The Steaks Are High
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How can architecture promote an intense grazing system that will define an educational farming facility that can bring forth a new and highly sustainable culture of beef farming?

Masters Thesis Explanatory Document

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Abstract

This research shows the design of an intensive, multi-storied beef production facility that competes with the output rate of the current, American based, Feedlot Model.

This research is about the design of an intensive, multi-storied beef production facility that competes with the output rate of the current, American based, Feedlot Model.

This Feedlot initiative of the late 19th century was intended to reduce the cost of beef by eliminating the cowboy driven herds of stock from the southern states of America north to Chicago by introducing a corn-based feed regime. The repercussions of corn feeding have subsequently been discovered to be very detrimental to the short term health of cattle, to the long term health of beef consumers, and health of the prairie ecosystem of the American mid-west.

This research limits its focus to a future reality, where it is hypothesised that expanding corn crop acreage is no longer possible, while the increasing world population continues to demand beef. A tower configuration (attempting to rival feedlot production concentrations) stacks feeding platforms vertically. The platforms initially assumed the grass/ruminant symbiosis as the model of healthy alternative intensification of beef production.

However, while attempting to incorporate stacked rotational grazing, it was discovered that the growth rate and density of ryegrass was unable to sustain the concentration of animals needed to justify the capital investment of a vertical beef ‘farm.’ A compromise was made and rotational grazing was then replaced with a hydroponic fodder production process. The fodder is generated by growing barley in a much shorter growth cycle than rye grass. This dramatically reduces both the scale of the tower and increases the tonnage of beef produced.

The project demonstrates how architecture can facilitate an intensive beef production operation (from breeding, to slaughter) within a dramatically reduced footprint, this allows the operation to be introduced into the urban environment, thus, bringing beef production to the people.

The dramatic visual appearance of these farming towers in the metropolitan landscape should raise the consumer awareness of the origins and implications of their food.
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1.0

introduction
1.1 Research Question

How can architecture promote an intense grazing system that will define an educational farming facility that can summon a new and highly sustainable culture of beef farming?

Figure 1.2 New Zealand Jersey Cow sketch.
Currently, New Zealand is not yet faced with an extremely high beef demand and extreme degradation of land. Therefore, we are able to take the animals to the grass which is a much healthier and economically successful alternative than making large investments in moving grain and animals to feedlots. But what will happen as the population continues to increase?

The aim of the project is to design an intensified farming system, which will be stacked vertically. The intensity nevertheless requires respect for the ‘one bite’ rotational grass fed beef farming method that resulted from Lincoln University (NZ) research in the late 1980’s.

This has the underlying intention of demonstrating that the intense farming effort of the beef corn feed lots of the American mid-west are inadequate on a number of levels.

The project will ultimately provide opportunities for education, demonstrating sustainable, natural methods of raising livestock to beef farmers globally. Such education will also involve the general public in reforming the link between the community and the origins of its food. Today, this understanding has generally been replaced with prepackaged meat and supermarket aisles. The goal is to incorporate into the project specific operations which organize and facilitate the cyclic process of grass fed beef farming. These include, but are not limited to:

- Grazing and feeding areas
- Meat works facilities
- Product sales and export facilities
- Educational facilities
- Systems/monitoring facilities

Through the exploration of layered pastures; the project will produce a dense farming system that can demonstrate a practical way of achieving grass fed beef output comparable to the corn feedlot beef output.
1.3 Outline of the Project

The following passage is a brief description of the focus and extents of the project.

The project will explore the possibilities of using an intense version of rotational farming methodology that have been applied in different parts of the world to transform desert into arable land. The project will pay careful respect to the principles of naturally grazing animals of the grasslands located in the temperate plains of earth between 66° north and 23° south. The project aims to formulate an architectural solution to promote the production of organic grass fed beef, through the modelling of the natural grassland ecosystem. The semi–intense modern agricultural version of that ruminant/grassland ecosystem is known as ‘Rotational Farming’. Rotational Farming is the localized, fenced grassland replication of the natural, wild original symbiosis of grass and ruminants.

Architecture that accommodates the natural life cycle of cattle provides many challenges, principal amongst these being the replication of this complex ecosystem. The challenges of modelling a complex ecosystem to produce organic beef within an architectural proposal, include, but are not limited to: functionality, productivity, economical, educational and social issues. The fusion of architecture and the complexity of a natural livestock cycle will entail an exploration of all organisms’ needs and relationships within the livestock’s designed ecosystem. The ecosystem will take account of the implications of the natural elements (sun, rain, etc.) which will fuel the eco system, rather than fossil fuels.

The functionality of the proposal will take into account animal wellbeing, product demand, urban conditions, site location, spatial planning, integration of natural elements and the relationships between the different parts of the building that fulfil different purposes.
1.4 Focus and Challenge

The focus of the project is to design a vertically arranged farming system that harmoniously combines the two following ideas:

- The production of healthy grass
- The rehabilitation of infertile land (as a global principle and objective)

The project will also serve the purpose of educating the global agricultural community about the symbiotic relationship between these two issues and, more importantly, how they are both equally reliant on one another. The production of quality beef cannot occur if grass is not the major source of the animal’s daily consumption.¹

Furthermore, if grasslands are not exposed to the grazing of ruminants the necessary cycles are unable to occur to promote the next growth of grass to come through, soon the land will dry out and become desert (see page 142 in appendix for further explanation).

The primary challenge of the project will be achieving density, whilst abiding by rotational farming methods. The risk of disease and illness is increased remarkably when animals are tightly grouped, certain precautions will need to be considered to ensure the quality of the products and the animal’s wellbeing. Such risks can be avoided by carefully planned grazing and the replication of the animal’s natural environment.

The project aims to address two major global issues and bring them together with the hope that future farmers will recognise the importance of reuniting ruminants with grass (refer to pages 142 and 146 in appendix for further information).


Figure 1.3 Ayrshire Cow cleaning itself.
1.5 Methodology

The modelling of a complex ecosystem will rely heavily on specialised information encompassing all organisms involved, symbiosis and natural cycles, and how each of these factors are affected by intensity and climate.

Below is a summarized overview of the research method.

Problem Statement
Understanding the aims and objectives of the proposal in order to seek the relevant information.

Surveying
Seeking information, categorising and organising data.

Analysis of Data
Extrapolate key points from the data pool to both include in the research document and to inform the conceptual phase of the project.

Reference of data
To refine and guide architectural proposal in later phases.

Design will be an on-going research method. As each of the above steps are taking place design will be utilized to discover new findings whilst producing solutions to problems identified in the researched data. All concepts and prototypes will be evaluated with reference to the sourced information and main considerations (functions, logistics, ethics and animal wellbeing, productivity) to support the reasoning for each design decision that is made.

Figure 1.4 Farmer with Jersey Cow sketch.
existing knowledge
2.1 Issues
2.1.1 Global Beef Farming Industry

The project will be driven by the premise that, currently, humanity has become trapped by a production system that, in order to meet growing population demands, has led the industry to raise unhealthy beef.

Beef farming in the 21st century is heavily reliant on two major elements; fossil fuels and corn. Corn is the most heavily subsidized crop of American commercial agriculture. It accounts for approximately 32% of deforestation in the U.S. currently. Fossil fuels are then required to harvest and transport the corn to the feedlots. In the U.S, this production system produced a record 1.17 million metric tonnes of beef in 2013. Clearly the ecosystem has lost priority (feedlot numbers continue to increase whilst grasslands become scarcer) as beef output continues to increase (not only in America but also China and other major export hubs) in an attempt to cater for growing populations.

It is believed that geographically constrained agricultural practices and land ownership have caused the global farming industry to destroy the symbiosis between ruminants and grass. Nowadays, global farming practice is either very intense grazing or has eliminated grazing altogether to maximise beef output, which is argued to be detrimental to the grass and soil structure. Locational issues are becoming a prominent threat for the global beef farming industry as many external factors, such as climate change, desertification and pollution, are reducing the area of grasslands.

The project will address these issues by providing education demonstrating to beef farmers sustainable, natural methods of raising livestock. Such education will primarily target agricultural specialists, but will also appeal to the general public to help reform the link between people and the origins of their food.

Some would argue that beef farming is inefficient and unsustainable and should cease. This project does not concern itself with this issue; instead it seeks solutions for growing beef demand and aims to display the implications for the public. Refer to page 148 in appendix for the positive dietary implications of consuming beef and the concerns of a vegetarian diet.

5 Pollan, Omnivore’s Dilemma, 121.

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4 Allan Savory: How to green the world’s deserts and reverse climate change,” TED, accessed February 10, 2014.
2.1.2 21st Century Beef Production

Beef production begins with a cow-calf producer who maintains a breeding herd to sell calves each year. Beef calves are weaned at 6 to 9 months of age (weighing approximately 320 – 360kg) and are transported to a feedlot. The majority of beef cattle spend approximately 4 to 6 months in a feedlot. The conditions of the feedlots are typically unsanitary, congested and stressful. The cattle are fed a mixture of corn, alfalfa, silage, mixed with liquefied fat and protein supplements, liquid vitamins, synthetic oestrogen, and antibiotics.

This feeding mix does not respect the animal’s digestive system or their nutritional needs. The drugs basically keep the animals alive in conditions that would otherwise kill them. Rapid production at low cost takes priority over the wellbeing of the animals and quality of the beef products. The animals are kept just long enough to reach market weight (around 12 months old weighing approximately 550kg – 630kg) then they are transported to a slaughter house.

At the slaughter house the animals are filed one by one into a ‘knocking box’ where they are shot between the eyes with a pneumatic gun. The gun shoots a steel bolt into the cow’s skull; this is expected to kill the cow. However, cows are often not executed properly at this stage of the process and regain consciousness when they are being bled, skinned and dismembered.


9 Ibid, 30.
10 Ibid, 67.
The success of any given grass fed beef farm is completely reliant on the dry matter output of the land on which the animals graze: the farmer’s ability to grow grass. If a farmer can create an optimum environment for grass growth he will get the maximum level of productivity from the land (no matter the scale). Growing grass, however, can be extremely complex as there are a number of parameters which must respect and relate to one another for the entire system to function effectively.

Such parameters may include:

- Number of animals on any given area of land
- Duration of time animals can spend on any given area of land
- Duration of time until animals can return to the same piece of land
- Climate
- Irrigation
- Sunlight
- Fertilisation

A large part of the project will be focused on how architecture can promote grass growth. Ultimately, the density aspect of the scheme relies on grass production. If the architecture can help to produce a high dry matter output then a method can be formulated to increase the density of beef farming whilst respecting the health and wellbeing of the animals.

The process of producing lush grass is not only for the benefit of grazing animals, but more importantly for the incredibly diverse community of organisms beneath the land surface. Approximately 1/3 of the root system dies when 1 cow feeds on a plant. Those roots rot and produce a biological feeding ground for billions of microbes, nitrogen fixing fungi, nutrients and earthworms. The digestive systems of such organisms transform micro rock and plant debris into rich and fertile excrement, dirt.

Dirt produces the necessary nutrients for almost all manner of plant life to occur. Through their root structures; plants and grasses lift nutrients from deep in the earth, injecting it back into the system by making it available to all organisms higher in the food chain.

Therefore, the production of grass via planned ruminant grazing embodies a network of ecological processes that serve countless species.

Modern agricultural practices (feedlots/grain fed beef) use up the top soil faster than natural processes can restore it, thus destroying the micro systems eventually evolving into a macro ecological crisis.

Figure 2.6 Ryegrass sketch.
Figure 2.7 Image of Kikuyu grass on site.

12 Pollan, Omnivore’s Dilemma, 157.
2.3 Rotational Farming

Rotational farming relies on the same principles as the natural habits of ruminants, but is an operation designed for a smaller scale and is planned depending on many factors specific to a particular farm.

Rotational farming is conducted by a concentrated group of animals continually grazing and moving in a particular cycle that is calculated to best promote the grass growth for that specific soil and vegetation type. Planned Grazing mitigates harmful pathogens that often occur when animals are grouped together. The soil structure and fertility benefit greatly from the rotational sequence of the animals.  

Factors such as the size of the herd, breed of the animals, type of soil, variety of plantation species, climate and demand for product can be different. Various other animals have been introduced into the rotational farming cycle to replicate natural processes or compensate for the increased intensity of the more localised rotational process that would not in fact be a problem for the original symbiotic relationship on the temperate grasslands.

For example, farmers have deployed chickens to follow their smaller herd. These reduce the insect populations, particularly flies in the animal’s dung, by scratching and feeding on larvae. They then fertilize the ground with their own much more dispersed nitrogen rich droppings, which are less offensive to the ruminants than is their own dung, meaning that they can rotate back into that part of the paddock much sooner than the original natural process would have allowed.

One other factor would be the introduction of dung beetles. Dung beetles excavate tunnels under the ruminant’s dung. The earth soil is deposited on the surface. The dung is then pulled down as small balls into tunnels to form incubation sites for the eggs of the beetles. This process reduces manure coverage on top soil, decreases methane emissions by up to 70% and pulls the nutrient rich manure directly down to the grass root structure.

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Figure 2.8 New Zealand tunneling dung beetle sketch.
2.4 Rotational Farming: Dietary Implications

Cows are not designed to consume grain; the move from grass to grain has altered the genetic make-up of the beef which has negative dietary implications when consumed by humans.\(^1\)

High stress levels in cattle have been proven to deplete the sugar (glycogen) reserves in the meat. It is important that the glycogen levels remain as high as possible to prevent harmful bacteria from infecting the meat, especially during the slaughter period.\(^2\) Therefore, in the proposal an element of comfort will be sought for the animals.

Grass fed beef (depending on the breed of the cow) contains approximately 2 to 5 times more omega 3 than grain fed beef.\(^1\)

Also, there are 3 strains of saturated fats in both grass fed and grain fed beef (stearic, palmitic and myristic). However, grass fed beef has significantly less palmitic and myristic saturated fats which are the 2 strands that cause high cholesterol.\(^2\) One other reason why grass fed beef is superior to grain fed is that grass fed contains considerably more vitamins, minerals and antioxidants.\(^2\)

Refer to page 148 for further dietary implications of beef.

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\(^1\) Kirby, *Animal Farming*, 102.

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\(^1\) Kirby, *Animal Farming*, 92.
\(^2\) Ibid, 112.

Figure 2.9 Frisian calf.
2.5 Global Beef Consumption

Reports have shown that global meat production has gone up 600% since 1950. This clearly is a result of the dramatic growth in population over the past 60 years.  

Traditional techniques of farming meat are unable to keep up with today’s high demand. This means modern machinery and mechanised systems are employed to co-ordinate meat production and distribution processes. Historically, people’s dietary choices about eating animal proteins were largely dependent on where they lived. In places with extensive grasslands people would gravitate toward grazing livestock. Coastal areas and island communities would rely on fish as their staple protein source. Today almost all products are easily exportable therefore the location of where the meat is produced has little to no influence on where it may be consumed.

On a per person basis, global beef consumption now averaging around 8.9 kilograms per year has dropped since the 9.3 kilogram average of the 1970’s. The population (growing by nearly 80 million a year) cannot escape the limits of nature, short term alternative methods such as feedlots, poultry factories and fish farms are being relied upon to feed the majority of the world today.

The EPI reports that there simply is not enough grass to keep up with the increased meat demand, the prices of the food are also increasing.  

The global meat industry must respect the earth’s ecology by rethinking meat and fish production practices to best serve both the earth and its inhabitancy. The current systems are detrimental in two major ways, firstly, due to mechanisation and mass production; carbon fuelled machines release tonnes of toxins into the atmosphere each year. Secondly, extracting animals from the environment by placing them in concentrated facilities terminates symbiosis between certain organisms, destroying natural processes and eventually leading to an imbalanced ecosystem.

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26 Ibid.


29 Ibid.

Figure 2.10 Diagram illustrating meat consumption per capita.
2.6 Precedent Architecture

Although the majority of the precedents sourced do not address the notion of grazing cattle in a vertical arrangement directly, each includes design initiatives that may contribute to the development of the project.

The analysis aims to identify the specific elements in each precedent that can inform areas of the project with similar functional requirements; for example, hydroponic systems or energy harvesting methods.

The investigation seeks to examine how the intense production of organic matter can take place above the ground level.

Figure 2.11 Photo montage of precedent architecture.
Precedent 1

Circular Symbiosis (competition entry), Chicago.

The concept of this precedent is to create a new habitat to raise cattle within the city. The skyscraper consists of spiraling platforms, or grass fields where cows will be free to roam. The designers claim that transportation costs will be non-existent and the raised animals will have a better quality of life. The project is located in Chicago as it has one of the highest beef consumption rates per capita in the world.30

Aspects of this precedent may be useful for the development of this research project, such as, the arrangement of the terraced pastures in relation to animal circulation and sun exposure. Refer to page 150 in appendix for further analysis of this precedent.


Figure 2.12-2.13 Internal renders of the project.
Figure 2.14 Diagrammatic renders explaining how the tower functions.
The “Ecological Design In The Tropics” Tower is being built with the financial support of the National University. This 26 storey tower will have over half its surface area covered by organic local vegetation. Up to 40% of the building’s energy demands will be produced by solar panels. Human waste will also be converted into an energy source via an on-site bio-gas facility. The Architecture firm TR Hamzah & Yeang is constructing the building using recycled and recyclable materials where possible.1

Like the EDDIT Tower, the research project will look to provide as much energy as possible, whilst putting in place cattle waste management systems.


Figure 2.15 Aerial render of the project.
Figure 2.16-2.17 Diagrammatic and sectional renders describing project.
Figure 2.18 Perspective render of tower.
The project was formulated around the idea of creating an independent ecosystem that speaks about cultural values and sustainability. The pavilion is derived from traditional values combined with contemporary culture. The architecture attempts to blend the two ideas together, promoting open mindedness whilst confirming the positive stereotypes of Dutch living by incorporating windmills and tulips.\textsuperscript{32}

The project puts forward ideas in response to dense populations and overcrowded cities, such as clean energy initiatives and multi-level public spaces. The architects claim that the act of arranging plantations on numerous levels above one another provides not only an extension of existing nature, but also an extravagant symbol of its artificiality.\textsuperscript{33}

The concept of an independent ecosystem in response to dense populations, is highly relatable to the research project.


\textsuperscript{33} Ibid.
Sky Greens, Singapore.

Sky Greens in Singapore is the first commercial vertical farm in the country. Hundreds of slowly rotating water powered aluminum structures support troughs of water through which the plants pass every eight hours. The farm grows numerous varieties of bok choi and cabbages which typically cost more but are popular among locals because it is locally grown and thought to be safer than imported produce. All organic waste on the farm is composted and reused.1

The Sky Greens project promotes ideas about mechanization and moving elements, which may be important for the irrigation and fertilization of pastures in the research project.


Figure 2.21-2.24 Internal photographs of the growing troughs and supporting aluminum structures.
Precedent 5

Vertical Farm Research Centre, South Korea.

An exploration of a building inhabited not by people but by plants, an agricultural farm where automated systems monitor spaces that have been technologically equipped to mimic a natural environment. From sunlight to humidity to carbon dioxide levels, the indoor environment is continually adjusted to allow for continuous plant growth regardless of exterior conditions. In certain parts of the building LED lights run 24 hours reducing the time to harvest by half. Oxygen and recycled carbon dioxide are pumped in to feed plants and generate systems. The plants are fed and circulated throughout the building via a semi-automated hydroponic system.

The Research Centre has been designed effectively as an incubator for natural processes, this research project will likely adopt the same architectural position in order to create a suitable environment for grazing ruminants.

The concept behind this research building is bringing actual farming practice and space into the core of cities. The ‘greenscraper’ could potentially bring jobs and fresh produce to underprivileged areas of inner cities and serve as ‘beacons of green technology.’

The project questions if the technologically advanced ‘greenscraper’ would spark some form of ‘Agro-tourism’ where the building could potentially attract outsiders and help to rehabilitate deprived or ignored areas of cities.

The design is stackable and modular and is based around a central core where all services and systems are deployed and distributed. The project architect Jacobs argues that this is the most efficient method to fully automate the building, whilst still maximizing natural light. The design can potentially cultivate a number of plant species with sectors that can be closed off from others to ensure different environments within the same building.

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37 Philip Jodidio, Green Architecture Now (TASCHEN America Llc, 2009), 138.
38 Ibid.
39 Ibid, 140.
3.0

design process
The aim of the project is to design an intensified farming system, which will require vertically arranged grazing pastures. The intensity nevertheless requires that the 'one bite' rotational grass fed beef farming method that resulted from Lincoln University (NZ) research in the late 1950’s be respected. The project will allow the semi-intensity of rotational grazing to shift into a seriously intense grass fed production that will produce nutritionally superior beef to the existing feedlots of America. The project will be sensitive to the physiology and psychology of ruminant animals.

**Design Parameters**
The proposition of elevating and or layering pastures above the ground level that are to be maintained for rotational farming include a host of design issues; these include, but are not limited to:
- Irrigation
- Exposure to sunlight
- Circulation and transportation of animals (horizontal and vertical)
- Ventilation
- Treatment of animal waste

The following systems will be required to enhance the project’s productivity and sustainability:
- Energy production (sun and possibly wind)
- Rainwater harvesting
- Animal waste treatment
- Methane gas harvesting

**PROGRAMME**
- Animal Transportation Dock (pick up and drop off)
- Educational Facilities
- Laboratories/Testing Facilities
- Breeding Facilities
- Pastures/Feeding grounds
- Viewing platforms
- Process Plant/Slaughterhouse
- Rendering Plant
3.2 Animal Journey - Arrival through to Slaughterhouse
An exploration investigating the light/shadow qualities of vertically layering and/or staggering floor plains.

The orientation and positioning of the pastures in relation to one another will be critical to allow light and therefore photosynthesis to sustain the grass cycles as the animals graze. This means that the floor plans must overlap and/or be offset in such a manner that grants each level an adequate amount of daily sunlight.

Figure 3.2 Conceptual montage of cows inhabiting the layered pastures.

Figure 3.3 Conceptual models predominantly investigating light and shadow.
A selection of possibilities in response to ruminant movement and circulation.

A user friendly yet productive response to the movement between pastures and vertical transportation of the livestock will be highly important. The aim is to systematically rotate the stock around the pastures to achieve a self-sufficient farming operation.
Sun and Site Orientation

An exploration investigating the possible arrangement of pastures in response to sun orientation (north facing).

This concept was derived from the idea of a linear journey. The animals would start grazing from one end, moving up the rises until they reached the other. Tracking the animals along one path would be a simple method for holistic management; ensuring the animals are not under or over grazing. Northward sloping sites would be most useful for the ramping form shown in figure 3.9.

Figure 3.8 Conceptual montage of ruminants occupying ramp systems that offer grazing and circulation areas.

Figure 3.9 Further conceptual models predominantly investigating light and shadow.
The ‘helix’ form allows sun exposure, whilst generating a visual form that expresses movement and journey. The cattle can be systematically monitored whilst they circulate up and or down the levels.

The floor plates, or parts of the floor plates, could slowly rotate throughout the duration of the day exposing the void to maximum sunlight.

Figure 3.12 Conceptual model and sketch exploration of an offset spiraling form.
Central Core Structure

*Investigating the idea of a structural core that serves as an anchor for ‘pastoral leaves,’ branching out from the central point.*

This form explores the idea of completely breaking up the floor plates by reducing each level to a ‘leaf’ which stems from the core. This form reduces the area of elevated pasture, but completely opens up the structure to the elements. The leaves overlap one another slightly; omitting an area of shade for each level at different times in the day.

Perhaps a balance between the full floor plates and the ‘pastoral leaves’ may be ideal; thus producing a sufficient area of elevated pasture, whilst allowing the elements to promote the grass life.

Figure 3.13 Sketch/photograph montage of a conceptual spiral tower model.
Figure 3.14 Investigating spiral form via computer generated models.
Figure 3.16 Sectional sketches exploring possible tower forms.
Floor Plate Arrangement

Floor plan layouts based around one central hub.

Identical floor plates may stem from one major structural core. The core could potentially incorporate the vertical circulation (for both ruminants and people). The core would also provide a central distribution hub on each floor for a number of requirements such as irrigation systems, energy systems and specialised feeding facilities, i.e. fodder and maize silage.

The floor plates must be dissected into segments in order to allow maximum light exposure to the majority of the pastures for the duration of each day. Various light/shadow tests can help to evaluate which floor shapes and floor to floor heights will best promote the grass growth cycle.

Figure 3.17 Computer generated models exploring floor plate forms and shadow.
Figure 3.18 Floor plate structural development.
Figure 3.19 Conceptual models of numerous floor plate arrangements.
Structural Balance

On each level the structural load of each floor plate could be countered by an identical floor plate directly adjacent.

This system may allow for little to no perimeter structure which would be ideal for solar exposure. Tension cables would be necessary to enforce further structural support on each level. In this case the core would serve as the central structural anchor with each floor plate branching off it. The floor plates would be off-set on each level allowing sun exposure spiraling vertically, creating the form of a double helix.

Figure 3.20 Diagrammatic illustrations of the 'double helix' concept.
Figure 3.21 Conceptual section investigating floor structure.
Balanced Floor Plates with Tension Cables

The balanced floor plates spiral around the core producing a double helix form.

With each level a huge amount of stress would be supported by tension cables. Here lies an opportunity to investigate megalithic tension structures for both their strength and the aesthetic qualities. A ‘web’ or ‘net’ of tension cables could also potentially serve as a weather buffer and/or shading device for the particular pasture it supports.

Tension cables will allow for the perimeter of the tower to have little to no structure; therefore exposing the true form and functionality of the tower to the public and surroundings.

Figure 3.23 Sketch of a model and double helix form.
Figure 3.24 Elevation of tower indicating levels of program.
3.4 Design Development: Tension Cables

*Santiago Calatrava demonstrates the structural capabilities of tension cables whilst producing a sculptural language throughout his projects.*

Calatrava demonstrates a series of different applications to achieve successful tension structures; these include overlapping, cross hatching, fanning and parabolic curves.

It is in this manner that tension cables could be introduced to the project to help break down the rigidity of the current conceptual form.

Figure 3.25 Photographs of Santiago Calatrava’s Projects demonstrating tension structures.
Tension Cables

Sketches demonstrating a series of tension formations that could support the individual hydroponic shelving systems.

The tension cables could wrap fully around the core to support the opposite edge of where the cable began. A series of overlapping cables wrapping around the core would both strengthen it, and offer a dynamic aesthetic to the otherwise megalithic surface.

The cables would also help to integrate the dramatic horizontal planes with the dominant vertical core.

Figure 3.26-3.29 Conceptual sketches showing variations of tension cables.
Figure 3.30 Conceptual sketch showing tension cables from the core structure.
To achieve the maximum level of density and, therefore, dry matter output; the pastures can be closely stacked to produce a hydroponic shelving system.

Each floor sector spanning from the core will comprise of a hydroponic shelving system. The shelving system is a series of closely stacked pastures that are cultivated via artificial systems only. The systems will include irrigation, UV light, and fertilisation. By producing the pastures completely from artificial systems everything can be controlled and monitored, thus enabling the design to facilitate the perfect growing parameters for perennial ryegrass 365 days of the year.

The individual pastures will rotate on a tracking system out into the open void allowing a particular number of animals to graze for a day. The grass shelf will then rotate back into the shelving system until it has grown back to pre-grazing length (given optimum conditions, this will take 15 days).

Figure 3.31 Digital models illustrating the rotational tracking system.
Figure 3.32 Plan sketches illustrating the rotational movement of the stacking system.
Hydroponic Shelving System

This concept illustrates 6 floor plates stemming from the core on each level. Each floor plate consisting of 5 ‘grass shelves.’ By quantifying the grass shelves in groups of 5, a 15 day rotation plan can be easily monitored for the ryegrass re-growth period.

The shelving system will consist of:
- Heating pads to keep the soil at an optimum 20 degrees.
- A sealed environment to maintain an environment to maintain an ideal air temperature and to minimise contamination or disease.
- An irrigation system which distributes a solution of water and fertiliser in a mist form. The mist settles evenly over the grass leaves which permits maximum absorption for the plants.

By layering each floor plate with closely stacked grass shelves the weight and stress of the structure will be enormous. Perimeter structure will be necessary to support the operation. It will also be required to support the tracking system on which the individual pastures are rotationally mobilised.

Figure 3.33 Digital model demonstrating the hydroponic system.
Each group of grass shelves will operate from its own energy generator and water distributor. On each floor there will be 6 small generators and water distribution systems servicing the six sectors.

Each grass shelf will consist of structural beams connecting to a concrete pad embedded with hot water pipes. The Damp Proof Membrane creates a barrier between the concrete pad and the 300mm of soil. A hollow grid structure disperses the water/fertiliser solution via a sprinkler system, whilst supporting the fluorescent tube lighting 150mm above the ryegrass.

Each individual ‘grass shelf’ will be completely enclosed when it returns to the shelving system for the post grazing growth cycle. This is to ensure optimum growing temperature and lower the risk of exposure to disease and/or contamination.

The animal droppings left on the grass can be evenly distributed via a ‘raking system.’ The raking system will consist of a hydraulic mechanical arm with wire bristles. The arm will rotate from the core in a circular movement scraping across the surface of the grazed pasture breaking down the individual mounds of manure to an even spread. Dispersing the manure ensures that the ensuing process carried out by the dung beetles is significantly faster and more evenly distributed across the pastures.

Figure 3.34 Exploded diagram showing hydroponic shelf structural assembly.
Stacking Concept

This concept demonstrates a stacking system in which the stacked pastures are separated, allowing animals to be inserted to graze.

The cows inhabit the core of the building when they are not grazing. When it is time for them to graze a crane system lifts a sector of pastures allowing the cows to enter. Once the cows have eaten the grass down to the optimal post grazing level they are removed. The crane then lowers the stack back down allowing that section of pasture to regrow for 15 days.

The stacked pastures are supported on grid-like structural systems and orientated towards the centre of the building to optimise animal handling and circulation. The dry matter output of each pasture can be precisely measured by calculating the size of the area and by monitoring the growing conditions. The number of animals and time that they can spend on any given pasture can then be calculated to optimise the entire system.

Figure 3.35 Illustrations demonstrating the functionality of the crane system.
Figure 3.36 Plans demonstrating the crane function.
Figure 3.37 Exploded view of concept components.
Rotating Floor Plates

This concept facilitates a radial arrangement of shelving systems, stemming from the core.

The sectors of stacked shelves continue right to the ground level, the negative spaces between provide a zone for the shelves to rotate out, allowing animals to feed. Crane systems support the outer edge of the shelf as it is being moved into place. Once in grazing position; the outside edges of the shelves are temporarily fixed to one another and are supported by the crane for the duration of the grazing time.

Between the shelving systems, openings will penetrate the core structure, allowing animals to be transported to each level. Share walls will be located where the shelving systems meet the core.

Figure 3.38 Digital models displaying the crane function.
Figure 3.39 Sketches exploring crane function.
As the models show on the previous page consideration has not yet been given to how the pastures will connect with the ground.

Originally, it was thought a multi-story base that supported the diameter of the pastures would be ideal to house specific programmes and produce a formal entrance into the building. The base would visually anchor the building to the ground and create a buffer zone between the roaming animals and street level.

However, this investigation considers the complete opposite, that is, to minimise the ground connection and suspend the pastures above via tension cables and the structural core. A minimal ground connection may be optimal in a dense city environment, this model illustrates how that might be achieved and what the visual repercussions of suspended pastures could look like.

Figure 3.40 Digital exploration showing tension cable developments.
Ground Connection

These sketches begin to express some thoughts about base integration.

How might the hydroponic shelves relate to the base? This investigation shows ideas of ground connection. The dramatic expression of structure was considered; tapering the structure out from the core, defining a strong visual anchor to the ground.

In other sketches the base is minimal with little to no expression of how the internal spaces might be arranged.

Figure 3.41 Sketches showing base ideas.
Digital models were then derived from the concept sketches.

The first model illustrates a compact arrangement with tension cables tying back directly to the base. As the form was developed large vertical structural elements were added; connecting to the core whilst running up through the shelving systems. The void between the base and the shelving systems progressively increased, lifting the grazing animals higher off the ground and visually improving the proportions of the tower.

The void defines a clear break between the programmes within the tower. It also helps to reveal the structure defining an industrially explicit quality that the farming tower hopes to achieve.

Figure 3.42 Digital models showing design development.
Figure 3.43 Concept sketches investigating formal ideas.
David Fisher has designed the first ‘Dynamic Skyscraper’ in which every floor is able to rotate independently, thus producing a tower with a constantly changing form.

It is not the formal aspect of this design but specifically the mechanism which is used to rotate each individual floor which is interesting. If a similar system could be applied to this project then the individual rotation of each floor could be harnessed to increase pasture growing area and, furthermore, overall dry matter output of the farming tower.

Fisher’s revolving floors operate on roller bearers responding to individual slewing gearboxes which are controlled by the inhabitants of the floor.

The gearboxes are powered by horizontal wind turbines between each floor. Each floor functions as a revolving cantilever in much the same way that a standard tower crane operates. Loads are transmitted through to the ground via the concrete structural core. The core also serves as a circulation hub and utility spine housing 16 lift shafts and distributing services such as electricity and water.\(^40\)

\(^{40}\) Andres de Antonio Crespo, "Conceptual Design of a Building with Movable Parts" (paper presented at the Massachusetts Institute of Technology, Cambridge, Massachusetts, May 22, 2007).
Roller Bearings: Rotating Grazing Discs

After researching David Fisher’s ‘Dynamic Tower’ it became apparent that the same rotating mechanism could be usefully introduced into the beef tower.

The roller bearing system meant that the ‘grass shelves’ could now expand into entire rotating discs with a single niche cut out that would serve as an area for the animals to graze on. To create an entire disc on each level, would structurally stabilize the operation of the roller bearing system.

This design step also meant that the grass growing area could dramatically increase on each level essentially boosting the beef output of the tower. Instead of each level consisting of 6 grass shelves and 6 open grazing areas, each level now consisted of only one concentrated grazing area and the rest as growing area.
The number of cows 1 disc could feed per day was then calculated. Given a 25m span from the core, each disc could only support 3 cows (approximately 30kg of dry matter output per day). 15 discs were then grouped into one modular system (the 15 day regrowth cycle of perennial ryegrass). Each modular system consisted of the structural core component, 15 grass growing discs connected to roller bearings and 4 wind turbines projecting enough energy to sustain the 15 discs. This modular make-up presents an opportunity for a range of different sized towers.

The number of modules a tower is made up of will relate to the meat supplying zone intended for each tower. The base and roof design of each tower will remain similar as each tower will serve the same purpose. The direct context of each tower (dependent on the site location) may influence the roof and base design slightly.

Figure 3.50 Exploded module.
Figure 3.51 Illustrations of a 3, 5 and 7 module tower.
Physical models were then constructed, beginning with a basic cylindrical shape made up by a number of identical modules. This symmetrical form allows structural balance and simplifies cattle movement and grazing/growing operations. The continuity of the tower ensures that each module consists of the same dry matter output and grazing rotation as the module above. Differing the floor shapes and sizes would change the grazing cycle of any given module; animal rotation then becoming unnecessarily complicated. This first model incorporates educational facilities and testing labs separating each growing module.

It was then realised that one lab/educational facility would be sufficient for each tower, therefore, this model demonstrates how the growing modules are separated only by horizontal turbines. The horizontal turbines break up the solidity of the form. The turbines provide a moving component to the façade that offer a stimulating demonstration of the tower’s energy production. As the images show, modelling a base for these towers has not yet been attempted. Further understanding of programme layout and connection will help to inform the base structure.

Figure 3.52-3.53 Physical models showing the development of the cylindrical tower.
Differentiating the diameters of the modules, producing non-cylindrical forms was investigated. These non-cylindrical towers would continue to function just as the cylindrical tower, but different sized modules would feed a different number of cows for a different number of days. Therefore, each module would need to operate on a different rotation speed; this would only complicate the overall functionality of the tower. In terms of both practicality and functionality the tower will best serve its purpose if all modules remain identical.

Ways in which the grazing modules could be suspended off the ground to minimise the tower’s ground connection were considered. It may not be an issue in New Zealand, but if a beef tower was to be proposed for a dense city, perhaps in Asia, the building footprint may become a critical problem. As this project intends to create a model for international export; multiple solutions will be considered.

Figure 3.54-3.55 Physical models exploring formal ideas.
Figure 3.56 Section demonstrating the scale of the grass cultivating tower.
Introduction of Fodder

The previous section illustrates the monstrous scale at which the tower would need to be to feed 3 cows per plate per day.

Obviously the height and width of a 6 module tower is far too large to justify housing only 21 cows (as can be seen in the comparison to Auckland’s tallest building, The Sky Tower). A dramatic increase in dry matter output would be needed to reduce the scale of the tower whilst producing a viable yearly beef output rate.

Given that each ryegrass disc can feed only 3 cows per day and there is a 15 day turn around before the cows can return to the same disc, the beef output of the tower would be so insignificant that it could not justify vertically arranging the pastures.

At this point it became clear that perennial ryegrass simply requires too much space and grows too slowly to support such an endeavor. The parameters of the project began to change dramatically (refer to page 139 in appendix for further explanation) as artificial provisions were introduced and alternative animal food sources were considered such as ‘Fodder’ (refer to page 157 in appendix for more information about fodder).
Fodder Comparison

Fodder can produce up to 8 times as much dry matter per square meter as perennial ryegrass in less than half the time with an eighth of the water. The downside is of course that the barley seeds needed to grow the fodder must be farmed, harvested and transported to each tower.

Initially this project set out to utilize only perennial ryegrass and intensive grazing to produce a viable vertical beef farm. However, through the design process, it has become apparent that a compromise must be made, and fodder is an energy efficient solution to produce enough daily dry matter to increase the number of cows per tower.

If a square hectare crop of barley is harvested for its seeds and used to farm fodder, approximately 6 times more dry matter can be produced than harvesting a hectare of grain to produce forage, which is what feedlot animals are fed currently. Refer to page 156 in appendix for more information about fodder.

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41 Kirby, Animal Farming, 67.

Figure 3.58 Diagram comparing areas required and growing cycle for both perennial ryegrass and fodder.
Applying Fodder

How many cows a tower could feed if the perennial ryegrass was replaced with fodder was then calculated. The width of the tower was then reduced by 20m which meant the discs would span 15m from the core structure as opposed to 25m.

Given this new span each disc can produce approximately 4200 kilograms of dry matter every week which can feed 60 cows per day on a 7 day rotation. Each module will consist of 14 discs which can feed 120 cows. So, if the tower had just 4 modules it could produce enough dry matter to feed 480 cows.

Though the tower can produce enough dry matter to feed 480 cows, the grazing areas will not permit this many animals to graze at once. The tower requires a balance between perennial ryegrass areas and fodder growing areas so an ethical yet productive animal density can be achieved.

Figure 3.59 Elevations comparing the fodder tower to the ryegrass tower.
In order to create a healthy density of cattle sectors of fodder were introduced into the ryegrass disc rotation. Cattle eat approximately 11 hours of the day, their remaining hours being spent chewing cud and resting/sleeping. The sectors of fodder will be responsible for 80-90% of the animals dry matter intake per day. Some grazing will occur on the ryegrass sectors, but mostly these sectors will be for chewing cud and resting.

Also, to avoid overly dense grazing areas, the disc rotation speed can be reduced and animals remain on the same disc for a number of days. A slower rotation would give the animals a chance to rest, whilst still getting their maximum daily dry matter intake.

Figure 3.60 Plan view of grazing discs showing the integration of fodder

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Growing Discs

Each disc is supported by a primary structural member connected to the roller bearer mechanism. The roller bearing’s inner ring is directly fixed to the concrete structural core. Supported by the primary plate structure; the perimeter structure cantilevers out to the edge of the discs. The disc alternates between sectors of heated concrete pads (holding the ryegrass) and permeable polyester (holding the fodder). The Ryegrass sectors require much more depth than the fodder sectors, and will be considerably heavier. The structure supporting the ryegrass areas will require additional thickness and fixings.

Figure 3.61 Exploded module indicating the grazing disc.
Figure 3.62 Exploded grazing disc.
The two major components that must be addressed:
- Exposure and population
- Practicality and functionality.

The project must be appropriately sited so a balance between the above two issues can be achieved.

If the project were to be located in Auckland’s CBD the public exposure and awareness would be optimal, but numerous impracticalities led to locating the site beyond the density of the city’s core.

The project therefore located in Penrose industrial area of Auckland. This area has the potential to offer the project both public accessibility/visibility whilst catering to the functional operations of the project.

Locational Requirements

Such impracticalities included:
- Transporting cattle to the site
- Ethical issues such as sound and odour pollution (slaughter house, rendering plant)
- Value of the land against beef output
- Light exposure

Placing the project in a rural area would be ideal for the farming practice and facilities, but public accessibility and visibility would then become an issue.

The project is located in Penrose industrial area of Auckland. This area has the potential to offer the project both public accessibility/visibility whilst catering to the functional operations of the project.

Figure 3.63 New Zealand outline.
Figure 3.64 Site identification in Auckland region.
Site

It is understood that placing a structure on protected farmland is contradicting the aim of the project. However, the project will provide a much larger area of pasture than is currently offered within the area of the existing site (via vertical stacking). Not only will the project offer a greater area of farmable land, but the educational implications will be hugely beneficial to the future of farming.

The regional park has 360° visibility to surrounding areas and excellent motorway exposure. This natural pedestal can help to raise consciousness about the problems currently threatening the global beef farming industry. Creating awareness throughout the New Zealand public will aid the Commercial Verification Process of the prototype, eventually leading to international export.

Figure 3.65 Image of Mutukaroa-Hamlins Hill Regional Park.
Figure 3.66 Aerial shot of the site.
View from the front of the site toward the North.
View from the back of the site toward the North.

Figure 3.67-3.68 Photographs of the site and its direct physical context.
This new direction creates an opportunity to design the entire site, i.e. truck access and animal circulation between and around the towers. Each beef tower will not incorporate its own slaughter house and rendering plant, that would be impractical and energy intensive. Instead there will be one large slaughter house and rendering facility on site that caters for all towers.

Circulation routes for both cattle and transport throughout the site must be addressed, along with access for product pick-up and animal drop-offs. Large water reservoirs will be located on site that will distribute to each tower. Each tower will also have individual water collection systems contributing to the main water supply.

When the Matakaroa-Hamlins Hills site was first considered, one particular section of the park on the north side was selected (see pages 152-155 in appendix for more information).

It was thought that there may be around 4 - 5 towers located on the site to serve as prototypes for an exportable vertical beef farm proposition. As the project developed it was decided to utilize the entire park, that is, to cover the hills with a number of beef towers, effectively transforming the regional park into a self-sustaining ‘beef hub’ for the Auckland area and neighbouring regions.

This decision has changed the course of the brief, the proposal is constantly shifting and adapting as developments unfold. A small ‘city’ of towers will produce a bold and exciting spectacle, primarily viewed by those passing on the Southern Motorway.
Figure 3.70 Conceptual perspective from motorway looking south.
Livestock truck routes must be mapped strategically to ensure smooth operations when navigating around the site. The trucks will have multiple circulation paths that can be used dependent on which towers the animals need to be picked up from and/or dropped off to on any given day. An existing raceway off Great South Road can allow trucks into the site through the southern boundary.

The Regional Park has 2 existing swamp/lake areas in the 2 bush zones located on the northern side. These will be developed into large natural water reservoirs accompanied by pump houses to distribute water to all towers.

Figure 3.71 Conceptual sketches showing site plan development.
Approximately one kilometre south of the Matakaroa-Hamlin Hills Regional Park Reserve is one of New Zealand’s largest meat processing plants. This plant is more than capable of processing the output of animals per year that are raised in the farm towers. Therefore, the project will adopt the position that the animals will be sent to the existing meat processing facility once they reach market weight (which once they arrive on site will take approximately 1.5 years).

With this development the site will not require its own slaughterhouse and rendering plant so total focus can be put into the design of the beef towers and site development.

Figure 3.72 Aerial photo indicating distance from site to existing meat processing plant.
3.7.1 Isolated Sectors

As previously explained, the animals grazing rotation now consists of both perennial ryegrass and fodder. Approximately 80% of the animal’s diet will be fodder; the ryegrass sectors allow for the remaining 20%, but primarily provide an area for chewing cud and rest. The ryegrass sectors require less area than the fodder; therefore the plan and structure of the building was reconsidered to serve the grazing cycle in a more efficient manner.

The small sectors will consist of perennial ryegrass and will remain static. The large fodder sectors will be the rotating component which the cows will step up onto when they overlap the ryegrass sectors.

Figure 3.73 Digital model illustrating conceptual plans.
Figure 3.74 Plan with integration of concrete pads.
Figure 3.75 Sketches illustrating the development of the triangular plan.
Figure 3.76 Developed plan exploring the relationship between the fodder sectors and concrete pads.
3.7.2 Zoning and Structure

The animals enter the tower at ground level and are transported vertically via the central lift shaft. When the animals arrive at their allocated level they walk out onto the exterior concrete pads. The grazing rotation can then commence; the ramp and fodder sectors are connected on one level and the concrete pads are directly below on another. The fodder level begins a slow rotation while the concrete pads remain static; the animals walk up onto the ramp to access the fodder. The animals spend one full day on the fodder then return to the core whilst the trays are washed down and a new batch of seed is spread. The sector then returns to the shelving system and begins an 8 day growing cycle. Over these 8 days the animals advance to a new level each day. At the end of the 7th day the animals return to the level at where they began.

Figure 3.77 Colour coded plan showing different function.
Figure 3.78 Technical plan showing structure and circulation.
PERIMETER STRUCTURE

OUTER ROTATING TRACK

SECONDARY ROTATING TRACK

ROLLER BEARING SYSTEM

BRIDGE FROM CORE TO EXTERIOR CONCRETE PAD

CONCRETE STRUCTURAL PAD

ROLLER BEARING SYSTEM FIXED TO CONCRETE STRUCTURE

ROTATING FODDER SECTORS CONNECTED TO ROLLER BEARING SYSTEM BEARING SYSTEM OUTER RUNNER
3.7.3 Structure & Function

This iteration dismisses the concrete pads and engages the core of the building as a holding zone more than the previous concepts. In a similar fashion to the previous solution the fodder sectors rotate out from the shelves, allowing the animals to access the food for approximately 23 hours.

Each level of fodder is one homogeneous piece of structure, extruded into 3 sectors. The sectors rotate out from the shelf then click into place; supported by the permanent perimeter structure as the animals graze.

Figure 3.79 Digital model identifying elements.
Figure 3.80 Thumbnail plans showing animal circulation.
Figure 3.81 Thumbnail plans demonstrating the rotating function.
Figure 3.82 Technical plan displaying structural members and roller bearing mechanism.
This concept requires each petal to split, rotating out into the open void where the animals can graze. The animals are transported vertically via 3 lift shafts around the perimeter of the tower. As can be seen in the 3 vertical illustrations; the lift shafts serve as a perimeter structure for the rotating floors. As the floors rotate out from the shelf they connect to the lift shafts and are supported for the duration of the feeding time. Once the animals have eaten they are moved to a new floor. Before the grazed area rotates back into the shelf it is manually cleaned and a new batch of seed is spread. The floor then returns to the shelf and begins the growing process again. The animals rotate through 9 different levels for 9 days before they return to the same level. The central core structure is reserved for worker circulation and services.

Figure 3.83 Digital model identifying split level elements.
Figure 3.84 Thumbnail plans showing animal entrances and split level rotation.
Figure 3.85 Vertical thumbnail plans demonstrating split level rotation.
Figure 3.86 Technical plan displaying split levels and perimeter lifts.
3.7.5 Feeding Operation: Separate Fodder Facilities

At this stage of the tower development it became clear that each concept was designed for the animals to physically walk on the fodder as they eat; an attempt to replicate their natural grazing habits with perennial ryegrass. However, this would mean a large percentage of the fodder would be wasted as the animals would tread, urinate and leave droppings on a large portion of their food.

During this project, every fodder farming operation that has been researched grows the fodder separately, then transports to the animals. Obviously the hydroponic environment needed to grow fodder is much different to that of a ruminant animal. The temperature and humidity must be precise to promote optimal growing conditions; such conditions are not suitable for ruminants.

The project then adopted the position of isolating the fodder growing facilities, which meant the food would be brought to the animals numerous times each day. This operation would be worker intensive, meaning that people would be constantly in touch with the animals. This ensures that the animals are regularly monitored and observed; health issues and/or risk of disease will be recognised and can be handled immediately.

Separating the animals from their food raised numerous questions such as:

- How will the food be transported to the animals?
- What surface will be appropriate for the animals to live?
- Will this affect the animal’s quality of life?

Figure 3.87 Diagram demonstrating fodder feeding process.
The fodder distribution must work in conjunction with the rotation of the disc.

The fodder growing levels will provide food for numerous grazing discs. This could be both above and below the fodder facility.

The central lift shaft could be used to deliver fodder to the allocated discs. There could be more than one feeding zone on each disc.

A system of chutes could be employed to deliver the fodder to the discs quickly and efficiently.
4.0

Figure 4.1 Mother and calf sketch.
4.1 Static Structure with Rotating Floor

The circular geometry of the disc is primarily responsive to the cleaning procedure. Various shapes and forms were considered but the fixed radius revolving around the static center provides the greatest coverage of cleaning surface whilst allowing fodder to be evenly distributed.

The disc will spin 3 times a day for 30-60 minute intervals at walking pace whilst the animals are fed (see page 159 in appendix for the importance of ruminant physical activity). The animals will be fed along the edge of the bridge ensuring that they walk in a lineal arrangement perpendicular to the rotation of the disc.

This developed floor plan consists of an immobile structural disc, on which is a rotating surface for the animals to dwell. The discs are structurally connected both to the central core and the ‘spine’ on the south side of the tower. Between each disc is a lateral platform which connects the core to the spine and serves as a bridge for the animals to exit the lift shaft then enter the disc.

Between the bridge and the disc is a bail arm which collects all the animal droppings as the disc rotates. The solids are directed into a chute which then falls to the biofuel reactor at ground level (see page 157 in appendix for further information about biofuel reactors). Once it has passed beneath the bail arm; water jets then spray the disc, cleaning any excess waste and ensuring that the animals continuously have a clean surface to walk on.

Figure 4.3 Axonometric and sectional sketch investigating industrial form.
Figure 4.4 Sketch plans showing functionality of rotating floor, disc cleaning and feeding operations.
Figure 4.5 Plan illustrating primary structural members in relation to central core and animal lift.
4.1.1 Structural Loop

This design consists of two primary vertical structural elements; the central core and the spine. These two elements form a structural loop which supports the modules. The central core houses the services, worker circulation and fodder distribution operations. The spine is the animal lift. Each tower consists of water collection and storage system on the roof and a plant room at ground floor, housing the biofuel reactor and generators.

The curved expressions on the roof and spine/ground connection were proposed as possible water collection devices. These circular gestures were somewhat incompatible with the overall rigidity and industrial quality that the rest of the tower conveyed; and therefore were not pursued. The symmetry and sharp geometry of the tower acknowledge its functional purpose and suggest the intensive operations occurring within.

Figure 4.6 Sketch plan and section.
Figure 4.7 Perspective section through tower.
Figure 4.8 Section through tower showing structural loop.
Figure 4.9 Constructional perspective of grazing disc.
4.1.2 Elemental Breakdown

A tower may consist of 2, 3 or 4 modules. The modular make-up of any given tower is flexible and dependent on the context and site location, catchment zone or desired beef output rate.

Each tower consists of 5 major elements. The core and spine serve both operational and structural purposes. Connected to the spine are the cattle bridges which form lateral links to the core between each grazing disc.

Figure 4.10 Renders of 3, 3 and 4 module tower.
Figure 4.11 Exploded view displaying elements of tower.
4.1.3 Module Components

Each module consists of 3 grazing discs, a fodder growing facility and horizontal wind turbine. The discs have a 35m diameter and can comfortably house 15 animals.

The grazing discs have a gradual fall toward the core, directing animal waste into chutes and then drained to the biofuel reactor on ground level. The discs will be a concrete surface with sections of rubber tiles. The tiles provide a comfortable surface for the animals to rest on, with the added value that they can easily be removed and cleaned as required.

Figure 4.12 Exploded module.
Figure 4.13 Render of 3 module tower indicating module.
Figure 4.14 Exploded grazing disc.
4.1.4 Fodder Facility & Distribution

Each fodder facility feeds all 3 grazing discs within the same module. The hydroponic growing shelves can be moved on the circular tracking system. The shelves are divided into thirds (as illustrated in the sketch below), with each third containing 9 shelves. 1 shelf from each third is fed to one disc per day (each shelf containing approximately 165kg of dry matter). The shelves are taken down the central lift shaft and brought out onto the bridge platform which serves as the feeding area (as indicated on the diagrams to the left). Once the fodder has been distributed, the shelf returns to the start of the 9 day growing cycle. The fodder facility also includes lab and research areas, heated water tanks and staff kitchen/bathroom facilities.
Figure 4.17 Render illustrating interior of fodder facility.
4.1.5 Animal Arrival

The animals are delivered to the site by truck via the southern entrance indicated in figure 4.18. Stockyards are located at the base of each tower for trucks to offload and load cattle.

The stockyards will be used to give animal’s individual treatment if necessary, and help to divide herds before taking animals up to their allocated discs.

Figure 4.18 Aerial photo showing existing site entrance.
Figure 4.19 View from animal’s point of view arriving to site.
Figure 4.20 Diagram showing truck drop off/pick up area.
Figure 4.21 Render of truck drop off area at base of tower.
Once the animals are delivered to their allocated discs, they are moved out onto the platform spanning from the ‘spine’ to the core, before being shown to the disc.

The platform provides an animal holding zone, which makes for a smooth transition from lift to disc or disc to lift, for both the worker and animals. The platform includes along one side, individual holding pens, and on the other, a fodder distribution area.
Figure 4.24 View from animal lift onto platform.

Figure 4.25 View from platform onto disc.
This site plan demonstrates the strategic placement of 2, 3 and 4 module towers, primarily in relation to site contours and neighbouring industrial facilities. The 4 module towers are concentrated in the centre of the site (the highest areas). As the contours fall from the centre of the site toward the boundaries the towers decrease in size. The 3 module towers generally occupy the middle zone whilst the 2 module towers are positioned around the perimeter.

By placing the smaller towers around the boundary of the site, the change in scale is softened in relation to the surrounding built environment. Also, the visual exposure from the surrounding areas is dramatically increased by positioning the tallest towers at the highest points of the site.
Figure 4.28 Site perspective from Southern motorway looking north.
4.3 Density Comparison

Figure 4.29, 4.30 and 4.31 illustrate the daily food output capacity per hectare of ryegrass, corn and barley (from left to right). The barley diagram however calculates the amount of fodder that could be produced from a daily seed harvest.

On the left is the ryegrass tower and its animal housing capacity in comparison to the fodder tower on the right. The difference in scale clearly demonstrates the dramatic change in density between the 2 propositions. 180 animals would require 36 hectares to be farmed via the traditional grazing method. This research project proposes that 180 animals could be raised in healthy living conditions within a 961m footprint (approximately 0.1 of a hectare).

Figure 4.29 Daily food production from 1 hectare of ryegrass.
Figure 4.30 Daily food production from 1 hectare of corn.
Figure 4.31 Daily fodder production from the seed harvest of 1 hectare of barley.
Figure 4.32 Animal capacity of ryegrass tower.
Figure 4.33 Animal capacity of fodder tower.
4.4 Weather Buffers

Deployable weather buffers were considered for the towers, and would be most suitable for the highest discs; vulnerable to severe wind conditions. These attachments could be included dependent on the climate and site conditions of any given tower. These could be manually or hydraulically controlled on a basic hinge system, pivoting from a horizontal position, swinging down to latch onto the perimeter fence as shown in figure 4.35.

Figure 4.34 Stored weather buffer.
Figure 4.35 Deployed weather buffer.
Figure 4.36 Elevation showing stored buffers.
Figure 4.37 Elevations showing deployed buffers.
At this stage of the project the focus was on the master planning and development of the Matakarooa-Hamlin Hills Regional Park. To occupy the entire site with beef towers would be to propose a ‘Beef Production and Exportation Hub’ for the Auckland region.

Calves would be weaned and transported to the site from all over the North Island. An animal would spend 18-24 months in a beef tower before reaching market weight and being transported to the Meat Works Facility. The arrival and departure of the animals would overlap so that new animals can be filtered in with experienced animals to learn the feeding patterns and way of life within the towers.

Each tower would have water collection and storage at roof level to safeguard against a power outage (gravity fed irrigation). Non-lactating cattle produce approximately 20-25 kilograms of manure per day. Therefore, (dependent on the number of modules) each tower will have a biofuel reactor that could be treating and harvesting anywhere between 1.8 – 3.6 tonnes of manure per day. Once the solids have been harvested for methane, trucks will collect it and transport it to fertiliser plants. A 2 module tower will house 90 animals producing approximately 10 tonne of beef per year. A 3 module tower will house 135 animals producing approximately 15 tonnes of beef per year. A 4 module tower will house 180 animals producing approximately 20 tonnes of beef per year.

A 2 module tower will require approximately 4,500 litres of water per day (this includes the fodder irrigation and cattle drinking water), keeping in mind that 70% of the fodder irrigation water can be reused several times before it becomes potentially harmful to the plants. A 3 module tower will require approximately 6,500 litres and a 4 module tower will require approximately 8,500 litres of water per day. The majority of the water will come from the reservoirs on site, whilst further water will come from individual tower collection.

Each tower has 3 major energy harvesting methods; wind turbines, methane collection and solar energy. The collected energy will be stored in the plant room at ground level and used to power the motorised cog systems which rotate the discs and also maintain the required temperature/humidity in the fodder growing facilities and heat the fodder irrigation water.

Each tower requires significant human involvement. The fodder growing/cattle feeding operations will be labour intensive. Also the workers will be monitoring the animals preventing the risk of disease and ensuring they are fit and healthy. There will be a separate building to serve as a worker headquarters on site, so all site operations can be monitored and overlooked from one central location. This building will include changing rooms, kitchen facilities, toilets and showers to accommodate the workers on their shifts.

Also on site will be a visitor’s centre; this may include a café/tasting room, educational facilities, laboratories and a lecture room.
The initial purpose of the project was to produce a beef farming tower prototype for New Zealand, which could then be exported to countries around the world in serious need of a space saving beef production initiative. New Zealand is generally looked upon as an extremely successful farming civilisation. Therefore, if the tower’s validity could be tested and proven here, it would be more likely that much of the world would recognise the potential and consider investing in such a proposition.

The Matakaroa-Hamlins Hills Regional Park site has been designed as a projection of a distant future reality where a number of these towers could create something of a “Beef Tower Metropolis”. This cluster of 41 towers occupying 41 square hectares can produce as much quality beef as the traditional beef raising method of New Zealand over approximately 1100 square hectares.

Figure 4.38 World map indicating global export from New Zealand.

Many countries around the globe are becoming more and more dependent on the feedlot system. Depleting grasslands and desertification have left the farming industries with little choice but to corn feed their beef. Countries that do not farm beef at all rely on the American system for exportable beef products. The project will now adopt the position that countries request that these Beef Towers be located in their most populated cities. The project will present a number of towers in numerous cities around the world, and show how they can function within an urban fabric; **bringing food production to the people**.

One module of each tower will be dedicated to a breeding program; allowing the reproduction of animals to occur on site. This will eradicate the need to transport weaned calves from distant locations; producing a closed loop system (from birth to market weight). See page 160 in appendix for further information about artificial insemination.
Initially, it was stated that the project would incorporate a slaughter house and render plant within the tower. This requirement was later disregarded during the development of the Matakaroa Hamlin Hills Regional Park site (it was more practical for one large facility to service all towers). However, now that the towers are being proposed in different cities around the world it may be viable to introduce this idea once again (the incorporation of these facilities will be dependent on the location of any given tower in relation to existing meat work plants).

The slaughter house plan proposes a system of chutes that allow the bones, edible offal, non-edible offal and skin to be easily transferred to the render plant below. See page 163 in appendix for further information on rendering plants.

Figure 4.39 Section illustrating tower programme/functions.
Figure 4.40 Initial slaughter house plan.
Figure 4.41 Sketches describing the development of the slaughter house and render plant plans.
5.0

design outcome
Figure 1.4 Farmer with Jersey Cow sketch.
A series of external renders showing 3 module towers knitted into the existing fabric of cities around the world.
ELEMENTAL COMPONENTS
Top left: Abattoir, allowing public to observe meat preparation/packaging process.
Bottom left: Fodder Facility: Tempered hydroponic growing facility for each module.
Rotational grazing is the small scale, fenced replication of the original wild ruminant/grassland system, which produces fertile soil and healthy root structure. The tower originally aimed to demonstrate this farming methodology to re-educate agriculturalists about criteria that sustainable farming practice on grasslands needs to satisfy. Beef production in many regions of the world is now controlled by the cultivation of corn, therefore, much of the underlying principles of rotational grazing are misunderstood and go unrecognized. New Zealand is not yet faced with such problems, furthermore, the tower was proposed an exportable prototype for countries that could benefit from densified beef production.

The incentive behind the vertical arrangement of farming operations was to minimize the footprint, which might allow it to then function within an urban environment. From a political and economic standpoint, the motive was to locate farming towers in densely populated areas in order to promote food production amongst the people consuming the beef whilst educating agriculturalists about sustainable farming methodologies in the rural context around urban structure.

However, as the project developed it became apparent that far too much area was needed to vertically arrange a pasture grazing system. Numerous attempts led to very large propositions, generating very little beef output. A compromise was then made to introduce the Hydroponic Fodder System, which dramatically reduced the footprint and also radically increased the beef production. The compromise was that there may be reduced corn cultivation but it is replaced to an extent by barley cultivation. Although the attempts to employ pastoral grazing were unsuccessful, the result is still a far more sustainable option than the current feedlot system.

This research does not formulate a prediction as to when or where in the future a vertical beef farm might actually be plausible. Furthermore, it is not concerned with forecasting economic circumstances that may accommodate such a proposal. The project simply adopts the position that, due to the harmful factors stated in the document, the current beef farming industry cannot continue. Therefore, the research aims to provide a prototype that is more sustainable and ecologically friendly than the current system.

The research shows how density can be achieved without compromising the quality of the beef or the animals living conditions. The fodder system effectively moved the project from one extreme to the other; from the rotational grazing of animals on ryegrass, to, revolving discs with scheduled feeding procedures. Perhaps there is a middle ground yet to be explored, that integrates both farming ideologies. If so, the question remains; to what extent will inefficiency be tolerated to allow the natural grazing cycle of ruminants to occur, in order to restore the grasslands, and the nutritional integrity of 21st century beef?

5.1 Conclusion
Books


Dissertations


Hal Harding, interview by Shane Tregidga, Dargaville, Northland, May 12, 2014.

Interviews


Websites


The initial intention of the project was to intensify the process of grass fed beef farming by formulating a stacked solution. The incentive being, that the vertical arrangement of farming operations would minimise the footprint; allowing it to function within an urban environment. From a political and economical stand point; the notion to locate farming towers in densely populated areas was summoned to promote moving food production to the people whilst educating agriculturalists about sustainable farming methodologies.

However, as the project developed it became apparent that far too much area was needed too vertically arrange a pasture grazing system. Numerous attempts led to very large propositions, generating very little beef output. A necessary compromise was then made to introduce the Fodder system, which dramatically increases the beef production but relied upon the cultivation and harvesting of barley seeds. Fodder effectively moved the project from one extreme to the other; from traditionally grazing animals to, rotating discs with designated feeding procedures.

Figure 7.1 Mechanical cow sketch.
7.2.1 Ruminants of the Grasslands

In their natural habitat, ruminants eat grass and, by re-chewing it, (the word ruminant means re-chewing or what is known as chewing “cud”) digest it by using bacterial action in their three to four stomachs. Habitually, the animals grazing on a particular grassland area will take one bite of a grass plant and then move on. Just one bite ensures that the remaining grass does not die. However, some of the root structure in the soil does die. This die-off matches and is an equivalent of, the quantity of grass leaves eaten. The next wave of growth starts about four days after the eating of the leaves.

The dead roots then break down by composting processes into hummus, creating a nutrient rich topsoil to boost the general level of fertility of the soil for continued grass growth. As the animals continually move, following their seasonal grazing patterns, the previously grazed areas have time to recover. Over time this process produces a deep fertile soil through layers upon layers of decomposed grass roots. In some cases there was as much as a meter top soil depth on the American prairie, now there is only about 150mm to 200mm left.

Animals will not naturally eat grass right down to the soil, however, when animals are kept, artificially, in an area for too long, they are forced to take a second bite which then begins to destroy the natural cycle, eventually resulting in desertification. In such cases, fertilisers and chemicals are then necessary to aid the grass back to good health and alternative food sources are required to feed the animals.

Joel Salatin’s ‘Polyface farm’ (refer to page 158) is a prime example of clear documentation that demonstrates ruminants can re-establish the movement part of their symbiotic relationship with grass, the recovery of such depleted areas is very fast.


Figure 7.2 Migration of Wilder beasts, herd crossing a river.
7.2.3 Desertification

Desertification is the process by which arable land is turned into desert. There is one way to reverse desertification, and that is to re-unite the land with large herds of moving ruminants.

Desertification now consumes approximately one third of the earth’s total land mass; just one of the repercussions of the global farming industry designed around the requirements of the production system. It is proposed by Allan Savory that it is necessary to respect the natural habits of the animals and plants we consume in order to rehabilitate the damaged land.\(^46\)

The major causes of desertification also include deforestation and inappropriate agriculture (too much of one species creates an imbalanced eco system), which continues to occur, as the feedlots expand the demand for grain increases.

The overgrazing of cattle will also diminish the quality of grasslands. Planned grazing is required to prevent ruminants from eating the grass down to roots.\(^47\)

However, if grasses are left to grow with no ruminant contribution, as seasons change the grasses die forming a layer of decomposed plant matter across the ground. This forms algae, which increases water run-off and evaporation, making it virtually impossible for the soil to absorb moisture and, therefore, support plant life.\(^48\)

\(^{46}\) “Allan Savory: How to green the world’s deserts and reverse climate change,” Youtube Video, 11:32.

\(^{47}\) Ibid, 12:42.

\(^{48}\) Ibid, 5:31.
Figure 7.4 Identification of decertified areas around the world.
Allan Savory is a farmer, environmentalist and biologist. He has dedicated much of his life to the restoration of degraded land and is the originator of ‘holistic management.’

Savory’s methods are designed to replicate the ruminant habits that once nurtured the vast grasslands of the earth (described earlier). Savory challenges the conventional environmentalist understanding that ruminants are to blame for the degradation of global grasslands into arid deserts. In fact, he proposes that the absence of ruminants is where the problem lies.

Savory believes there is a fundamental symbiotic relationship between the ruminants and the grasses, furthermore, one simply cannot exist without the other. There is much speculation doubting Savory’s beliefs with the notion that the grasslands must be left alone in order for the ecosystems to repair themselves.

The current New Zealand farming method is proof in itself that Savory’s claims are viable, where animals are introduced to an area of ryegrass just before it seeds (approximately 150-200mm tall).

The animals are left on the piece of land just long enough to eat it down to around 50-80mm, they are then circulated to the next piece of land while the grass is given time to repair.

The animals are monitored specifically to eat the grass to this length and no more to ensure that there is enough leaf and root structure left to sustain the plants next growth cycle. Each time the grass is eaten down the root structure that grows back is more than what had previously died. So, the animals are in turn promoting a solid healthy root structure by periodically grazing on the same areas of grass numerous times.

Obviously there is no universal rule about this planned grazing method as variables are forever changing such as climate, number of animals, area of farm, type of soil etc. However, the underlying principle that both organisms benefit one another remains intact.

48 “Allan Savory: How to green the world’s deserts and reverse climate change,” Youtube Video, 11:32.
49 Hal Harding, interview by Shane Tregidga, Dargaville, Northland, May 12, 2014.
The development of the human body and mind has been fundamentally linked to the consumption of red meat in many ways. The acts of killing animals and consuming meat have contributed massively to human evolution and have a synergistic relationship with other distinctive qualities that make us human. The large human brain has benefited from consuming high quality proteins, and sequentially, hunting and killing large animals has contributed to the evolution of human intelligence and the development of language, planning, socializing and co-operation.

Human minds, organs and functions have progressed and operated on an omnivore diet. Therefore, the nutrients that we gain from both red meat and vegetables have become vital parts of our overall wellbeing. A balance between these 2 food groups is required for optimum health.

Certain nutrients can only be obtained through animal sources and all are abundant in red meat. These include Vitamin B12, Creatine, Vitamin D3, Carnosine and Docosahexaenoic Acid (DHA). Each of these is a vital brain nutrient which cannot be sourced from plants. The human brain only makes up around 2% of our body weight but uses 20% of our energy, therefore it is crucial that we provide it with the correct nutrients (as we should every organ) so that our energy is being effectively processed and utilized.

People who refuse to eat red meat must find alternative sources to gain their daily intake of such nutrients. However, many people do not realise that much of the nutrients supplemented from alternative sources such as fruits, nuts and vegetables are much harder for the body to consume and digest (thus it requires more energy and time) than if it were sourced from red meat, in particular iron and zinc.

Also red meat has higher concentrations of such nutrients, for example; 100g of red meat has around twice as much zinc as the equivalent quantity in nuts and 5 times as much as fruit.

“Meat consumption is a part of our evolutionary heritage; meat production has been a major component of modern food systems; carnivory should remain, within limits, an important component of a civilization that finally must learn how to maintain the integrity of its only biosphere.”

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52 Ibid.

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57 Smil, “Should Humans Eat Meat?”

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Figure 7.9 Sketch illustrating the evolution of the human skull. The size and shape primarily driven through the enlargement of the brain as consumption of red meat (protein) became a major part of the human diet. Figure 7.10 Photograph of a toddler chewing steak.
Detailed Critique: Circular Symbiosis Tower

This tower is merely a concept, it does to some extent investigate the vertical arrangement of pastures and the natural grazing habits of ruminants, but it fails to address many factors that would be necessary to promote this project as a plausible solution to the feedlot system.

The Symbiosis Tower does not address the density factor that this project is striving to achieve. Later investigations will reveal that ryegrass alone cannot produce enough dry matter for an intensified beef farming tower. Furthermore, the growth rate at which ryegrass grows under natural conditions is far too slow to validate an intense grazing cycle (artificial procedures can reduce costs for greater output).

In the Symbiosis Tower the cows are ‘free to roam.’ This means the tower does not acknowledge the importance and complexity of holistic management which would require the animals to be strategically monitored and constantly moved to maximize the grass output of each terrace within the tower. This tower is an interesting concept but a deeper understanding of its functionality reveals that the key principles of growing grass (thus producing beef) have been overlooked.

The Symbiosis Tower also does not include a slaughter house or rendering plant, therefore the animals are transported from the tower to a location where these operations can occur. The research proposition will include these operations and produce sufficient energy to facilitate an entirely self-sustaining beef production system.

The research project will also introduce artificial operations in order to maximize dry matter production and therefore beef output. Artificially monitoring the pastures will allow an environment that can optimize ryegrass growth 365 days of the year.

Figure 7.11 Diagrammatic renders explaining how the tower functions.
7.4.1 Disgarded Site Plan: Selected North Facing Slope

When the Matakaroa Hamlin Hills site was first considered, the section of land outlined in red was the proposed site for approximately 6 beef towers.

This area was primarily selected for its north orientated slope falling approximately 20 metres from the ridge toward the motorway. The slope is ideal for sun exposure and forms a natural amphitheatre visible to the passing traffic and residential zone to the north.

It was decided that the siting of the project could be pushed further. There was an opportunity to occupy the whole of the Matakaroa Hamlin Hills Regional Park to create a bold statement, illustrating the future possibilities of the beef towers.

Figure 7.12 Initial site selection.
Figure 7.13 Conceptual render showing 6 towers on site.
7.4.2 Initial Site Selection

This site offers many positive aspects that will help to strengthen the functionality, productivity and awareness of the project.

Maximum Sun Exposure
The site slopes downward toward the north.

Green Belt
Large open area between project and existing built environment. This is ideal for ethical issues such as noise and odor emissions from the slaughter house and rendering plant.

Motorway Accessibility
Optimal for visitors and cattle truck operations.

Elevated Site
Great visibility from motorway and surrounding areas to raise public awareness.

Large Area
Necessary to accommodate the large scale project. Site approximately 46,000m²
Hydroponic Fodder Farming

Many 21st century farmers argue that growing fodder is a sustainable and energy efficient method of feeding cattle.

Fodder requires a very small area for a tremendous amount of dry matter output. The fodder is grown in a controlled environment 24 hours a day, so the growth rate is maximal with little to no chance of disease or contamination. The fodder is sprayed 6-8 times per day with a mist made up of water and fertiliser. The plants absorb almost 100% of the solution, unlike grasses that grow in the earth which loose approximately 80% of water into the soil.

59 "BK Hydroponic Fodder for E-mail.wmv," Youtube Video, 0:21, posted by Yusoo Kim, May 23, 2011, https://www.youtube.com/watch?v=llFaWZRMjS4

Figure 7.17 Lush fodder dry matter with root systems and stacked hydroponic growing trays.
Biomass into Biofuel

Each farming tower can sustain enough animals to justify the installation of a biofuel reactor or methane digesters.

A biofuel reactor is designed to process thousands of kilograms of manure and is useful only when dealing with large herds.\textsuperscript{60} The manure is collected from feeding pads, i.e. concrete or other hard surfaces, and then channelled to a large catchment tank which is normally dug into the ground.\textsuperscript{60} The catchment tank could have multiple manure inputs and solid waste outlets.

The catchment tank is sealed to create anaerobic conditions, but must have a release valve to trap biogas and allow for its release. The animal waste enters the catchment tank near the bottom continuously feeding the anaerobic digestion process.\textsuperscript{60} The methane containing biogas rises to the top of the tank where it can be extracted and converted into heat energy for the water holding tanks.\textsuperscript{60} The digested sludge can be removed and employed as fertiliser for the perennial ryegrass and fodder operations.\textsuperscript{60}


Figure 7.18 Basic diagram of a livestock waste Bioreactor.

Joel Salatin

Joel Salatin is an American farmer, lecturer and author widely recognised for his 550 acre farm known as the ‘Polyface Farm.’

Salatin has written numerous books and given many lectures based largely on holistic management and the importance of the symbiotic relationships between various animal and plant species that occupy his Polyface farm. These species include, livestock, pigs, chickens, dung beetles, grasses and clovers.1

Salatin believes that there is strength in decentralisation, and that agriculture on a human scale can feed the entire planet if it is planned and distributed strategically. He has shown (through the Polyface project) that food production on the human scale can produce superior quality products to that of the global agricultural industry and that his methods respect and give back to the ecosystem.2

Salatin’s methods have transformed desertified non-arable land into profitable grassland, he has also helped various farmers to maximise the productivity of their land no matter the size or condition. Salatin often speaks about the importance of symbiotic relationships between organisms on the Polyface farm.3 Each organism fulfils a role that activates a following process fulfilled by another organism. Each organism depends on another in order to survive.

Salatin’s expertise involves creating the optimal ratio between number of animals, time to graze and area to graze.4 This operation can be highly complex when a farmer must factor in climate, soil type, different species, food sources, fertilisation, irrigation etc. Salatin believes that once the ratio is correct then any farm can function as one large self-sustaining organism that is profitable and eco-friendly.5

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Figure 7.19 Photograph of Salatin and his mobile chicken coop.

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67 Ibid, 84.
Ruminants + Exercise

A significant character of nutritional ruminant meat is vitamin B12.

Vitamin B12 aids the normal functioning of the human brain, nervous system and blood formation.\(^{70}\) Studies show that physical exercise is fundamentally related to vitamin B12 levels in oxidative type muscle.\(^{71}\) Animals exposed to physical activity revealed almost double the vitamin B12 than in the muscle tissue of ruminants housed within restricted areas.\(^{72}\)

The rotating surface on each grazing disc ensures physical activity for the animals whilst providing a clean surface to live and feed on.


\(^{72}\) Ibid.
Artificial Insemination (AI) is the process of collecting sperm cells from a male animal and manually depositing them into the reproductive tract of a female.73

Artificial Insemination is becoming increasingly popular in beef breeding herds due to the increased access and marketing of superior and favorable proven sires.74

Artificial Insemination is becoming increasingly popular in beef breeding herds due to the increased access and marketing of superior and favorable proven sires. The potential benefits of Artificial Insemination include but are not limited to:

Increased efficiency of bull usage: During natural breeding, a male will deposit more semen than is necessary to produce a pregnancy. During the AI process collected semen can be diluted and extended to create hundreds of doses.75

Increased potential for genetic selection: AI allows male to produce more offspring, therefore fewer males are needed. Only the males with the best genetics can be chosen to reproduce.76

Reduced disease transmission: Natural mating allows the transfer of venereal diseases between males and females. Although some pathogens can be transmitted via AI procedures, the semen collection process offers the screening of disease agents.77

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75 Nuclear Techniques in Food and Agriculture, “Artificial insemination (AI) of cattle.”
76 Ibid.
77 Ibid.

Figure 7.22 Farmer performing Artificial Insemination.
A rendering plant is a processing operation where dead animals are recycled into products from animal food to biodiesel to human health products. The un-used remains from slaughterhouses are the primary contributors to render plant facilities such as heads, hooves, bones, blood and offal (internal organs). With the increasingly high volume of meat consumption in the world today, the rendering plant industry is mandatory to manage the issue that is animal remains. Without this recycling from slaughterhouse waste, we would be threatened with uncontrolled viral and bacterial epidemics.

The rendering process grinds up raw material (meat by-products and dead animals) which are then placed in cookers, which evaporate moisture and free fat from protein and bone. A series of conveyers, presses and separators continue the process of extracting fats from solids. The finished fat (tallow, lard, yellow grease) goes into separate tanks, and the solid protein (meat and bone meal, poultry meal) is pressed and processed into animal feed. Rendering plants provide livestock and poultry producers with a convenient, safe, and economical alternative for the disposal of animal and bird mortality.

80 KD Morgan, "What is a Rendering Plant."
81 Geoffrey Becker, "Rendering Investigation."

Figure 7.23 Ruminant skeleton sketch.
Harvesting Ruminant Flatulence?

Research shows that cows can produce up to 300 litres of methane through flatulence per day (enough to run a fridge for 24 hours). Scientists have produced ‘back packs’ that connect to a tube which is put into the animal’s rumen (largest digestive tract). The methane is then extracted and stored.83

Throughout the development of the project it was decided that the animal grazing/living areas will be kept open to ensure air circulation and high quality living conditions for the animals. However, after discovering the opportunity for methane harvesting from flatulence, the position was reconsidered.

Perhaps it would be possible to both, give the animal’s fresh air, whilst also collecting the methane from the flatulence. This would require closing off the void between the grazing discs around the perimeter of the building.

Fresh air would then need to be pumped into the grazing areas mechanically, and extraction fans would evacuate polluted air and put through a methane filtration system.

This would totally alter the conditions of the tower façade, also lighting and overheating would then become a major problem. For these reasons, the methane harvesting of cow flatulence was not pursued. The majority of the methane being produced by the animals is being harvested via the biofuel reactor.

Figure 7.24 Beef animal wearing methane storage backpack.

Versitile System: Cater to Many Species

Fodder is used to feed various animals, therefore, this tower has the potential to house numerous farmed species.

The dimensions of the towers proposed in this research have been designed specifically for the habitation and circulation of cattle, but with minor changes (e.g. fence height, floor to ceiling height) the tower could potentially be suitable for deer, pigs, sheep and goats.

The versatility of the tower would allow it to serve in different countries among a range of religions and food preferences.

Figure 7.25 Night render of 2 module tower.
Figure 7.26 Range of species that may be housed in the towers.
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Reproduced from: [http://savenaturesavehuman.blogspot.co.nz/2012/02/wildebeest.html](http://savenaturesavehuman.blogspot.co.nz/2012/02/wildebeest.html)


Photograph of Allan Savory.

Photographs taken years apart of the same pieces of land, showing the tremendous impact of Savory’s work.

Sketch illustrating the evolution of the human skull.

Photograph of toddler chewing steak.

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Diagramatic renders explaining how the Symbiosis Tower functions.


Initial site selection.

Conceptual render showing a 6 towers on site.

Aerial photograph of selected site.

Reproduced from: http://maps.aucklandcouncil.govt.nz/aucklandcouncilviewer/

Longitudinal section cut through site.

Site outline with cross section.

Photographs of dry matter with root systems and stacked hydroponic growing trays.

Reproduced from: http://upload.wikimedia.org/wikipedia/commons/6/61/Fodder_growing.jpg
http://www.cropking.com/sites/CropKing.com/files/images/Fodder%202023.preview.jpg
http://farmtek.files.wordpress.com/2013/05/1117638.jpg

Basic diagram of a livestock waste Bioreactor

Reproduced from: http://solarbiofuels.org/biomethane.php

Photograph of Joel Salatin and his mobile chicken coop.

Reproduced from: http://24.media.tumblr.com/tumblr_lo30cjkNCd1qzprb01_r1_1280.png

Mid-year render of animal grazing disc.

Cow on treadmill.

Farmer performing Artificial Insemination.

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Ruminant skeleton sketch.

Reproduced from: http://www.stirfrycentral.com/line_drawings/theobald_agricultural_zooology/cow_skeleton.svg

Beef animal with methane storage backpack.

Reproduced from: http://jobloggz.files.wordpress.com/2014/05/cowfart5_16x9_1600.jpg

Night render of 2 module tower.

Range of species that may be housed in the towers.

http://images.clipartpanda.com/black-sheep-clipart-yikzjoeiE.jpeg
http://www.stickthisgraphics.com/images/Pig%20Silhouette%204%20(Small).jpg
http://www.clipartbest.com/cliparts/nTB/Xbp/nTBXbp emerging.jpg
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Cow #403 close up.

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