi fruit are expected to be down in 2014 by 43% compared with 2013. The industry needs to transition to Psa tolerant varieties. This necessitates a research and development programmes that will identify new kiwifruit varieties both tolerant to Psa and also meeting key attributes such as storage and taste.

   The cost to the NZ Industry and society is very large. The cost of lost export earnings will depend upon how long it will take to get new species developed and planted. Greer and Saunders (2013) look at two scenarios; 1) the assisted scenario, whereby growers are assisted to replant, and, 2) an unassisted scenario. They calculate the total cost of the loss if it takes 5 years, 10 years or 15 years to fully replant the kiwi fruit acreage.

   NPV of the Cost of Delay

	Assisted	Unassisted
5yrs	310m	410m
10yrs	500m	600m
15yrs	740m	885m

   The research in Strategic initiative 1 contributes in several ways to dealing with the Psa issue:

   a. It is pivotal in the breeding programme for Psa tolerant species. Genomic analysis provides the basis for breeding resistant plants, by identifying candidate genes as targets for resistance breeding programmes.
   b. A major contribution is tracing the evolution and transmission of diseases. The work focuses on determining the origin, population

structure and defining features of this pathogen (McCann, 2013). There are also other source populations in wild relatives of kiwi fruit that could be sources. The tool/knowledge developed in this research help to identify those, and can inform biosecurity. The fact that we now have Psa in the country doesn't mean we don't need to worry about movement of plant material, because, amongst other things, other strains of Psa could be equally problematic.

Strategic Initiative 2: Innovative Technologies for Global Research: *Imaging Evolution: Inferring Evolutionary Processes Using Networks*

The most tangible output from this initiative will be software for building and analysing haplotype networks (such as the PopArt programme being developed mostly by Jessica Leigh and David Bryant) - this will be free software (i.e. no patent, or sale involved) but such software will likely be used by not just academics on purely scientific questions but for applications that have economic impact. For example, if you look at other free software that people in the AWC have developed (e.g. BEAST by Alexei Drummond et al. and NeighborNet by David Bryant et al. they are used all over the world each week on all sort of problems to do with phylogenetic analysis of data (academic, medical, commercial etc.). Alexei's BEAST publication has been cited more than 4000 times, Bryant's two network papers about 2600 times together.

The mathematical models and techniques are used in optimization models developed to ensure that conservation dollars are appropriately targeted. Techniques for managing and analyzing huge genomic data sets rely on continuing developments in this area.

Strategic Initiative 3: Evolutionary Processes & Species inventories for Conservation Management – *Speciation & Adaptation in New Zealand Invertebrates*

This work is adding to knowledge of our endangered fauna. The giant weta research has led to better targeting and efficiency of management effort of these species (Rod Hay, *pers com*).

Strategic Initiative 5: Innovative Technologies for Biodiversity Management Agencies – *Hidden Treasure – A New Zealand Genomic Observatory*

The research develops cutting-edge molecular techniques for rapid assessment of biodiversity of different sites from substrates such as soil, leaf-litter etc.

New information technology for managing and analysing this type of data.

1. Ecological monitoring is an activity required by the Govt for many purposes such as environmental reporting. Ecological monitoring is the collecting of biological data, from an area. Currently the way we go about that is to send a team of people to do data plots. Many plots, many people involved, very expensive in terms of time, salaries, etc. Also when we do this for very sensitive area, (like our islands) there is also a biosecurity risk.

   The research is aimed at offsetting this large expensive (but necessary since the monitoring is required for achieving our conservation objectives) by developing a tool that can do the same by simple taking soil sample and other samples from the area and getting the same information.

   The molecular data makes it much easier to identify the biodiversity of the area and also is much more powerful to use.

   Hence, if we can get this for ecological monitoring, the cost savings would be very large. Potentially much of it could be automated.

   As Rod Hay from DoC states "The potential savings from even a small increment in efficiency are significant, given the seven figure sum committed annually to biodiversity monitoring. Should the techniques reach their full potential, then the payoff will be large." (Rod Hay, *pers com)*

2. When species are translocated (rare species like the tuatara), health checks need to be conducted before translocation. This is very expensive per animal and for a large number of animals the costs to do a full

analysis are huge. Using molecular tools, this is made much simpler. Again a cost saving and a much fuller analysis.

3. Two other areas of application Craig Bishop (Auckland Regional Authority, *pers com)*.

    a. Policy setting. The tools allow us to identify unique and sensitive remnants which would be hard to recreate if destroyed. Policy then is guided in terms of regulations for preserving such environments.
    b. Off-sets. The tools enable the identification of how much of equal value is the restored eco-system or how long it takes to bring it up to equal value. The tools enable to obtain the baseline data for destroyed or impacted environments.
    c. By better determination of the biodiversity present on a site we can also learn more about the ecosystem services and the value of those to society.

Strategic Initiative 6: Bringing Our Rarest Birds Back From the Brink – *Relationship between susceptibility to disease and loss of genetic diversity in New Zealand's threatened species.*

The research has developed new tools to identify and model genetic diversity in species. In New Zealand, conservation of endangered species is an important goal as part of overall preservation of Biodiversity. The centrepiece of species conservation in New Zealand is translocation and this is risky without a good understanding of the genetics of the birds and their populations. Successes of recent translocation exercises have been due to this understanding, obtained by using the molecular biology tools developed.

In the past, small numbers of birds were translocated, and up to half of these could die. This has implications for inbreeding. In addition, when only small numbers of birds are captured for translocation, a limited range of genetic diversity is selected and translocated. With the use of new molecular techniques and modelling, it is possible to look at the consequences of the resulting inbreeding.

While in the past translocation initially appeared successful, it transpired that the reproductive rate of the translocated population was low (even without predators present), as was the survival rate. DoC understands the importance of the genetic issues and wishes to understand the minimum numbers of individuals that should be released in translocation exercises. It is not, try to catch as many as you can and then translocate these. Catching and translocating is a very expensive exercise, consequently it is cost effective to use tools and models that help to identify the minimum number of a species that should be caught and translocated to maximise the benefits. The implication being that cost savings are likely to be significant in some cases.

For example, in a case dealing with the transfer of Kiwi into a fenced enclosure, the use of modelling helped determine the minimum number that should be translocated. While one party wanted to move 40 individuals, the other party involved wished to move only 10 Kiwi for good reasons, such as not wanting to deplete the source population. Modelling of both options clearly demonstrated that translocating only a small number now would require having to bring in many more later to maintain genetic diversity. This would incur large future cost and increased risk, therefore, it would be both cost effective and preferable to translocate 40 Kiwi at the outset.

In summary, the new technologies developed in this research and their applications today, have achieved success in the conservation of endangered species in New Zealand. While conservation is not an economic outcome as such, it is of great value and improved social welfare is attained at least cost.

Strategic Initiative 9 – *Building a Shared Future*: Uawanaui Sustainability Project

This project is a community-led initiative by the Uawa Tologa Bay community with Te Aitanga-a-Hauti and in partnership with the Allan Wilson Centre. Taking an integrated approach, the aim is to work collaboratively to ensure that Uawa/Tologa Bay is environmentally, economically, socially and culturally sustainable for generations to come. The commitment is long-term, as are the anticipated outcomes.

Much work to date has focused on developing relationships with the stakeholders of the Uawanui, which includes sheep and beef farmers, croppers, forestry companies, Te Aitanga-a-Hauiti (and Hauiti and Mangaheia Incorporations) and the community of Uawa Tolaga Bay. Improving the health of the environment and increasing biodiversity is an overarching aim and the Allan Wilson Centre is seen as an independent and credible organisation, which is about science and public goods. As such it is seen as providing real value around integrating biodiversity and improvement of environmental quality, vital for long-term environmental, economic and social sustainability.

The Riverbank Restoration Guide has been prepared (encompassing ecological and cultural values) and the school, landowners and marae have been early implementers of this restoration work. Local Maori land managers are committed to taking responsibility for sustainable land management (and their Incorporations have, for instance, the largest Maori-owned cropping operations in New Zealand), and have worked with the Allan Wilson Centre to complete an environmental scoping across their lands and an action plan to restore the Kaitawa Estuary. Fencing has begun around this estuary (Peter Handford, Groundtruth, *pers com.*).

We cannot put a precise dollar value on benefits to date, however, it can be stated that in the longer term, benefits are expected to be significant. Active participation by the community is already taking place and as this continues it creates a real sense of pride. A change of focus is beginning, to look toward improving water quality in the river catchment and estuary (through the restoration project), increasing local food production (particularly within the non-cash society) and plans to educate school children (and others through applied EIT courses) around sustainable land management practices, including teaching technical skills. Anticipated benefits are in areas such as, high-value agricultural and horticultural production on the fertile plains, and high-value authentic tourism. In addition it is expected that cost savings will be realised resulting from improved nutrition and health, reduced obesity, reduced benefit dependency, improved education and motivation for children to do well (Peter Handford, Groundtruth, *pers com.*).

Whilst arguably ambitious objectives, the partners and stakeholders are optimistic that it is achievable, particularly given the contained environment, of the Uawa river catchment (50,000 ha) and a section of coastline, a limited number of stakeholders including one sub-tribe, Te Aitanga-a-Hauti (which also owns the Maori incorporations) and one small urban area. With generic principles it is seen in the long-term, as being a valuable model that has the potential to be tailored to similar projects in other communities elsewhere.

Research Projects

1. Coastal conservation management: The genetic stock structure of NZ snapper and grey mullet.

Snapper is New Zealand's largest recreational fishery and its most important one, and also one of the country's largest coastal commercial fisheries. The export value of snapper in 2012 was $36.8million (Ministry of Primary Industry, 2013). The value of recreational fishing is difficult to estimate because of the paucity of data on recreational fishing in New Zealand. The only project that provides information on the value of recreational fishing in New Zealand was carried out by the South Australian Centre for Economic Studies (SACES) in 1998. Snapper was assessed as the most valuable of five key New Zealand recreational species evaluated by SACES.

The research, using genetic techniques to determine the breeding patterns of snapper and what contribution different nursery areas make to the adult snapper population, is crucial to understand the fish population and its growth. The impact of land use intensification around nursery areas (like the Kaipara Harbour which is a major nursery) on the water and the growth of seagrass (food for juvenile snapper and also a hiding place) have a significant impact on the total number of juveniles. Fewer juveniles means smaller stock sizes and reduced productivity. This knowledge is important for restoration efforts of a stressed fishery and informs management of this shared fishery, which delivers large economic benefits to New Zealand through the commercial catch, and recreational and customary value.

2. The genetic stock structure of Hapuku in NZ and Australia, and genome sequencing for new aquaculture development.

This research has two parts:

1. The use of genetic markers identify the specific number of stocks and their boundaries

In New Zealand for the year of 2008, hāpuku had a commercial value of NZ$37m with an export value of NZ$4.29m at a price of NZ$10.29 per kg. Hāpuku is a species that is fished both commercially and recreationally in New Zealand. It is highly sought after but catches are relatively low, and is a species that is managed in the New Zealand Quota Management System (QMS). There is however uncertainty when applying management plans and stock assessment models, and sustainability of current catch number is unknown (Forest and Bird (NZ) rank Hapuku as Red-Avoid in their Best Fish Guide.

This research will offer a real opportunity to maximise the benefits of this fishery resource by better matching management boundaries to biological productivity.

Potential economic benefits resulting from better management of the resource lead to a greater return from the fishery (commercial and in terms of recreational benefits to society).

2. To develop genomics techniques to uncover natural adaptive genetic variation in species such as hapuku and attempt to use the genetic variation that evolution has been moulding, to fast forward aquaculture developments and selective breeding

The global demand for seafood continues increase. Global fishing catches have peaked or are falling due to over exploitation, which means that aquaculture production needs to grow to supply increasing demand. NZ's fishing industry contributes significantly to our overall economic earnings. Ninety percent of our commercial seafood production is exported. In 2013 the value of NZ's seafood exports reached NZ$1.51bill (83% from wild catch fisheries, and 17% from aquaculture).

The NZ aquaculture industry cannot simply expand its low-value farming model to keep up with the rising demand. The industry needs to adapt and innovate to unlock the genetic and economic potential of new high-value native finfish species such as hapuku.

There has been significant interest globally for development of this species for aquaculture. In Europe a very similar species of wreckfish is highly prized and considered a local delicacy. Because of this, the *Polyprion spp.* have been overfished in most areas. Its premium market position, high value, and limited supply have created a lot of interest for this species in the aquaculture sector. In New Zealand, National Institute of Water and Atmospheric Research

(NIWA) have embraced hāpuku as an opportunity for New Zealand to expand and have identified markets for this species locally in New Zealand and Australia and internationally in Europe and Asia.

The aim of this research is to find adaptive genetic variation in wild populations using state-of-the-art genomics and evolutionary analyses to seed new selective breeding programmes in the New Zealand aquaculture industry. Detecting and utilising natural adaptive genetic variation will help fast-forward new aquaculture developments by bringing together ‘elite’ stocks already selected in the wild for specific environmental conditions and enable innovative crosses to be made during domestication.

Economic benefits are in the future in terms of increased production and export revenues from aquaculture.

References

Conway P. and Meehan L. Productivity by the numbers: The New Zealand experience. New Zealand Productivity Commission, 20/09/2013.

Duncan GE (2011) The Economic Benefits of Food Safety Regulations, Master of Public Health thesis submitted to the Department of Public Health, University of Otago, Wellington

Greer G and Saunders C(2012) *The Cost of Psa-V to the New Zealand Kiwifruit Industry and the Wider Community,* Report to Kiwifruit Vine Health, Agribusiness and Economics Research Unit, Lincoln University, Canterbury

Koh THW and PK Wong (2005) Competing at the frontier: The changing role of technology policy in Singapore's economic strategy, *Technological Forecasting & Social Change* 72 (2005) 255-285

McCann HC, Rikkerink EHA, Bertels F, Fiers M, Lu A, Rees-George J, Anderson MT, Gleave AP, Haubold B, Wohlers MW, Guttman DS, Wang PW, Straub C, Vanneste, J, Rainey PB and MD Templeton (2013) Genomic Analysis of the Kiwifruit Pathogen *Pseudomonas syringae* pv. *Actinidiae* Provides Insight into the Origins of an Emergent Plant Disease, *PLOS Pathogens*, www.phospathogens.org, Volume 9, Issue 7, June.

Ministry of Primary Industries (2013) Situation and Outlook for Primary Industries 2013, Wellington

Sears A, Baker MG, Wilson N, Marshall J, Muellner P, Campbell DM, Lake RJ, and NP French (2011) Marked Campylobacteriosis Decline after Interventions Aimed at Poultry, *New Zealand Emerging Infectious Diseases* • www.cdc.gov/eid • Vol. 17, No. 6, June