

Will It Have Legs?

An Investigation into Synthetic Food and the Implications
for NZ Agriculture



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Executive Summary

Synthetic food (SF) is being touted as a revolution in food production that could replace animal products. While the industry is more bark than bite at the moment, it's rapidly gaining awareness and attracting significant funding by being portrayed as a solution to many of the global problems associated with conventional agriculture. As the pressure intensifies on humanity to curb climate change, all options are being considered and, with a carbon footprint larger than the global transport sector, agriculture is well and truly in the spotlight. Agriculture has held relative impunity from climate mitigation strategies up until now but SF is bringing that into question by providing a potential alternative method of food production.

The environment is one of the key drivers behind SF but there are others as well. The drivers are being used as a platform to promote SF as the way of the future and leveraging off the growing disconnect between consumers and the farms that currently produce their food. It's too early to know if SF will actually compete at scale on a cost and quality basis but nevertheless, the messaging around SF is already having a negative impact on the perception of agriculture. Countries like NZ who rely heavily on agricultural exports are at risk of losing market share to SF as well as being tarred with the same 'industrial agriculture' brush as other countries and becoming what one journalist has described as the "Detroit of agriculture".

As with many emerging technologies though, things don't happen overnight and the devil is often in the detail. The NZ primary sector needs to resist the urge to take a stance against SF based on weak journalism and instead be part of an informed conversation. The first response from people a year ago, when discussing SF, was 'yuk, it will never take off because people want natural food'. Thankfully, the conversation is now shifting to 'what could happen if SF did take off and how do we approach this potentially disruptive technology?'. SF needs to be approached with an open mind and lots of questions rather than building a wall to defend our patch.

NZ Ag needs to get a better handle on how conventional food measures up against SF based on the ruler that tomorrow's consumer will use. Carbon emissions, soil conservation and animal welfare are some of the attributes that consumers will look for and this needs to become part of our marketing approach in the future.

In reality, conventional agriculture is more of a threat to the SF industry at the moment, not the other way around. SF consists of startup companies with products in the development phase and markets that are built on promises. This isn't a reason for us to rest on our laurels but instead a window of opportunity to get involved and have a say in how the SF industry evolves.

We can choose to be disrupted or help shape the future of food production by understanding the drivers behind SF and being part of the solution, not part of the problem.

Foreword

I chose a career in farming because I believed it was an industry that makes the world a better place. My guiding light has always been that the primary industries use natural resources and renewable energy to create essential products for the human population. I've always thought we operated honestly and transparently and that we generally had the understanding and support of the public.

An unexpected outcome of my year as a Nuffield scholar was discovering that a lot of the world doesn't view farming so fondly. I don't live in a complete bubble but I've always put any differing perspectives on farming down to a lack of understanding and the well publicised 'rural/urban divide'. A year of reflection has made me realise that it's me as much as anyone who's lacked the understanding. I've had a window into the future and not everything I've seen reconciles with my once rock-solid farming roots. Some days I've felt like closing the curtains!

While it's been unsettling, I guess that's the nature of change and the whole purpose of a Nuffield scholarship. I still love getting my hands dirty and I'm just as positive as ever about the future of the primary industries so the challenge for me now is to keep the curtains open and use what I've learnt to help shape how we farm in the future.

I'd like to thank Nuffield New Zealand for the opportunity for which I'm deeply grateful and my wife Amy for managing the business, our kids and my life to allow me the freedom to explore.



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Executive Summary	1
Foreword	2
Strategic Partners	3
Programme Partners	3
Service Partner - Ocular	3
Introduction	6
Methodology	7
General Findings	9
History	9
What to Call It	9
How It's Made	9
Availability	10
Markets	11
The Drivers and the Claims Behind Synthetic Food	13
New Technology	13
Animal Welfare	16
The Environment	17
Nutrition and Food Safety	19
Population Growth	20
Wealth Creation	20
Implications for NZ Agriculture	22
Threats	22
Opportunities	23
Conclusion	25
Recommendations	26
Raise the Awareness	26
Get Involved	26
Understanding the NZ Food System	26
References	27

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Introduction

Synthetic food. What is it? How is it made? What does it taste like? Is it good for you? How much does it cost? What is the environmental impact? In this digital revolution is it naive to assume that agriculture will be immune to the massive advances in technology or disruptive innovation that seem to transform other industries overnight? Will there be a time when animals will be replaced with machines to produce the same products? Futuristic and a bit weird perhaps but maybe not so far away afterall.

Industries are evolving faster than ever. The Oil company Shell has recently announced its intention to add car charging stations to its forecourts throughout the UK and Holland in an attempt to be part of the shift from fossil fuel powered vehicles to a transportation system that runs on electricity. Existing industries have the option to be part of the shift or become part of history. What could SF mean for conventional agriculture and especially for a country like NZ whose economy and rural communities rely so heavily on a prosperous and competitive primary sector? Opportunity or threat? Lots of questions.

SF is the umbrella term used to describe the process of making animal products without the animals. There's also a range of products other than food being made synthetically like leather, spider silk fiber, rhinoceros horn, gelatin, and dyes to name a few but this report focusses more on food and specifically meat and milk for which any new competition would have the greatest impact on the NZ farming sector.

The SF industry is in it's infancy. There are a few products available at exclusive restaurants and selected supermarkets but nothing is being produced at scale yet so it's impossible to line up SFs with their natural counterparts to compare the hard facts. The true cost and the nutritive qualities that may ultimately determine the fate of the industry remain speculation only.

It's the claims about SF however that are ahead of production. The modelling that's been done based on small scale production is being used to market SF as the way of the future and the story itself is generally far exceeding what farmers can claim. Regardless of whether or not the SF concept does indeed grow legs, it's having an impact on the way people see agriculture already. The drivers behind it cut to the core of agriculture and bring into question the current global food production system.

This report aims to explain where the current SF industry stands and explore the drivers and claims behind it without building a case for or against it. It also considers the implications for the NZ farming sector and provides some recommendations on how to approach it.

Methodology

The learning process was broken down into three parts:

1. Desktop research was initially done to gather contacts and to get a handle on activity in the SF space around the world. This continued right throughout the year because it's a new field and there were regular media releases and opinion pieces from companies trying to promote their products and commentators who have an interest.
2. The Nuffield Contemporary Scholars Conference (CSC) and the Global Focus Program (GFP) were used as a means of gauging general awareness of the topic and to consider the context of the different countries visited in regards to food and agriculture.

Image 1

The authors GFP group touring a farm in South Africa - a typical scene

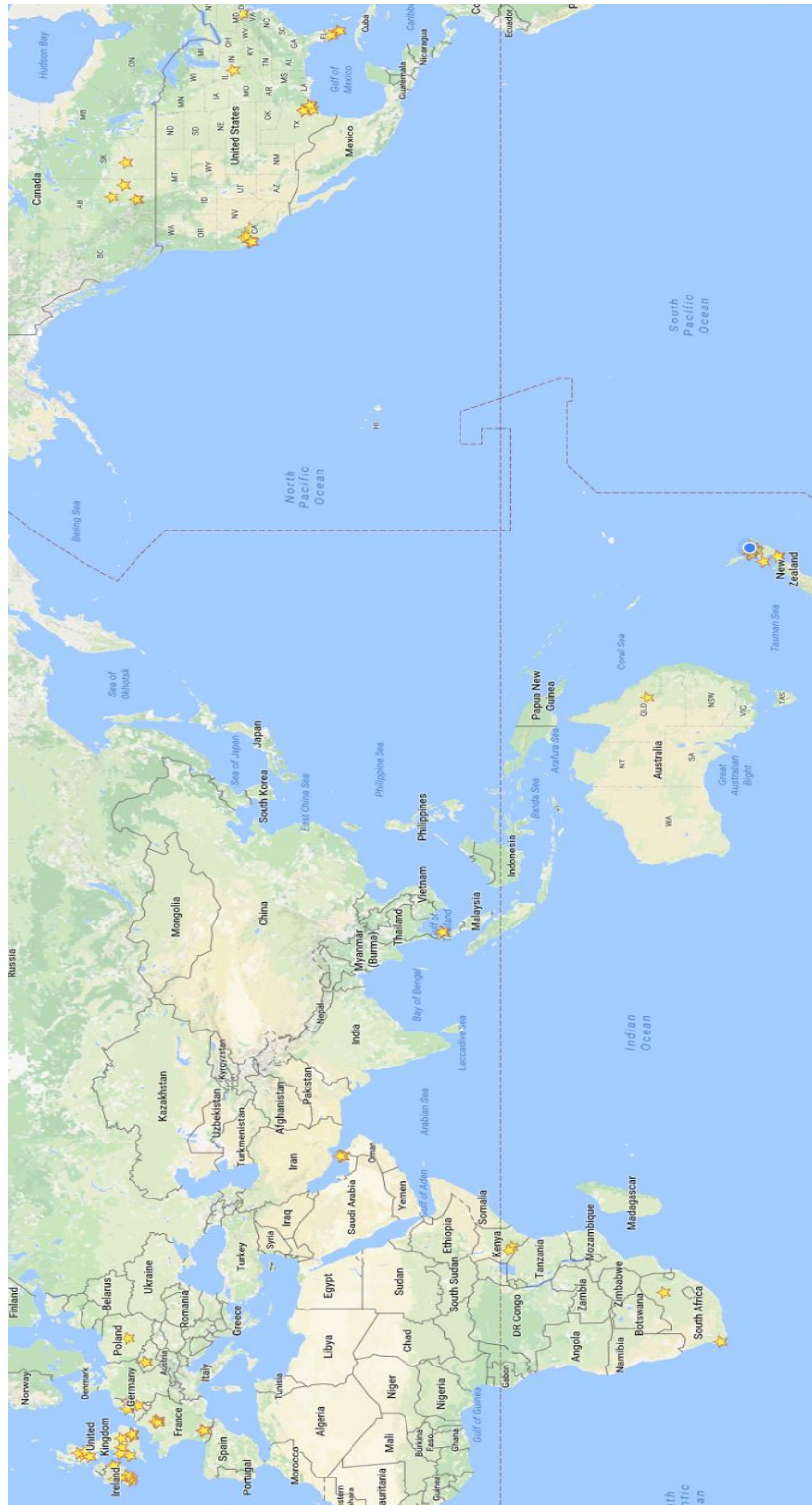


3. A series of interviews was conducted over a 12 month period. The interviewees are listed in the appendix and include producers (of SF), researchers, investors, supermarkets, farmers and marketers food companies.

Eighteen countries were visited in total with the main focus on Europe, North America and Africa as highlighted by the stars on the map in Image 2.

Image 2

The author's travel map



1. General Findings

1.1. History

"We shall escape the absurdity of growing a whole chicken in order to eat the breast or wing, by growing these parts separately under a suitable medium," Winston Churchill.¹

The concept of SF isn't new, as shown by the Winston Churchill quote dating back to 1932. The first veggie burgers appeared on the market in the US in the early 1980's ² and soymilk has been made for over 100 years.³ Smooth muscle cell was first cultured in 1971 and in 2013 the first burger patty made from cultured cells was cooked and eaten in London.

Dr Neil Stephens a sociologist from Brunel University in London is following the evolution of SF (specifically meat made from stem cells) and covers the history and social aspects of the novel technology in his paper "What is In-Vitro Meat?".⁴ In an interview, he explained how the success or otherwise of an emerging technology hinges on how it's initially perceived by the public and how the early years of production and marketing will be critical to acceptance of SF.

1.2. What to Call It

The term 'Synthetic Food' is being used to describe a range of different products being produced to provide approximations to animal products without the need to farm animals. It doesn't describe the actual production techniques very well, nor is it what the SF companies refer to their products as, but it's the term that most people relate to because that's how it's been referred to in the media. The different SF companies will most likely market their products as 'cell cultured' or 'plant based' but 'SF' is appropriate for the sake of this report. Along similar lines, the debate around whether or not the products can be called 'milk' and 'meat' will be left for another day.

1.3. How It's Made

There are three main methods of making the SFs referred to in this report:

- 1) Using the basic components from plants to reconstruct something that looks, tastes and performs similarly to the products they're mimicking;
- 2) Using cell propagation technology to grow animal cells in-vitro
- 3) Genetically modifying yeast cells so that they secrete the components of animal products when fermented. The cell propagation and fermentation processes are being commonly referred to as 'cell culturing' or 'cellular agriculture'.

It could be argued that the plant based alternatives aren't really new because the likes of soy and rice milk have been around for some time, as have meat substitutes like tofu and quorn. There's a new generation of products though (particularly plant based burger patties) which are claimed to come much closer to matching the real thing. They're also being marketed with the same promissory narratives (better for animals, people and the planet) as for cell cultured food so hence they've been included in this report.

1.4. Availability

"Beyond Meat" burger patties can be purchased at Whole Food supermarkets throughout the USA at a cost of US\$5.49 for two ¼ pound patties or US\$24.20/kg. "Impossible Foods" burger patties can only be brought at select restaurants in the USA at this stage and cost US\$18 as part of a burger meal with fries.

Image 3

A 'Beyond Meat' plant based burger purchased by the author from wholefoods



There are no cell cultured products on the market yet. Perfect Day Foods predict they will have a milk product in supermarkets by the end of 2017⁵ and Memphis Meats say they will be selling cell cultured meat into food service chains within 3 years and will have retail products within 5 years.⁶

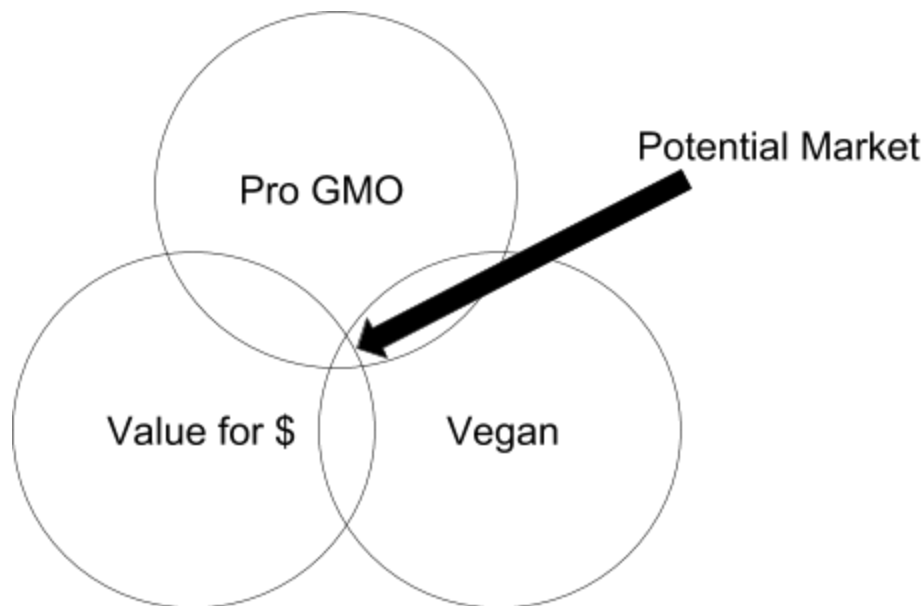
1.5. Markets

Consumer perception will be critical to the uptake of SF. In a survey conducted by Maastricht University, 79% of the people surveyed didn't know what cultured meat was but 52% said they would definitely or probably try it if it were available in supermarkets. 63% said they wouldn't pay more for it than they would for animal meat.⁷ In another study⁸ most consumers expressed an initial disgust at the idea of eating cultured meat and couldn't see how there would be any personal benefits. Some were more open to the idea if they understood the potential societal benefits. Nicki Briggs from Perfect Day Foods said that they've been getting strong interest in their cultured milk concept but, "consumers won't compromise personal health for a perceived future societal benefit".

Based on current consumer groups, the market for SFs could actually be very small as displayed in the following diagram⁹.

Figure 1

Potential market for SF as explained by Dr James Richardson (Texas A&M University)



SF companies are very aware of this and are being careful not to appeal to just one group. "We don't want to be labeled as vegan because that's a limited market and might turn the average consumer away," according to Professor Mark Post of Maastricht University in Holland.

At the moment, none of the SF companies can match animal products on cost (even though the plant based milk and meat substitutes come close). Their target market is therefore the

conscious consumer who's heard about synthetic foods and is willing to pay more just to try something new or because they buy into the story. Perfect Day Foods (previously called Muufri) plan to begin production with a range of niche yoghurts and cheeses until their cost of production comes down. Perumal Gandhi, the co-founder of Perfect Day Foods, thought they would eventually become cost competitive and that it would be cow's milk that ends up being the niche product.

While the initial reaction of most people when first introduced to the concept of SF is negative, it's conceivable that this could be managed through clever marketing that plays down the negative connotations and focuses on the perceived benefits. If SF becomes widely accepted, it might not only be on supermarket shelves but could also make up a large component of ingredients within the foodservice sector. There are many examples of substitutes or blends on the market now (margarine, artificial sweeteners, non-dairy creamers etc), which consumers seem to trust and readily accept. While the initial reaction is currently 'yuck', it could become 'who cares' over time which would give SF a free licence to infiltrate the food chain.

Image 4

Non dairy creamer at a hotel in Florida



2. The Drivers and the Claims Behind Synthetic Food

The most significant aspect of SF for agriculture at the moment are the drivers behind it and how it's being promoted. SF is being marketed as the way of the future - a silver bullet for a lot of the world's major problems that are being associated with conventional agriculture. Conventional agriculture is being stereotyped with smart and simple messages that paint it as archaic and detrimental to people, animals and the planet. At the same time, SF is being portrayed as the next step in human evolution. The drivers and the claims behind SF are critical to understanding the motivations of the people producing it and where they plan to take the industry.

"We're developing a way to produce real meat from animal cells, without the need to feed, breed and slaughter actual animals. We expect our products to be significantly better for the environment, the animals and humanity" (Memphis Meats website, 2016)

Image 5

Images from the Beyond Meat website



The main drivers are broken down into the following sections.

2.1. New Technology

The development of new technology and the advancement of existing technology is a significant driver behind SF. There are plenty of examples of industries that have been transformed through technology: e-mails replacing letters, microwave ovens replacing conventional ovens and, closer to home, synthetic carpet replacing wool carpet. The basic principles behind food production will always remain the same - a nutrient source and an energy source are required to

turn raw materials into something edible for humans. However, there's a chance that technology could allow it to be done vastly more efficiently than conventional agriculture.

The theory behind the plant based foods is that plants can be broken down to the basic components of proteins, carbohydrates and minerals and re-constructed as meat and milk substitutes that are similar to the real thing. It takes more energy and land area to grow animals than it does just to grow plants ¹⁰ (18 times the land area to supply a meat based diet vs a plant based diet according to the Cowspiracy movie) so in theory, plant based meats could be made with less resources. Synthetic meats such as Quorn, which is made from fungus, and Tofu, which is made from soy, have been on supermarket shelves for years along with a growing range of plant based milk substitutes like almond and rice milk. The new generation of SFs supposedly get a lot closer to the real thing though by adding other ingredients such as heme (a component of blood) which gives meat the red colour and a certain flavour. It's claimed that the new generation of plant based SFs have a much more realistic look, feel, smell and taste.

Using fermentation to make food obviously isn't a new process, but it's the gene editing and 3D printing technology that's allowed Perfect Day Foods to create milk proteins without a cow. They download the cow genome off the internet, select the genes that they require, get them 3D printed by a third party then insert them into a live yeast cell which secretes the proteins once fermented.

Perfect Day Foods believe that the ultimate system would be to have a tissue "udder" that could be fed nutrients directly and it would produce milk. Leila Strickland of 108 Labs in North Carolina is working on exactly that. She explained that she's able to take mammary cells from either cows or humans and get them to secrete milk outside of the body.¹¹ The cells are currently collected from abattoirs (in the case of cows) and from hospitals that perform human breast reductions (in the case of humans) but she envisaged a time when the cells themselves could be grown with the same process used to make cell cultured meat.

Growing meat cells in the lab to be used as food instead of for medical purposes isn't a completely new concept but it was more science fiction than reality up until 2013. Mark Post, the creator of the first lab grown burger, has used his background in vascular tissue science to take the technology from a medical use to a food use. At this stage, only a mince-like substance can be created because of the challenges involved in replicating the structure of real meat. Only the muscle cells were used for the first prototype, but work is now being done on replicating fat cells to add flavour as well as growing the cells on a 'scaffold' to create something that has the textural characteristics of real steak. Blood serum from animals is currently being used as a growing medium; a plant based substitute has yet to be developed, although Mark Post was 95% confident that it would be.

The meat pattie created in 2013 cost €250,000 but Post forecast that in 5 years time the cost would be down to \$US65/kg. He has proved that the concept is possible and, with further advances in technology, he firmly believed that cell culturing would replace conventional meat

production. 3D printing a steak that's ready to eat still seems like a fantasy at the moment but there's plenty of work going into making it a reality.

Image 6

The author with Mark Post holding €10,000 worth of cell cultured meat - Maastricht University



In contrast, most of the advances in technology within agriculture seem to be incremental changes to the same model. The compounding effect over the last century has been impressive but there's a sense that enough blood might have been squeezed from that stone and, if anything, agriculture needs to de-intensify. Initial signs of SF production are that it could be more efficient and have fewer tradeoffs than agriculture and, considering the early stage of the industry, one can only assume that there are many more technology advances still to come.

2.2. Animal Welfare

There seems to be a growing perception in the world that livestock farming is cruel to animals. People are becoming further removed from the idea that it is farms that produce their food, as the generational link back to a farm slips further into the past. David Salmonsens of the American Farm Bureau explained that “100 years ago, the majority of the population in USA were farmers and now they make up only 2%”.¹² This is just a reality of the growth in urban populations and the amalgamation of farms, however a negative outcome is the diminishing understanding of farming practices. Many in the developed world now have limited knowledge of how their food is produced, and little or no relationships with those who produce it.

Animal welfare activists are very effective at filling the void of information by using the media to spread selected examples of poor practice in an attempt to turn the public against farming. They're far more co-ordinated at telling the bad stories than farmers are at telling the good stories, even though they're often built on emotion rather than fact. Andrew Campbell, a dairy farmer and social media specialist from Ontario USA made the observation at the 2016 CSC that “statements from activists don't have to be true, they just have to be believable”.¹³ The net result is that a lot of people associate animal farming with cruelty and will make buying decisions based on their perception.

Although it's not overstated on the various SF websites, animal welfare often came up as a strong reason for producing SF when researchers or the owners of the companies were interviewed. In the USA in particular, there was a perception that large scale farming was bad for animal welfare. Animal welfare is on the radar for consumers more than ever and products that are marketed on the basis of providing a better life for animals can attract a premium.

Image 7

Milk being marketed as better on the basis of animal welfare - Whole Foods, San Francisco



Perumal Gandhi from Perfect Day Foods said he hopes that “cell cultured milk will replace that from factory farms”.¹⁴ He thought there’d always be a niche market for small dairy farms because “they look after their animals” but he despised ‘industrial’ farms with herd sizes in the thousands where the cows spent their life within stalls lying in their own excrement.

Mark Post from Maastricht University in Holland estimated that his cell cultured meat production system could feed the world with beef using just 35,000 cows to provide the stem cells. His view was that it would be best to keep a herd of animals to maintain genetic diversity, whereas Perfect Day claim they can do away with the cow and just download a copy of her genome off the internet.

The numbers, and perhaps more importantly the sentiments, are really stacked against agriculture when it comes to animal welfare. It’s already been proven that SFs can be produced without (or with only minimal use of) animals so it will become more and more difficult to justify the farming of livestock in the face of any growing consumer resistance.

2.3. The Environment

Agriculture and livestock production in particular is being labeled as one of the lead causes of most of the world’s anthropogenic environmental problems. Links are commonly drawn to soil degradation, deforestation, water pollution, loss of biodiversity, overuse of resources and climate change. One of the most referred to reports is “Livestock’s Long Shadow” which was produced by the Food and Agriculture Organisation of the United Nations (FAO) in 2006. It estimates, for example, that agriculture is responsible for 18% of the world’s greenhouse gas emissions which is higher than that from global transport. While calculations like this are based on estimates and huge assumptions, and there are other reports that conclude both higher and lower levels of emissions, there’s a growing acceptance that agriculture is having a significant effect on the environment.

A 300 page report such as “Livestock’s Long Shadow” isn’t going to be read by the general public but there are plenty of books, blogs and movies that address the topic in a more digestible format. One such movie that’s had widespread viewing is “Cowspiracy”¹⁵. It’s centered around the idea that a plant based diet has less impact on the environment than a diet containing meat. The movie cherry picks facts and examples to support an obvious agenda of discouraging livestock farming, however it’s well done, and in the absence of some good balanced discussion, makes for a compelling story.

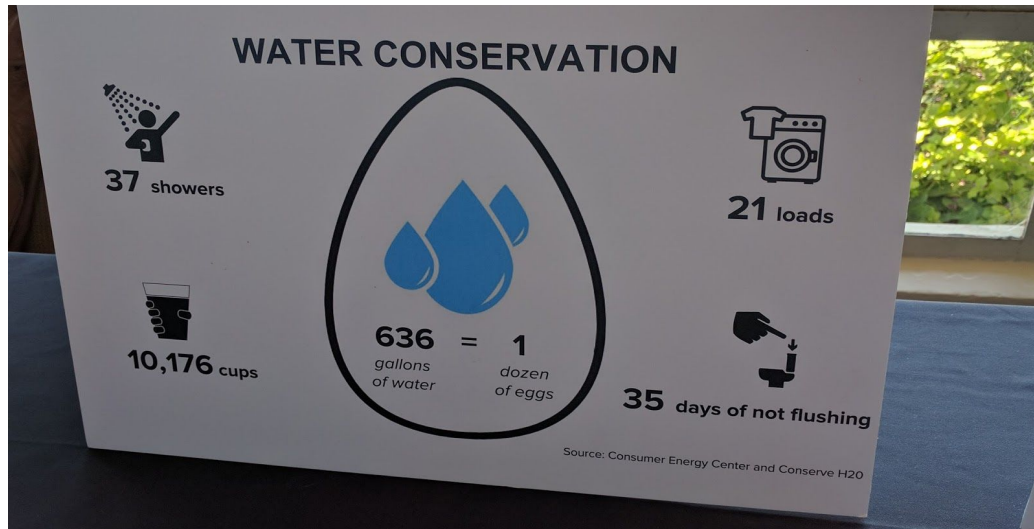
SF producers are using environmental impact to differentiate themselves from agriculture. They use measurements from a particular industry and line them up against estimates of their own production system to try to sell the argument. Perfect Day Foods claim that their cell cultured

milk will require 98% less water, 90% less land, use 65% less energy and will emit 80% less CO₂, compared to milk production from cows.

Clara foods, which aims to produce egg whites through a similar cell culturing process, hasn't put any numbers around their own production system, but make claims around the environmental impact of conventional egg production to distance themselves from it.

Image 8

Clara Foods stand at the 2016 New Harvest Conference



Mark Post wants to be able to keep eating meat but believes that current farming practices are unsustainable. He wouldn't make any claims about the environmental impact of cell cultured meat but "felt like it could be more efficient".

Impossible Foods, the makers of plant based beef patties, has done a life cycle analysis (LCA) of its product and compared it with various LCA studies for animal beef. It's claiming that their version emits 76 - 90% less carbon (CO₂ Equiv.), requires 91 - 97% less land and uses 86 - 91% less water.

As the global awareness of environmental issues and the pressure on governments and consumers to mitigate anthropogenic effects increases, links to agriculture will continue to be drawn. A number of countries are now recommending that their citizens eat less meat in an effort to curb climate change, including the Chinese government who's recommending a 50% reduction on current levels.¹⁶

Agriculture has held relative immunity from mitigation measures in many countries (e.g. exclusion from the NZ emissions trading scheme) because of the need for people to eat. This debate may be revisited in the light of SF if it can be proven that similar products can be made with a much smaller environmental footprint.

2.4. Nutrition and Food Safety

The nutrition and food safety driver behind SF's can be categorised into two main areas;

- 1) providing cheap protein to undernourished people who can't currently afford it; and
- 2) creating products that actually deliver a healthier diet to people who can afford food but don't necessarily eat well.

In developing countries where money and resources limit nutrition, people want more cheap protein, and as incomes increase so does the level of consumption. In China, dairy consumption increases 0.8% with every 1% increase in income.¹⁷ In theory, there's a strong market for alternative meat and dairy products that are competitive on price simply because there are people in poorer countries who are undernourished now. If SF could be produced at a low cost in the areas that need it, it could be a means of feeding undernourished populations.

In developed countries, the issues relate more to overconsumption of certain food groups like saturated fats, sugar and salt, along with the under consumption of other food groups like fruit and vegetables, which leads to health issues like cardiovascular disease (CVD) and diabetes. In particular, there's increasing evidence linking the overconsumption of meat and processed meat products to CVD. In theory, a shift toward plant based meat substitutes could lead to a reduction in CVD where this is an issue.

The SF companies are making bold claims about their products in regards to nutrition and food safety.

Figure 2

Content from the Perfect Day Foods website



2.5. Population Growth

More people means more food consumption, which means more farming and more intensive production. This has been the message for NZ farmers in recent times and is the justification for pushing scale and productivity.

There's now plenty of commentary though to suggest that this linear model isn't going to work and that population growth is actually a reason to look for an alternative to conventional agriculture. The global population is projected to reach 9.7 billion by 2050 and yet the size of the planet stays the same and the natural resources used to make food are shrinking. It doesn't paint a great picture and while there's plenty of food in the world to feed everyone at the moment, not everyone is being well fed. "Those in the world's poorest countries will remain the most vulnerable to malnutrition, who are least able to access good quality protein sources (from both plants and animals), and will worsen if costs of protein increase" (Billing, 2016).¹⁸

Simon Billing from Forum For The Future explained how their recent study into the challenge of supplying enough protein for the world's population identified SF as a promising alternative to large scale agriculture, saying, "Cheap animal protein might be a thing of the past".

There have been great efficiency gains in agriculture. However, the trends in population growth coupled with resource scarcity would suggest that doing more of the same, just slightly better, won't be enough. People are looking for a step change in the way we produce food and SF could become part of the solution to feeding the world's growing population.

2.6. Wealth Creation

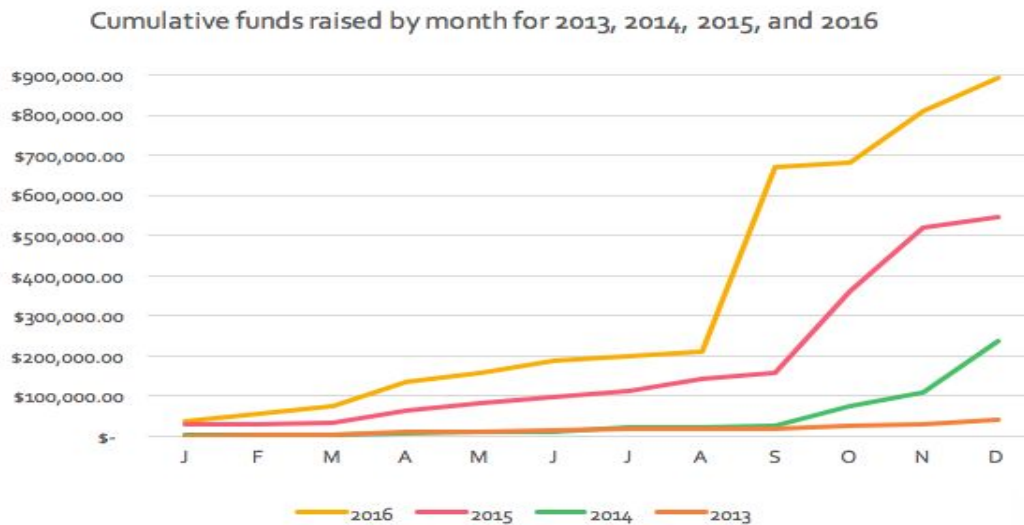
Wealth creation is the other main driver behind SF because people see it as an exciting new industry and a way to make money. The funding going into SF can be broken down to two parts:

- 1) Seed funding to help companies get off the ground; and
- 2) venture capital where investors are funding startups in return for a stake in the company and a return on investment.

One of the main facilitators of seed funding is the non-profit organisation New Harvest. New Harvest is based in New York and acts as a fundraiser and facilitator to help new SF companies get off the ground and raise general awareness about the industry. It's not a huge funder when compared to the venture capital market but has grown significantly over the past four years as shown in Figure 3.

Figure 3

Graph showing the fundraising achieved by New Harvest



Another form of seed funding has been philanthropic investments like Sergey Brins' (co-founder of Google) \$330,000 support of Mark Post's first lab grown burger. The funding allowed Post to hold a media event where the first burger was tasted on TV and the concept was launched onto the world stage.

The venture capital market is a different story and seems most developed in the USA. It's a whole industry on it's own, led by a few big players like Kosler, Sequoia and New Horizons. The big players can afford to take big risks on new ventures, partly because they have the capital behind them but also just because others will follow them and justify their decisions. To a certain extent, the investment decisions of the big players don't just follow trends but actually lead them because of the secondary funding they attract. Rob Leclerc, the founder of Agfunder in San Francisco explained how "investment from one of the top tier funders sends a message to the rest of the market which starts a snowball effect".¹⁹

People are investing in SF because they see it as an emerging market with huge growth potential. For the SF companies themselves the funding is like fuel going into a jet engine that increases the power which in turn, draws in more fuel. The initial funding allows the development of a business case which attracts more funding to pay for a CEO who can do some clever marketing to attract more funding to pay for the actual development of the product. If it all comes together, the company grows exponentially in a short space of time. Impossible Foods was established in 2011 to create plant based meat and cheese substitutes - it's held four funding rounds and attracted US\$182m from the likes of Bill Gates, Horizon Ventures and Kosher.²⁰ There's a buzz around SF and it's attracting money on the basis that it could be the 'next big thing'.

3. Implications for NZ Agriculture

3.1. Threats

SF currently poses two main threats to NZ agriculture. It could reduce demand for all animal products by damaging the reputation of animal farming and/or it could compete directly for market share if the SF products can be made to a similar standard at a lower cost.

Direct competition in the form of end consumer products (plant based burgers, cell cultured milk etc) is unlikely to be a significant threat in the near future because the plant based alternatives just aren't the same (experience of the author) and the cell cultured products that might come closer to a match are still in early development. There's an imminent threat though that SF competes strongly in the foodservice sector. It's hard to see a real steak ever being replaced by a plant based substitute but it's not hard to see McDonalds offering a veggie burger range or doing a 50% meat, 50% veggie blend to reduce its carbon footprint. It will sound ridiculous until it happens. Entry into the foodservice chain could rapidly increase the scale of SF and decrease consumer resistance.

NZ could be one of the first primary producers to feel the impact because of its reliance on export markets. If countries in North America that currently take 58% of NZ's exported beef ²¹ can suddenly fill demand through domestic production of cheap synthetic beef, one can only assume that imports from foreign countries will be the first supply on the chopping block.

The long term threat is that the overall demand for animal products could reduce if the overwhelming message to consumers is a dumbed-down generalisation about the global food system..... "SF good, animal farming bad". NZ products may not be differentiated well enough in the eyes of consumers to maintain a niche market based on clean/green, free range, pasture fed etc. The general consensus at the moment is that there's little difference in carbon emissions between a pasture based farming model vs an intensive confinement model and despite the best animal welfare standards in the world, ²² the NZ farming model would be hard to justify up against a production system that doesn't need animals at all. The NZ farming story could get lined up and shot alongside other countries without a real trial.

3.2. Opportunities

Competition from SF could lead to a reduction in demand for the real thing, but if that were the case, there would also be opportunities for farmers to be part of SF production. The most obvious opportunity at the moment is supplying the plants used to make plant based foods - as with the likes of soybean production for soy milk. The most common inputs seem to be potatoes, peas, wheat and soy which all have to come from somewhere. Landcorp Farming Ltd, NZ's largest farming company, has been in talks with Impossible Foods to consider if growing the ingredients could be a viable land use option to reduce its environmental footprint in certain areas.²³ Cell cultured food not made from plants directly still needs plants to provide a feed source for the cells to grow on. In the case of Perfect Day Foods, the source at the moment is glucose and sucrose, derived from wheat, corn or soy. If farmers still own the land and control what it grows, then it's conceivable that farmers remain an integral part of the supply chain

A niche opportunity could be supplying the stem cells needed to sustain the cell cultured meat industry. Illtud Dunsford, a farmer and specialty meats producer from Wales, has set up a venture with Bath University to look into such a partnership. His ultimate goal is to produce high value, specialty meats through a cell culturing process by using cells from traditional breeds. He has an interest in providing another income stream for small farmers but is also excited by the concept of growing the meat that he wants for his butchery without all the by-products. When interviewed he explained, "The trouble is, there's only so many good cuts of meat on an animal and the rest is either low value or a waste product".²⁴

Image 9

Illtud Dunsford at his butchery - Wales



On a different scale but with similar thinking, Paulo Gaspar from Lusiaves Group (the largest poultry producer in Portugal) was at the 2016 New Harvest conference and wants to be part of the SF industry if it takes off. His family's company is renowned for innovation and he's looking for a chance to invest with a cell cultured food producer to hedge his bets on their conventional poultry production.

There could be an opportunity for NZ Food companies to be early investors in SF. Other conventional food companies are already investing. In 2016 Tyson foods, the largest US meat company brought a 5% stake in Beyond Meat, and Danone, a large dairy processor from France, has purchased Whitewave Foods, a plant-based dairy producer based in Denver USA. While SF is being touted as a replacement to agriculture at the moment, it could instead be used to complement it. The likes of Fonterra, who already has vast expertise in nutrition, food processing and distribution, not to mention a global network of customers who are loyal to the company and its brands, may be in a perfect position to add a SF product range. A synthetic food option or blend could give consumers a choice based on environmental impact, animal welfare or a certain nutritional aspect that isn't currently available. This could ultimately increase the demand for cow's milk by widening Fonterra's consumer base and educating consumers about the NZ farming model. It could also be a means of 'flattening out' the supply curve for the dairy industry if cultured milk production could be increased over the winter months when conventional milk production is traditionally down. The synthetic food industry pales in comparison to the size of the NZ's agricultural industry at the moment so now might be the perfect time to invest and shape how it evolves.

Perhaps the biggest opportunity for NZ farmers right now is simply getting better at what we do. This doesn't mean working harder and producing more for less, it means changing farming systems and doing a better job of explaining them to give consumers what they really want. We need to shift from 'defending what we've always done' to 'doing the right things because it's the right thing to do'. Animal welfare is a great example of this. Yes, the often discussed rural/urban divide leads to a lack of understanding on the part of urban folk when it comes to the intricate details of daily life on a farm. This doesn't mean though that consumers shouldn't have just as much say (and possibly more) on how animals should be farmed if they're the one's buying the product. This extends to the environment, where farmers currently have the responsibility of managing public resources like water, and to nutrition where consumers become ever more aware of what goes into producing their food. SF could ultimately give consumers more choice. The opportunity for NZ farmers is to listen to consumers and offer them even better choices.

The long term opportunity for the NZ primary sector is being one of the world's farmers of choice. Animal products provide a trusted source of nutrition which our bodies can readily utilise because we've evolved with them as part of our diet. Animals also form part of our culture as companions, a revenue source and in some cases, a currency. Despite some predictions, it seems unlikely that animal products will ever be completely replaced. Just as the Germans are synonymous with precision engineering, NZ could be the exclusive producer of premium natural food. This is no new concept and many farmers will roll their eyes at the 'adding value' rhetoric

but the stakes could be higher than ever if SF becomes a significant part of the food chain. NZ has the natural assets, the farming expertise and the political stability to produce natural food better than anyone else. If SF takes off and there's little opportunity to join in, then the NZ farming sector could play an important role in sustaining animal products as a vital part of our diet.

Conclusion

The concept of making food synthetically isn't entirely new. People have been using technology to create animal product substitutes for years and consumers don't think twice about eating or drinking them now. There's a new generation of SF companies becoming established though which are being driven by growing global trends and perception around modern agriculture. SF companies may be exaggerating the trends in an effort to promote their own product in some cases but that's not to say that the trends aren't real. There's an increasing awareness of the impact that agriculture is having on the environment, on animals and on people's diets. While agriculture has held relative immunity from mitigation measures because 'people need food', SF is bringing that immunity into question by providing an alternative.

In an era where disruption is viewed as progress and where there's a venture capital market poised to throw petrol on the flames of every 'next big thing', there's a real risk that agriculture will be labeled as yesterdays news. It's too soon to say whether the leaps in efficiency claimed by the SF companies will actually be achieved and whether consumers will switch to alternatives based on perceived future benefits but agriculture is likely to experience some turbulence while the answers are worked out.

There is space for farmers to educate consumers on how they produce food but there's potentially more space for farmers to educate themselves on what consumers want. If the amount of interest in SF is an indication of the discontent toward the current food system, then there's reason for farmers to take notice. The threat is that consumer demands keep changing regardless of whether or not farmers are listening. The opportunity for NZ farmers is to take notice and be a part of the change.

Recommendations

1. Raise the Awareness

That Ag industry organisations (Federated Farmers, DairyNZ, Beef and Lamb, NZ Young Farmers, Dairy Women's Network etc.) help to raise the awareness of SF amongst farmers. This needs to be done with as much objective information as possible so that farmers can build an understanding of SF and the implications instead of just building a wall to defend their patch.

2. Get Involved

That food processors, including NZs co-ops keep a close eye on developments in the SF industry. There's a party going on in the SF world at the moment and our food companies (including co-ops) need to just turn up uninvited. There were no NZ companies at the New Harvest conference on Cellular Agriculture in 2016 but it would be good to see a NZ contingent at the next one. It would be even better if Agriculture had representative speakers at such conferences to balance the debate. NZ food companies could also invest in SF companies right now to have some say in how the industry develops. The SF startups are hungry for capital but also lack the nutrition, product development, marketing and distribution expertise that many of the NZ food companies could offer.

3. Understanding the NZ Food System

That the Ministry for Primary Industries develops clear and simple messages about NZ Ag based on its unique attributes that will differentiate our food production from those in other parts of the world. Tomorrows consumers will be looking for label claims on carbon emissions, soil conservation, animal welfare, GM as well as nutrition so the sector needs headline figures which it can proudly stand by. Much of the data is already available but it's buried within scientific reports and needs to be packaged up in a form that's easy for food companies to disseminate and consumers to understand.

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Appendix 1

Record of interviews

Date	Person / Company Interviewed		Main Topic
22/1/16	Rennie Davidson (ANZCO, Christchurch)	Personal interview	Awareness amongst the NZ meat industry
4/2/16	Andrew Gibbs (Deloitte, Wellington)	Phone interview	Awareness and uptake in Middle East
9/2/16	Isha Datar (New Harvest, USA)	Phone interview	Purpose of New Harvest. Who's doing what and where
11/2/16	Ian Proudfoot (KPMG NZ)	Phone interview	Relevance of SF to NZ
22/2/16	David Pachico (Agresearch NZ)	Phone interview	NZ Ag and carbon emissions
25/2/16	Cathal Garvey (Indibio Ireland)	Personal Interview	Biotech and its application to food
9/3/16	Dr Edmund Harty (Dairymaster, Ireland)	Personal Interview	Awareness in Ireland
21/4/16	Sandy Norman (Tesco South Africa)	Personal Interview	Awareness and uptake from supermarkets
25/4/16	Haylon Smith (NZ trade commissioner - Middle East)	Personal Interview	Awareness and uptake in Middle East
3/5/16	Mark Post (Maastricht University - Holland)	Personal Interview	Production and uptake of cell cultured meat
10/5/16	Alexandra Sexton (Kings College, London)	Personal Interview	Consumer perceptions and uptake
12/6/16	Illtud Dunsford (Welsh Farmer)	Personal Interview	Opportunities for farmers
16/5/16	Neil Stephens (Brunel University, London)	Personal Interview	Evolution of SF

16/5/16	Simon Billing (Forum for the future, London)	Personal Interview	Global food systems
17/5/16	Abi Glencross (Kings College, London)	Personal Interview	Making a cell cultured steak
13/7/16	New Harvest Conference (San Francisco)	Multiple speakers about SF production	Production, environment, animal welfare, consumer uptake, funding
15/7/16	Rob Leclerc (Agfunder San Francisco)	Personal Interview	USA venture capital market
16/7/16	Perumal Ghandi (Muufri - Now perfect day foods)	Personal Interview	Science and the drivers behind cell cultured milk
25/7/16	Dr James Richardson (A&M University - Texas)	Personal Interview	Awareness and uptake in USA
31/8/16	Tim Mackle (DairyNZ)	Personal Interview	Potential impact on NZ dairy industry
9/12/16	Phil McKenzie and Gordon Williams (Landcorp Farming Ltd)	Personal Interview	Landcorps approach to climate change and SFs
9/12/16	Suzi Kerr (Motu, NZ)	Personal Interview	Climate change and NZ Ag
14/12/16	Jeremy Hill (Fonterra)	Phone Interview	Fonterra's stance on SF
15/12/16	Nicki Briggs (Near Boil, New York)	Phone Interview	Consumer trends