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Abstract

Veganism has been touted as a ‘silver-bullet’ solution to many of modern industrial agriculture’s devastating repercussions. Yet, current vegan food production retains some flaws, namely its reliance on environmentally harmful industrial farming methods and on animal inputs, thereby inadvertently supporting animal exploitation. This research project then, seeks to understand how vegan food production can become more sustainable by investigating two alternative food systems: veganic farming and permaculture. In addition to analysing the capacities and synergy of these two approaches to making vegan food production more sustainable, their ethical tensions were explored. Since permaculture is not inherently vegan, the movement’s philosophy towards animals conflicts with veganic farming and so it is worth exploring where these approaches differ and whether this can be reconciled. Finally, the scenario of Scotland adopting an entirely veganic permaculture food system was considered, highlighting the potential benefits, drawbacks and hinderances to this vision.

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1 - Introduction

Agriculture's Detriments

Modern agriculture is entangled within, and in some instances at the root of innumerable socio-ecological problems. Agriculture is heavily implicated in the climate breakdown, accounting for 26% of anthropogenic GHG emissions. It requires substantial resources and occupies ~43% of Earth's ice- and desert-free land (Poore and Nemecek 2018). Agriculture's growth has extensively altered the distribution of global animal biomass, where humans and domestic animals now considerably outweigh the biomass of all terrestrial vertebrates (Bar-On *et al*., 2018). Oceans are likewise suffering under our current food system. Predatory fish biomass is ~10% of pre-industrial levels (Myers and Worm 2003), sharks are being killed faster than they can re-populate (Worm *et al*., 2013) and agricultural runoff is causing oxygen depleted 'dead zones' to form near coastal areas (Breitburg *et al*., 2018). Wildlife is dwindling at such a rate that a sixth mass extinction is now said to be in motion (Ceballos *et al*., 2015). Access to nutritious food is severely unequal with more than two billion people malnourished in some form, while there are even more people suffering from obesity (Weis and Weis 2007).

Why Veganism?

Veganism has been proposed as a seemingly straightforward and far-reaching strategy to mitigate or solve many of agriculture's environmental issues. Animal agriculture requires higher amounts of land and resources than growing plant foods. Poore and Nemecek (2018) estimate that ~83% of global farmland is dedicated to animal agriculture yet it provides only 18% of our calories. Globally, agriculture is already producing surplus calories to feed its population a vegan diet (accounting for the expected population growth to ~9.7 billion people in 2050) except that many human-edible crops are being fed to livestock (Berners-Lee *et al*., 2018). If Scotland phased out animal agriculture, ~2,320 km^2 of additional cropland could be freed to grow crops directly for humans. Pastureland could also be restored to native forests, sequestering an estimated 1,062 Mt of CO_2, preventing further non-CO_2 emissions from livestock, and improving the ecology (Harwatt and Hayek 2019). Shifting towards veganism could alleviate pressure on marine species used as food, help avert the prospect of a post-antibiotic era (Yao *et al*., 2016) and mitigate the spread of zoonotic diseases like avian

influenza (Horby *et al*., 2014) which are linked with the squalor conditions of concentrated animal feeding operations (CAFOs).

Importantly, agriculture's repercussions are suffered by human and non-human animals alike. Veganism then, can not only make agriculture more sustainable but can emancipate farmed animals and support wildlife.

Despite the scepticism over a vegan diet's nutritional adequacy, if it is well planned with a focus on the consumption of whole foods, it is a suitable diet for all stages of human life (Craig and Mangels 2009; Melina *et al*., 2016).

Beyond Vegan Industrial Food Production

Despite the significant potential benefits of a vegan food system, it is not without its own set of problems. There are worries that universal veganism would simply exacerbate industrial crop production which can also cause extensive environmental devastation (Fairlie 2010; Milligan 2010). Tillage is on average eroding soils one to two orders of magnitude higher than soil can be produced (Montgomery 2007). Monoculture food systems substantially reduce biodiversity and pollinator numbers (Varah *et al.*, 2013). Pesticide and fertiliser use in intensive agriculture is linked to the rapid decline of insects, which if left unabated could lead to the extinction of 40% of Earth's insect species in the coming decades (Sánchez-Bayo and Wyckhuys 2019).

Given that vegan food is produced with chemical fertilizers, pesticides and other detrimental inputs, organic methods should then be considered a crucial component of an ecologically harmonious vegan food system. Importantly however, many organic inputs like manure and compost are animal-derived and thereby inadvertently support the animal agriculture industry (White 2018). Indeed, there is a misconception that animal manure and domestic animals are a required component for organic farming (Milligan 2010). But this presumption is being challenged by 'veganic' (vegan-organic) farming; an organic system which excludes all animal inputs apart from functions provided by free-living animals like wild bees (Schmutz and Foresi 2016). A move towards veganic farming as the new baseline in agriculture should then be desired.

Permaculture: Potential Synergy with Veganism

Yet, veganic farming is not without its critiques, both in terms of its technical ability and its underlying philosophy (Fairlie 2010). To address these critiques, I want to examine another alternative approach to food systems called permaculture. Permaculture is an ethical design framework that when applied to a food system could be described as the mindful design of landscapes, mimicking ecosystem patterns and relationships in order to meet human needs in a sustainable and regenerative way (Rhodes 2012). In researching permaculture, I want to assess its agricultural capabilities and how well it can respond to critiques of veganic food production in the context of Scotland.

While permaculture can be practised in conjunction with veganism, domestic animals and their inputs are still readily used in the movement. Using domestic animals in permaculture does not necessarily violate its ethical principles and the idea of excluding them based on principle is a controversial one (Rhodes 2012). For these reasons, I also want to investigate the conditions of animals in permaculture and how permaculturists perceive the role of animals in their systems. In doing so, I hope to establish the tensions and synergies between veganism and permaculture's ideal ethical relationship with non-human animals

Lastly, I want to consider the scenario of a complete shift to veganic permaculture methods in Scotland. How might this combination of veganic and permaculture ideas and visions affect Scotland's human and non-human inhabitants and its environment, and what factors obstruct this transition?

With these aims in mind, my dissertation seeks to answer these three research questions:

1. How does permaculture perform as a means of producing veganic food in Scotland?

2. How inclusive is permaculture in its consideration of non-human animals in both its practices and the attitudes of people involved in them?

3. What would be the potential implications of Scotland adopting a veganic permaculture mode of food production?

2 - Literature Review

Research Framework

By grounding my research framework in veganism, I want to ensure this is not deployed in a biased ideological manner. I take inspiration from Jenkins, who conceptualizes veganism as a "necessary component" which for her sits within a larger "feminist ethics of nonviolence" (2012:504). Veganism is not so much an identity as it is a tool which requires honing. I too see veganism as a necessary component, but for the broader purpose of enabling the optimal flourishing of the geographic community. This framing of veganism is built upon the coupling of two concepts: Lynn's (1998) concept of geocentrism and the geographic community, and Cuomo's (2002) concept of an ethics of flourishing.

The geographic community speaks to the entanglement of multiple human and non-human animal communities who share the same geographic living space. In contrast to anthropocentrism, geocentrism extends the boundaries of the anthropocentric moral community to encompass the geographic community. This displaces humanity as the centre of moral value and instead establishes a plural centre of morality that values the individual (human and non-human), species and ecosystemic components of the geographic community all at once. In doing so it avoids overly emphasizing the moral value of the individual or collective life-form.

Flourishing is an ethical approach that is positively motivated in that it seeks to not merely reduce suffering, but to let human and nonhuman life-forms thrive in the most optimal balance possible. This approach attempts to avoid the excessive flourishing of one species at the expense of another. This concept also helps direct the use of veganism as a set of actions we can take in the best interests of the geographic community. My analysis of veganic and permaculture food systems then, seeks to establish how holistic these systems are, how well does it meet the needs of the different members of the geographic community.

A Vegan Perspective on the Ethics of Animal Agriculture

In discussing the ethics of keeping animals for food, focus will be turned to small-scale farms as these are more pertinent to what permaculture food systems entail. Small-scale animal farming also raises more ethically contentious issues than say CAFOs, which makes it important to outline my vegan perspective on these points, in turn giving background to the later analysis of permaculture.

The kind of veganism being defined here is one that avoids all *unnecessary* harm to animals, viewing unnecessary harm as unethical; what Abbate (2019b) terms the Nonmaleficence Argument. Harm can be considered morally unnecessary, if there are alternatives that cause less or no harm, or if the means do not justify the ends. When determining whether some harm is morally necessary, it is crucial that this accounts for the geographic community and not just human interests.

Small-scale animal farming often justifies animal exploitation on the basis that the animals otherwise enjoy high standards of wellbeing throughout their lives. However, there are numerous problems with this justification. To contend that humanely killing an animal is permissible because their life was pleasant misses the point that death is harmful, even when done painlessly, due to the fact its death was unnecessary (Abbate 2019b). Even where animals may not be slaughtered, like keeping honeybees or hens, farming animals requires that they be controlled to some degree (Barnhill and Doggett 2018). Keeping animals in controlled, enclosed spaces is a central way in which they are harmed (White 2015), which Simmons (2016) argues, harms them through denying to a certain extent, the self-determined pursuit of their interests. Namely, their desire for mobility, to roam and explore. The content of these spaces is similarly important and subtler harms like boredom or depression may arise by a lack of stimulation in the environment (Simmons 2016). Wrenn (2013) argues the system itself is intrinsically problematic because the animals' commodity status results in their treatment as mere means.

Ethics however, become blurred in circumstances where animal products can seemingly be harvested without harm. Fischer and Milburn (2019) argue that in the specific context that you have rescued a chicken from industrial farming (without the primary motive of consuming their eggs) and take good care of it, eating their unused eggs is not unethical.

They acknowledge there may be morally preferable uses for these eggs but that no harm is necessarily done in eating them. While this situation is perhaps too idealized, I would agree that similar opportunities exist where consuming an animal product does not directly harm the animal it came from. However, if we view this scenario through the ethical lens of flourishing, eating an egg is not helping us humans to flourish as they are not necessary for our health. Indeed, the geographic community could make better use of the egg. It could be left to decompose, returning nutrients to the soil, or be eaten by opportunistic wildlife or be purposely given to domestic animals that benefit nutritionally from it (Donaldson and Kymlicka 2011). By the very fact that the egg has some better use, why would we not strive to choose this option? This reasoning likewise applies to why its preferable not to consume other animal products even where it can be consumed harmlessly like roadkill (Abbate 2019a).

Realistically though, food systems employ animals to fulfil some function. This function is not always to produce food from their bodies. Animals may be used to prepare fields through fertilising it with their manure or turning the soil surface or controlling pests. Chickens are sometimes referred to as 'tractors' because of the extra services they provide (Machovina *et al*., 2015:428). Animals are chosen precisely for their utility to humans. Consequently, animals who have no function to give (e.g. hens who stop laying eggs) are usually discarded or culled (Wrenn 2013). It remains to be seen how the treatment of animals differs from the 'humane', small-scale farm as described, with permaculture-based food systems.

In response to the harms imposed by animal agriculture, White calls for "empty cages, not larger cages" (2015:26) for these animals. While I share this long-term goal, it must be acknowledged that even a gradual transition away from animal agriculture leaves us with the question of what happens to the leftover animals? How and where will they live out the rest of their lives? More research is crucial to answering these questions.

Criticisms of Veganic Food Production

Here I want to explore several criticisms launched against veganic farming so that I can then factor in how well it responds to these issues in my analysis.

One critique is that crop production involves the collateral death of potentially larger numbers of animals (Lamey 2007). Machinery kills small mammals, fertiliser runoff and pesticides poison fish, insects and birds, and animals in fields are more susceptible to predation (Fischer and Lamey 2018). This argument, however, fails to realise the difference between unintentional and/or undesirable deaths caused in the necessary task of growing crops with intentional deaths caused by unnecessary meat production (Jenkins 2012). Nevertheless, Fischer and Lamey (2018) are right in that a serious effort should be taken to avoid field deaths in crop production. While this critique is less applicable to veganic farming, its pest control methods are still worthy of analysis.

Veganism has also been criticised for placing more pressure on imported, and often luxury foods, thereby decreasing food security and increasing food miles (Fairlie 2010). Avocadoes are one such high-demand food that is impoverishing small-scale farmers in the Global South (Serrano and Brooks 2019). Furthermore, there is a tendency that the more plant-based one's diet becomes, the further afield its components are sourced (Schmutz and Foresi 2016). Although dietary change reduces GHG emissions significantly more than eating locally (Weber and Matthews 2008), relying less on imported foods is still worthwhile as food security will become increasingly important in our warming climate.

It has also been questioned whether vegan agriculture can be sustainable without animal-derived manures and composts. Without the abundance of animal inputs, sustaining or building fertile soils could be difficult (Milligan 2010). In veganic systems, nitrogen is comfortably supplied by green manures, but having sufficient phosphorous in the long-term is less secure (Fairlie 2010). If animals are not being used to bring in phosphorous from marginal lands, Fairlie contends that veganic food systems will need to recycle phosphorous-rich human excrement and urine to be sustainable.

Veganic agriculture may also not be applicable to all geographic locations. For many people living in marginal lands like mountains or islands, they may not be able to rely solely on crops and need animals to consume vegetation inedible to humans so they can then obtain food from the animal (Milligan 2010). So, if people were to exclude animals, a local food source and the livelihoods dependent on this would be lost.

Status of Permaculture

Permaculture, perhaps because of the limited scientific research into it, has been criticised for making unsubstantiated claims about its design principles, its ability to produce yields, its geographic applicability, and for downplaying the difficulties that come with building and maintaining such systems (Ferguson and Lovell 2014; Hathaway 2016). Yet, Krebs and Bach (2018) have demonstrated that evidence exists for all twelve of permaculture's design principles (Table 2.1). However, evidence for some principles is more substantial than others. The principle "Use edges and value the marginal" is supported by research showing higher field edge densities is linked to increased biodiversity and marginal land attracts beneficial pollinator and pest-predator species, reducing the need for pesticides (Krebs and Bach). On the other hand, the principle "Obtain a yield" has more varied evidence and it seems the quantity of food produced is dependent on the site and the system's design (Krebs and Bach).

Table 2.1 – The left column lists permaculture's 12 design principles originated by David Holmgren co-founder of permaculture and their description is quoted from Rhodes (2012:156). The right column lists examples of the implementation of these principles as provided by Krebs and Bach (2018).

Design Principle	Examples with Evidence
1. Observe and Interact - By taking the time to engage with nature we can design solutions that suit our particular situation.	Adaptive management
2. Catch and Store Energy - By developing systems that collect resources when they are abundant, we can use them in times of need.	Organic mulch application Rainwater harvesting measures Woody elements in agriculture
3. Obtain a Yield - Ensure that you are getting truly useful rewards as part of the work that you are doing.	'Emergy' evaluation Ecosystem services concept
4. Apply Self-Regulation and Accept Feedback - We need to discourage inappropriate activity to ensure that systems can continue to function well.	Enhancement of regulating ecosystem services Natural habitats in agricultural landscapes Wildflower strips
5. Use and Value Renewable Resources and Services - Make the best use of nature's abundance to reduce our consumptive behaviour and dependence on non-renewable resources.	Legumes and animal manure as nutrient source Mycorrhizal fungi
6. Produce no Waste - By valuing and making use of all the resources that are available to us, nothing goes to waste.	Animal manure Human excreta Waste products as animal feed
7. Design from Patterns to Details - By stepping back, we can observe patterns in nature and society. These can form the backbone of our designs, with the details filled in as we go.	Natural ecosystem mimicry Use of grazing animals in cold and dry climates Structurally complex agroforests in tropical climates
8. Integrate Rather than Segregate - By putting the right things in the right place, relationships develop between those things and they work together to support each other.	Integration of livestock in corn cropping Cereals and canola used for forage and grain harvest Integration of fish in rice cropping Polyculture (crops)

9. Use Small and Slow Solutions - Small and slow systems are easier to maintain than big ones, making better use of local resources and producing more sustainable outcomes.	Inverse productivity-size relationship Agroforestry systems
10. Use and Value Diversity - Diversity reduces vulnerability to a variety of threats and takes advantage of the unique nature of the environment in which it resides.	Plant species diversity Pollinator diversity Habitat diversity Diversified farming systems
11. Use Edges and Value the Marginal - The interface between things is where the most interesting events take place. These are often the most valuable, diverse and productive elements in the system.	High field border density Field margins Edges with forests
12. Creatively Use and Respond to Change - We can have a positive impact on inevitable change by carefully observing, and then intervening at the right time.	Decision-making under uncertainty Increase ecological resilience Directed natural succession

While there is a scarcity of research on permaculture and much of this focuses on tropical latitudes, there are several studies relevant to permaculture food systems in temperate climates. Nytofte and Henriksen (2019) measured the average annual yield of a 0.08 ha permaculture food forest in the Scottish borders. They extrapolated these results to an area of one hectare, suggesting similar food forests could provide enough carbohydrates, fat and protein for 7, 4 and 3 males and 9, 5 and 4 females respectively. They also cite a yet to be published study by Lavoll *et al*. (2019) who found that a temperate food forest could produce enough food calories for ten people per hectare. More generally, Morel *et al*. (2018) found that permaculture farms focusing only on food production, were very variable in terms of their production levels, inputs, labour and income, echoing Krebs and Bach's (2018) findings on permaculture yields. This range of variability though is comparable to farms that employ organic, low-input and agroecological methods (Morel *et al*., 2018). Permaculture food systems are potentially economically viable too as Morel *et al*. (2015) found that a permaculture-based market garden in France could make a monthly income of €898-1,571 on an average of 43 workhours per week without mechanisation. Fittingly, Fairlie performed some rudimentary calculations testing whether the UK could feed itself using veganic permaculture; where permaculture was taken to mean the large-scale "integration of lifestyle with natural and renewable cycles" (2010:100). Remarkably, the UK could theoretically meet its food needs using this approach, feeding 8 people per hectare on average and leaving 11.2 million hectares of land for non-food uses.

Permaculture's emphasis on designing food systems for sustainability often means the inclusion of perennial crops, especially trees is encouraged. In temperate climates, alley cropping (a simpler design of a permaculture food forest) is the most intensive way of integrating trees with annual crops whilst still retaining high productivity. By growing annual crops between rows of trees, alley cropping over-yields, meaning it produces more food overall than growing tree and annual crops separately (Wilson and Lovell 2016; Wolz et al. 2018). In addition, alley cropping has several other benefits including climate change mitigation and resilience, better labour and market stability, energy production, and they can be suitable for marginal lands (Wilson and Lovell 2016; Wolz et al., 2018). Although Rhodes (2012) notes that if agriculture was more aligned with permaculture and integrated more perennial species, grain yields will be much lower than current industrial-scale outputs. Our diets would then need to consist of larger proportions of other plant-based food groups.

Notably, some research indicates permaculture is well suited to fostering deeper ecological consideration and practical engagement amongst its practitioners (Hathaway 2016). Millner (2016) finds that there is a striving in permaculture to support human and non-humans through the establishment of 'permanent cultures' which act as multi-species ecologies. In addition, Puig de la Bellacasa argues that in doing permaculture, we develop an awareness of our interdependency with all the non-human beings in the system. So no longer do we perceive animals as "there to serve 'us'. [But rather] They are here *to live with*" (emphasis added, 2010:161). In this regard, the doing of permaculture and sharing our immediate space with animal others could counter anthropocentric attitudes (Puig de la Bellacasa 2010) which may then lend consideration towards veganism. However, in reading permaculture's ethical principles (Table 2.2), the implicit reference to animals as part of the wider ecosystem has tones of ecocentrism (Lynn 1998) and certain aspects of the principles are open for personal interpretation.

Table 2.2 – Lefthand column lists permaculture's 3 ethical principles and the righthand column describes how they are implemented. Adapted from Rhodes (2012)

Ethical Principle	*Explanation*
Earth Care	Ensuring all life systems can continue and multiply. Involves: • Working with nature • Opposing destruction and damage • Making considerate choices • Making minimal environmental impact • Meeting our needs by designing healthy systems

People Care	Ensuring people can access those resources they need to live. Involves: • Caring for oneself and others • Cooperating • Helping those unable to access life's necessities • Lead low impact lifestyles • Designing systems to be sustainable
Fair Share	By meeting our own needs and living lightly, surplus resources can be used to further the other principles. Involves: • Restricting our consumption so there is enough for all at present and in the future • Creating economic 'lifeboats' • Establishing common unity • Changing our lifestyle now and not waiting • Reconnecting with nature to shift our thinking and being.

Scotland's Agricultural Suitability

Understanding Scotland's biogeographic conditions is vital in connecting generalised agricultural knowledge from the veganic and permaculture movements, to specific localities. Table 2.3 outlines Scotland's different classes of agricultural land and Figure 2.1 shows the distribution of these classes.

Table 2.3 – This table contains information on Brown and Castellazzi's (2015) three main classifications of agricultural land in Scotland. The table information is adapted from The James Hutton Institute (2010).

Land Category	Land Cover	Biogeographic Limitations	Land-use Potential
Prime Agricultural Land	~625,800 ha. (8% of Scotland's land area)	Favourable climate, less precipitation Flatter terrain Deep, fertile soils with good drainage	Land capable of producing wide ranges of crops and/or high yields of crops.
Improvable Agricultural Land	~2,946,800 ha. (38% of Scotland's land area)	Less favourable climate, more precipitation Rougher topography with steeper slopes Soil drainage may be limited	Land capable of producing a narrow range of crops at less high yields. Some areas are more suited for grassland.

Unimprovable Agricultural Land	~4,035,800 ha. (51% of Scotland's land area)	Adverse climatic conditions: wet, cool and cold Rough topography with steep slopes Soils are poor being shallow, acidic and/or poorly draining	Land deemed capable only for rough grazing or of very limited agricultural value.

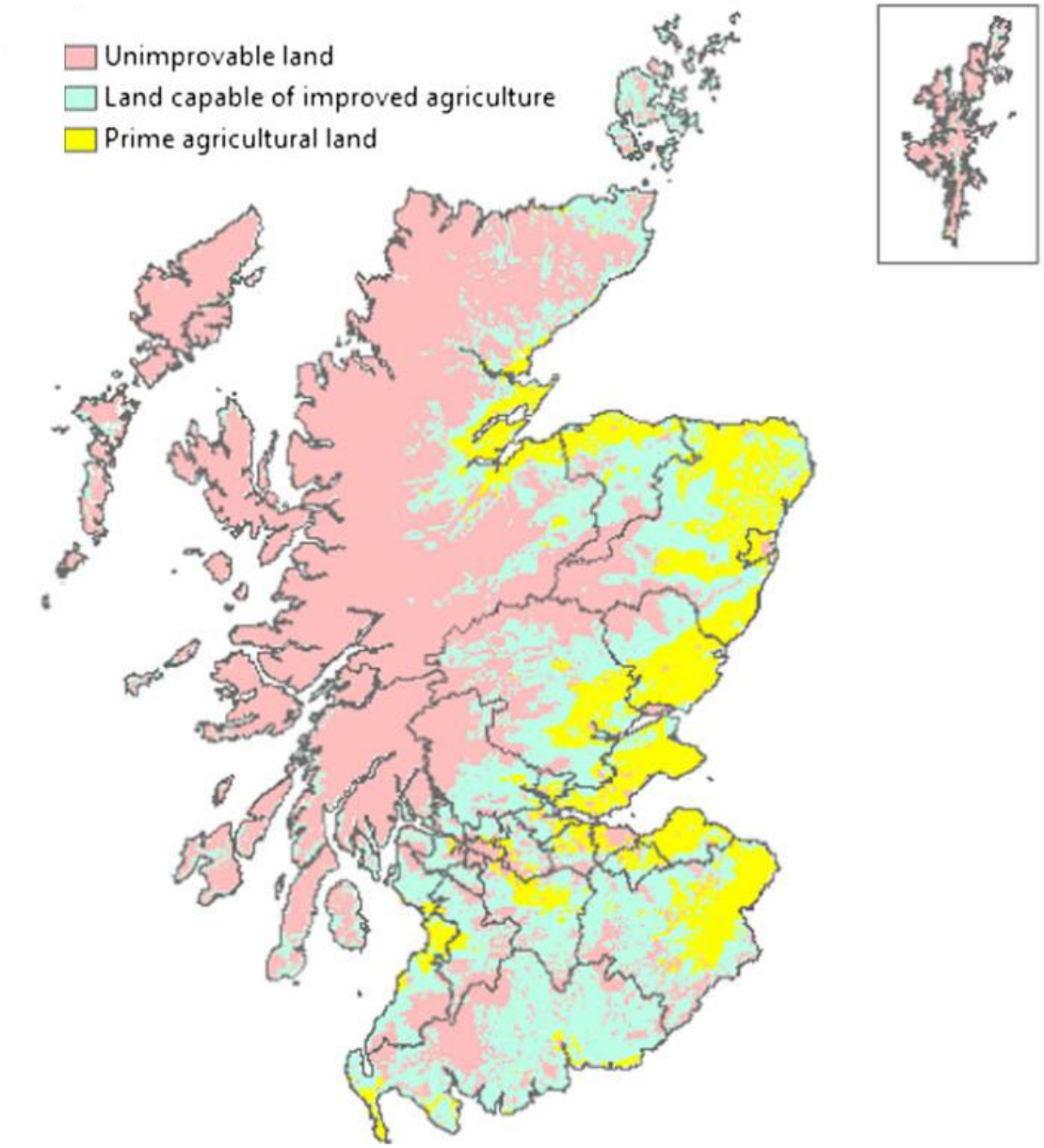

Figure 2.1 – Map of Scotland showing the distribution of prime, improvable and unimprovable agricultural land for the years 1991-2010. Map is adapted from Brown and Castellazzi (2015).

From this information, veganic food production would likely be concentrated in Eastern Scotland since less human-edible crops can be grown in the West. Still, there are some examples of small-scale growers who have adapted their holdings (some using permaculture)

to the adverse conditions on these marginal lands so that they are still productive to some extent (Speakman 2018).

The implications of climate change on Scotland's agricultural land is also significant. Initially, it appeared that the area of prime land was set to increase with climate change (Brown *et al*., 2008). Though, Brown and Castellazzi's (2015) follow up study, showed there was significant short-term variability in the classification of agricultural land. This means that certain areas of prime land, like in South-West Scotland, might instead be considered sub-prime because the prime conditions only prevail infrequently. However, some areas are still expected to have increased and stable prime land in the future, like the North-East. Generally, the climate in West Scotland may be more variable interannually than the East. While the climate will cause fluctuations in the quality of good agricultural land in the East, the West will remain inherently constrained by its poorer soils (Brown and Castellazzi).

Research Niche

Currently, the amount of research on permaculture is lacking, and in the case of veganic farming, the literature is even sparser. This research then finds a niche in the intersections between geography, veganic farming and permaculture, adding to the body of knowledge in each area. Additionally, the exploration of the tensions between permaculture and veganism's stance towards domestic animals is original to this research.

3 - Methodology

Study Area

Scotland was chosen as the study area because research concerning veganism and its relation to GHG emissions, agriculture and food security often takes a UK wide or broader context (Berners-Lee *et al*., 2012; Harwatt and Hayek 2019). While this is useful, it means that local intricacies important to Scotland are overlooked. For instance, the UK overall has ~58,000 km^2 of cropland to work with whereas Scotland has ~4,800 km^2 of cropland (Harwatt and Hayek).

Data Collection

A mixed methods approach was taken to gather data with documentary analysis representing the bulk of the collected data and semi-structured interviews supporting this. Using mixed methods enables the triangulation of different data sources and maximises our understanding of the research topics in question (Longhurst 2016). Moreover, the use of qualitative methods can give meaning to generalised, quantitative data by connecting it to specific places, helping to solve human problems (Yeager and Steiger 2013). In this case, the documentary analysis and interviews are connecting data to Scotland in order to solve human-animal problems.

Documentary Analysis

Primary data was gathered in the form of qualitative documentary sources. The documentary sources covered multiple formats (Table 3.1). Documentary sources were chosen for their instrumentality to this research which Dittmer (2010) claims leads to a more thorough analysis. Overall, the sources draw upon a broad set of perspectives, evidence and first-hand experience of veganic and permaculture practices. Additionally, the contents of the sources were analysed for their relevancy to the geographic conditions in Scotland.

Table 3.1 – Table outlines all the documentary sources used in this research. While the documentary sources are large in terms of data, my analysis sought out only the relevant parts of each source.

Source Title	Source Type and Quantity	Description
The Land	Magazine (5 issues analysed)	Covers a variety of land-based issues mainly in the UK. Some issues heavily feature discussions of veganism, veganic farming and permaculture.
Growing Green International	Magazine (42 issues analysed)	Explicitly caters to vegan audiences (being produced by the Vegan-Organic Network). Contains lots of information on veganic growing and some articles on vegan permaculture.
Permaculture Magazine	Magazine (47 issues analysed from spring 2010 to autumn 2019)	Explicitly caters to permaculturists. Provides technical information on the capabilities of permaculture, attitudes towards animals and accounts of keeping them.
Growing Green: Organic Techniques for a Sustainable Future	Book	Technical manual on veganic growing, including commercial growing.
Growing Sustainability	Book	A collection of smaller articles by the same author. Covers numerous issues around veganic growing and touches upon permaculture too.
The Vegan Book of Permaculture	Book	Practical guide on how to implement vegan permaculture on a small scale. Also covers the broader implications of vegan permaculture.
Edible Forest Gardens Volume I	Book	Covers the scientific underpinning of temperate forest gardens / food forests, providing lots of in-depth, technical information.
Tap o'Noth FarmVlog	40 YouTube Vlogs	A vlog series documenting the everyday life of a commercial permaculture farm in NE Scotland. The farm includes geese, goats, ducks and chickens.

Documentary analysis was a key part of my methodological toolkit because it allowed me to gather large amounts of diverse and good quality data that would not otherwise be possible to generate through other methods like interviewing (Tyrrell 2016). Documentary analysis was also particularly suitable because the sources themselves "…shape, inform, and constrain spatial practices and social spaces." (Doel 2016:228), and since the practices of veganic growing and permaculture are relatively niche, documentary sources like books and online articles will significantly influence the spatial practices in each movement. Seymour

and Wolch (2010) note that this method works well on researching animal geographies and animal welfare, because different attitudes towards animals can be deconstructed through the way's animals are discussed.

Interviews

Five permaculture practitioners were interviewed in various locations throughout Scotland and these interviews were digitally recorded (Table 3.2). In line with Secor's (2010) reasoning, interviewees were chosen not to be representative of the permaculture movement, but for their expertise and experience of doing permaculture in Scotland. Recruiting of interviewees with experience in veganic growing was attempted but none were successfully recruited.

Interviews were semi-structured with some standardised questions although the order questions were asked in changed slightly with each interviewee. Longhurst (2016) notes that having different types of questions helps produce different kinds of answers. Questions and the type of answers they would likely elicit varied depending on which research question they were geared towards. Generally, the questions were technical when concerning permaculture and veganic systems or were more philosophical and emotional regarding the use of animals. Each interviewee was asked standardised questions, in addition to questions tailored to their expertise, project or location. Having a semi-structured format also allowed the interviewees to direct the topic of conversation (Longhurst 2016). Thus, the interviewees who have much more experience in permaculture could introduce unfamiliar or overlooked topics which would be relevant to my research.

As Seymour and Wolch (2010) state, interviews have the benefit of being able to directly question what animals experience during their life, whereas in documentary sources some parts of their lives may not be discussed explicitly or at all. In addition, interviews generate data embedded in a Scottish geographical context and thus offer more localised and specific information, whereas the content of documentary sources is more generalised.

*Table 3.2 – The table provides information on each interviewee and the interview itself. Interviews were arranged beforehand and participants filled a consent form. *The audio recording file for the interview with 'S' became corrupted so only field notes could be relied on. Information they gave is still included but they were omitted from the coding tallying because their codes would not be representative of the whole interview.*

Interviewee Code	**Location**	**Interview Length**	**Involvement in Permaculture**	**Interview Date**
'M'	Findhorn Ecovillage	~1 hour 20 minutes	Several years practising permaculture. Teaches permaculture.	8th July 2019
'A'	Findhorn Ecovillage	~1 hour 45 minutes	Over a decade practising permaculture. Teaches permaculture.	8th July 2019
'S'	Tomnah'a Market Garden	~2 hours*	Several years practising permaculture. Uses permaculture in a commercial market garden.	19th August 2019
'G'	Coldstream Forest Garden	~1 hour 25 minutes	Decades practising permaculture. Teaches and has written books on permaculture.	21st August 2019
'C'	The Lion's Gate	~45 minutes	Several years practising permaculture. Has done research on permaculture and is setting up a permaculture project within his university.	22nd August 2019

Data Processing

After gathering the data, interviews were transcribed word-for-word from playback of the audio recordings. The transcriptions along with the documentary sources were then coded (Appendix II). An open coding method was used, which involved a very scrutinous, line-by-line reading of the text for pre-determined and emergent themes. This method ensures that subjective data can be accurately understood by organising it in such a way that connections, themes and patterns can be drawn from the data (Cope and Kurtz 2016). Table 3.3 shows all the coding themes and how they were arranged. Code frequencies were counted (Appendix I), and illustrative quotes were highlighted and collated under different themes. Taking note of code frequency helped to determine the (perceived) importance of each theme and allowed comparison between different data sources. This also ensures quotations are representative of the data, showing the extent to

which certain views or arguments are common or outlying. The sources included quantitative data too and allowed me to compare and integrate this with empirical quantitative data by performing basic calculations (Appendix III).

Table 3.3 – All coding themes are listed. The frequency of these themes is detailed in Appendix I.

	Animal Ethics (A)		**Veganic and Permaculture Systems (B)**	
Code No.	Treatment of animals (AI)	Attitudes towards animals (AII)	Food production (BI)	Wider effects of these systems (BII)
1.	Mobility, restriction of space	Anthropocentric	Yields	Land-use
2.	Suitability of the environment	Non-anthropocentric	Rate of food production (steady/seasonal)	Ecology and biodiversity
3.	Forms of control/forcing	Utilitarian	Efficiency (resource input vs. output)	Climate change mitigation/adaptation/resilience
4.	Direct harm/death	Biocentric	Pest and disease control	Pollution
5.	Freedoms granted or care given	Ecocentric	Soil fertility and health	Food security and self-sufficiency
6.	Ability to interact with their own/other species	Geocentric	Variety of crops (mono vs. polycultures)	Labour
7.		Non-interference	Non-human animal harm/death (field deaths)	Energy
8.		Obligations to animals	Limiting geographical factors (slopes, soils, climate etc.)	Economics
9.		Unnecessary harm	Land requirements	Public Health
10.			Criticisms and drawbacks	Animal Welfare
11.			Sustainability	
12.			Incorporation of permaculture/veganic principles	
13.			Scale	

Positionality

I want to address my positionality in this research. Given the research focus on the capabilities of veganic farming and the treatment of animals, it must be acknowledged that I am vegan and support a total liberation framework "…which challenges all forms of domination and exploitation that concern human, nonhuman animals and the Earth" (White 2015:25). Consequently, I am to some level invested in the outcomes of this research which is why I initially chose this topic. This in turn means that my positionality could lead to bias, in how data has been collected and interpreted and so this should be kept in mind (Widdowfield 2000). As stated earlier however, I view veganism as a means to broader ends than itself and hope this looser attachment to veganism will not hinder critical reflection.

4 – The Value of Permaculture in Veganic Food Systems

Research Question Recap: How does permaculture perform as a means of producing veganic food in Scotland?

Maintaining Soil Fertility

> "*... it's all to do with soil fertility...*" ('A')

Soil fertility was the most frequently occurring theme in this research and makes sense considering it is the literal ground upon which veganic growing depends for its success. 'G' states that "good soil" is all one needs for successful veganic growing and 'A' similarly states there is "...not a limitation" on veganic systems provided you can "…make the soil fertility abundant enough". Permaculturists and veganic growers were confident that leguminous green manures can comfortably supply the soil with enough nitrogen. It was however noted that green manures take up a significant portion of the growing space: on average 25-40%, and even 50% on especially poor soils, thereby limiting the growing space ('S'; Darlington 2010; Hall 2008). It can take several months to a year for green manures to amass nutrients which could be problematic for new veganic farms if the land cannot immediately be put into production, particularly if the land is initially nutrient poor (Darlington 2010). Whilst some green manures can capture carbon and nitrogen from the atmosphere, in the long term, the reserves of other critical nutrients in the subsoil, like phosphorous, could be mined faster than they can be replenished (Hall and Tolhurst 2015).

Solutions to these issues frequently related to permaculture design principles 5 (Use and Value Renewable Resources and Services) and 6 (Produce no Waste). Regarding the establishment time of green manures, two articles noted that human urine is a good alternative source of nutrients, especially nitrogen, when other sources of fertility are not readily available. Kelly states that:

> "*Our urine contains significant levels of nitrogen, as well as phosphorous and potassium (typically an N-P-K ratio around 11 – 1 – 2.5, similar to commercial fertilizers). Studies conducted in Sweden (Sundberg, 1995; Drangert, 1997) show that an adult's urine contains enough nutrients to fertilize 50-100% of the crops needed to feed one adult. Urine can be especially beneficial for fertilizing in city environments*

> *where other local forms of fertility may be scarce due to lack of green spaces.*" (2012:38)

Human urine may thus be an adequate short-term fertility source during the establishment phase of green manures and its continual use in food systems could reduce the need for other sources of fertility. Whilst urine is said to be "...almost always sterile", in the unlikely case it is not, it can be stored for several months to reduce health risks (Kelly 2012:38).

Over the longer term, the depletion of phosphorous remains a problem. Deep rooting green manures and trees can be used to maximise access to phosphorous reserves, but this nutrient can still become depleted in the long-term (Hall 2008; Darlington 2010). Humanure was a frequently mentioned solution to long-term phosphorous depletion as this returns the minerals to the soil in the form of composted human excreta (Hall 2008; Darlington 2010; Burnett 2014a). Although, under the current UK standards for commercial veganic practices, the use of humanure is restricted, possibly because it may be hard to prevent contaminated human excreta (e.g. antibiotics) getting into the food system (Burnett 2017:15). This issue could, however, be circumvented by applying humanure to non-food crops like green manures and trees, which converts contaminated humanure into a safe form of fertility to be used on food crops (Burnett 2017; Hall 2008). Darlington (2010) also notes that if we want to ensure all the minerals we remove are being returned to the soil, human corpses, in addition to our excreta need to be recycled. If veganic farming is to be sustainable in the much longer-term, then these taboo topics will need to gain mainstream acceptance.

Pest Control

> *"[In veganic systems] ...pest control issues could be addressed only by separation, rather than by integration and coexistence."* (Filippi 2019:47)

Though veganic systems do not entirely rely on exclusionary methods of pest control, they do play a large role. This may stem from a prevalent attitude among veganic growers, of "non-interference in the lives of other animals" (Darlington 2010:167), and a reluctance to personally inflict harm. Barriers are common in veganic systems, being simple and effective. Netting may be used against birds, entrenched fences block out small and burrowing mammals and tall or double fences exclude deer (Filippi 2019, Rofe 2011, Hall and Tolhurst 2015). Electric fences and sonic deterrents may also be allowed, but some veganic growers are sceptical of their

supposed safety and harmlessness (Rofe 2011). Some veganic growers held disdain to have to exclude wildlife with barriers at all. One grower stated:

> "*To deter them I'm afraid we have had to succumb to that necessary evil – chicken wire.*" (Robertson 2006:37)

Another labels his rabbit and slug barriers a compromise on his part and an "...interference in the right of these animals to live." (Darlington 2010:167).

The non-interference attitude is not necessarily a weakness however and veganic systems synergise well with permaculture approaches to pest control. Permaculture addresses pests primarily through mimicking natural ecosystems and reframes their presence positively:

> *"Most gardening books will tell you that aphids are a problem. Actually you have a problem if you don't have aphids – what will the blue tits eat? All creation has a right to be in our garden and by approaching it as creating habitat we are simply trying to keep it in balance, so it looks after itself."* (Bell 2015:12)

With this logic, it is entirely acceptable and even advisable to leave up to 10% of crops for pests, as some veganic growers mentioned (Darlington 2010, Groleau 2005). Hence, pests should be managed "rather than trying to get rid of them completely." (Burnett 2014a:93). One veganic grower even suggests planting "A sacrificial or 'trap crop'" (Rofe 2011:15). Attracting pest-predators requires creating suitable habitats for them. This can range from planting specific flowers, designing a beetle-bank, or creating a small pond to attract slug-eating amphibians (Hall and Tolhurst 2015). It could however be remarked that veganic growers enlisting predators to "...do the deed [of killing] for them" (Webb 2008:8) is ethically equivalent to the field deaths in industrial crop production (Fischer and Lamey 2018). Indeed, it appears that killing pests is an inescapable necessity of veganic agriculture. Nevertheless, from a geocentric perspective this approach to pest control leads to more flourishing overall, as the pests provide a food source for predators, which in turn increases the biodiversity of the local ecosystem. Moreover, with the worrying trends of insect decline (Sánchez-Bayo and Wyckhuys 2019), using this form of pest control helps to increase insect populations while avoiding other collateral deaths associated with pesticide use (Fischer and Lamey 2018).

Whilst predation can work well for controlling many pests, some animals in Scotland have proven particularly troublesome, like deer, rabbits, squirrels and certain bird species ('S'; 'G';

Robertson 2006). The reason for this may not be the inadequacy of predators but rather the lack or complete absence of them in Scotland. Darlington argues that:

> "*Rabbits will be much less numerous once a programme of re-introduction of the red kite and the buzzard into the north-east of England is complete*" (2010:167).

Additionally, in Scotland, pine martens are helping to reduce grey squirrel numbers, and could consequently make tree food crops more viable as well as relieving pressure on red squirrel populations (Parsons 2019). However, re-introducing absent predators, like the wolf or lynx to control deer, is still controversial and would take significant time to come into effect if it were accepted (Grayson 2013). Attracting predators also requires that some threshold area of surrounding habitats and wildlife corridors is met (Jacke and Toensmeier 2005). For veganic farming to be more integrated with wildlife and to fulfil the non-interference ideal, re-introducing apex predators may be the logical conclusion, but until then, methods of separation are still needed.

Yields and Scalability

The discussion of yields was characterised by the comparison of annual and perennial crops. Within permaculture there was often more focus on using perennials, but this is not necessarily because they are believed to be higher yielding. Rather it may be that financial security is preferable to maximising food yields:

> "*If your main aim is to produce a lot of food, [then] …in the present economic situation this isn't necessarily the best choice. Most of us could earn in a day the cash value of the food we could produce in a domestic garden over a year.*" (Whitefield 2013:17).

Indeed, there was acknowledgement that perennials cannot out-yield annuals in a temperate climate, nor can they provide as many calories (Sugden 2017; Smaje 2015; Brown 2013). The value of perennials lies in their ability to provide "...yields year after year for several years, with little work after the first year." (Crawford 2013:33), to "give food during the 'hungry gap'" (Brown 2013:32), to conserve soil and build soil fertility, and their nutrient density (Jacke and Toensmeier 2005). Some perennials, like trees, do however "take several years to begin cropping" and can be thought of as a "long-term investment" in a secure food source (Burnett 2014a:224). Thus, if the objective of the system is to maximise food yields sustainably,

permaculturists and veganic growers generally agree that a mixture of nutrient-dense perennials and calorie-dense annuals is desirable (Smaje 2015; 'S'; Darlington 2010).

Currently, most permaculture food systems operate on a small scale which has led some to question its application on larger scales (Whitefield 2013). However, the assertion that permaculture food systems even need to be scaled up is debatable. Some permaculturists pointed out that small scale food systems tend to out-yield large scale systems in food produced per hectare ('G'; Whitefield 2013). Moreover, small-scale systems can be more intricately designed allowing for more diverse polycultures and zero-tillage growing (Smaje 2015; Smaje 2010; Whitefield 2013). Although, producing large quantities of annuals using zero-tillage may not be feasible as this would require significantly more mulching or composting materials (ToN 2019b; Smaje 2015; Hall 2011). These materials could be brought in externally, but Hall (2008) argues this is an inefficient use of land particularly on larger scales. Realistically, tillage – albeit minimal tillage – may be a necessary evil if we are looking to feed our populations (Smaje 2015; Hall 2011).

Certainly, for the same area of land, multiple small-scale farms could obtain yields on par with a single larger farm. But, to be commercially viable (particularly if grains are being grown), scaling up food production is required, and permaculture is just as relevant in this context ('M'; Smaje 2010). To keep the system manageable, its design must be simplified resulting in less diverse polycultures and more linear cropping patterns to ease harvesting (ToN 2019e; Whitefield 2013; Anderson 2014; 'S'). Yet, this still provides substantial benefits like increased biodiversity, over-yielding, and economic and climate resiliency (Whitefield 2013; Jacke and Toensmeier 2005; Woodcock 2016).

Veganic-Permaculture in Marginal Lands

There were a few examples of veganic and permaculture holdings that had adapted to the poor conditions afforded by marginal lands in Scotland such as in the Outer Hebrides, Arran and the Northern Coast (Lauruol 2014; Robertson and Robertson 2012; 'M'). Permaculturists also detailed various methods to cope with poor site conditions like terracing, tree row windbreaks, hardy plant varieties, growing under cover or improving poor soils with mulch or compost (Jacke and Toensmeier 2005; Holzer 2011; Woodcock 2016; Speakman 2017; Withall 2009; 'S'). While growing in marginal lands is evidently feasible, it is inherently limited in many

regards, especially as the range of crops able to cope will be predominantly perennials. Subsequently, this affects a grower's ability to make an income solely from food production. For veganic-permaculture systems then, this land could be utilised to a limited degree, but it would be more desirable to grow intensively on more suitable land and spare marginal lands for other uses.

5 – Permaculture and Domestic Animals: Progressive yet Incomplete

Research Question Recap: How inclusive is permaculture in its consideration of non-human animals in both its practices and the attitudes of people involved in them?

An Animal's Purpose

Domesticated animals were commonly included in small-scale permaculture holdings, primarily being used as food sources or for other services they provide, like controlling pests or supplying manure. Apart from beekeeping, I found no instances where animals were included in permaculture systems entirely for their own sake. Predominantly, they were included to fulfil some practical function. In smaller, garden-scale holdings, ducks and hens were frequently kept (ToN 2019a; 'M', 'G', Ashley 2010). Ducks are deemed useful as slug predators and for their manure, and hens similarly provide manure as well as eggs or meat. On larger holdings, bigger animals like pigs, horses and cows were frequently included, again for similar purposes like food, labour and manure (Fox 2012; Lant 2013; Provan 2017). My interpretation that these animals are principally included to fulfil some function is reinforced by the preferential selection and specific treatment of the sexes in different species. For example, one permaculture farmer stated: "…we keep most of the girls [for breeding]; however the boys go to the butchers" (Thorogood 2018:53). With chickens, hens were disproportionately kept, due to their supply of eggs, and roosters, if they were kept alongside hens, were few in numbers at most, mainly serving the role of breeders ('M', 'S', ToN 2019a). Animals were also preferentially selected according to their breed. One permaculturist initially kept two ex-battery hens, who repeatedly escaped the holding and damaged plants. However, these hens were stolen and were subsequently replaced with a different breed; silkies, who were selected for being less destructive and easier to keep enclosed (Hebbourn 2014). These examples of the specific selection of different species, sub-species or sexes to play some desired role in the larger system, suggests domestic animals are treated as a mere means within permaculture (Wrenn 2013; Barnhill and Doggett 2018).

In contrast, beekeeping, specifically natural beekeeping, may be an exception to the use of animals as mere means. In natural beekeeping:

> "*Little or no management is attempted, and rarely are splits made or queen-rearing conducted beyond what the bees do themselves. Hives are rarely opened; routine inspections are discouraged; honey is rarely taken; other hive products barely at all.*" (Chandler 2014:14).

Evidently, there is less interference and much less value is attributed to the bees' various products which could be of interest to humans. The purpose of keeping bees here may not reflect an intention to harness their productivity for human desires. Permaculturists may instead interpret themselves as "'bee guardians'" (Chandler 2014:13), "keeping bees for the bees' sake rather than for their honey" (Burnett 2014a:201).Whilst, there remains a degree to which the bees are treated as mere means through the occasional taking of their honey, this is not the primary motive.

The Treatment and Conditions of Animals

While the inclusion of domestic animals as mere means by permaculturists is inherently problematic, the treatment and conditions of these animals is perhaps the most favourable aspect of permaculture's usage of animals. Many times, the welfare of domestic animals in permaculture was attested to:

> "*The meat produced on small-scale permaculture farms around the world are very likely to be high welfare, happy, healthy animals.*" (Thorogood 2018:53)

> "*…permaculture is care of the animal, the care you provide for your animal will be as good of a care as you can provide just by definition. I mean there's no other way to do it. Whatever those methods are that are involved with looking after and caring for the animal that you are then exploiting in some way for your own health, then they will be well considered.*" ('C')

Even a veganic permaculturist recognised the higher quality of life for animals kept by permaculturists:

> "*...animal husbandry within a permaculture context is a million light years away from the industrialised factory 'pharms' that currently supply the sterile little packages on the supermarket shelves.*" (Burnett 2005:16)

Although he similarly highlights the contradictions of keeping animals in such a way:

> "*[Permaculture principles] for integrating cattle, pigs and birds into broad scale food forests are based on understanding and meeting their natural behaviours and needs, thus ensuring a high quality of life...Yet at the end of the day, even though [the] …animals have 'had a good life', they still wind up dead for the purpose of providing human sustenance.*" (Burnett 2014b:25)

Amongst permaculturists, there is a keen attention to simulating natural living conditions for the animals they keep, enabling them to lead more natural lives. For example:

> "*The main consideration when preparing for animals is having an awareness of how they would live in their natural state. Although many animals have been 'domesticated' and have evolved a lot from their wild ancestors, when their diets, group sizes, habitats and behaviours are most similar to how their wild ancestors would be, the animals exhibit the highest levels of welfare as we can perceive them to be*" (Thorogood 2018:51)

Attempts to emulate natural conditions for animals commonly included outdoor spaces to roam, appropriate shelter, co-habitation and largely unrestricted interactions with individuals of the same species, and species-specific diets ('S'; 'M'; Ashley 2010; Barlow 2014; Provan 2017). One of the interviewees took this effort of providing natural conditions even further. They allowed their chickens to be "radically self-ranging", meaning they were free to roam throughout the whole village and perhaps further if they desired ('M'). Instead of fencing the chickens in, crops were fenced to keep the chickens out.

Yet, not all permaculture holdings can afford to allow such uninhibited mobility. On one holding, hens who repeatedly escaped had their wings clipped several times (Hebbourn 2014:26). Free-ranging is often not feasible, especially when permaculture holdings are focused on food production. Here there is a temporal aspect to their daily mobility, where access to other enclosures is dictated by the permaculturists. Within these enclosures, the animal's behaviour may also be closely monitored in case they try to eat or damage important crops (Reid 2015; Ashley 2010, ToN 2019d; 2019f). Whilst the enclosures may themselves be stimulating, large and outdoors, the animal's mobility remains restricted and constitutes a harm to them (Simmons 2016).

It appears that there is also a fundamental conflict between using these animals for productive human purposes and enabling them to live natural lives. On 'M's holding, the ability of chickens to roam over such a large area meant some of their eggs were often not found. In contrast, the efforts of a permaculture-based calf-at-foot-dairy to maintain high welfare standards can interfere with the commercial operation:

> "*Having enough milk available for the customers at all times without pushing the cows to produce large volumes can be a struggle.*" (Provan 2017:20)

Furthermore, the dairy artificially inseminates their cows sometimes, perhaps because allowing them to naturally mate is too slow for their business needs (Provan 2017). The same conflict of interests exists among production-focused beekeeping too:

> "*What we want is not the same as what bees need. They need to be healthy, to resist predators, to reproduce successfully and to survive in adverse conditions. What the beekeeper wants, and what the bees need, conflict. Bees want to swarm: to divide and multiply to increase the overall population. Beekeepers prevent colonies from swarming to maximise the honey harvest. Strategies employed by the beekeeper may inadvertently destroy bees' capacity for survival.*" (Barlow 2014:21)

It is also worth noting that regardless of permaculturists efforts to recreate natural environments, some animals are non-natives and will find it hard to adapt unless great effort is made to accommodate them. For instance, sub-tropical chickens are not adapted to Scotland's temperate climate and may suffer when overwintering (Kelly 2011). The experience of goats and chickens on one permaculture farm testifies to this, where they were both observed to dislike the cold weather. The chickens were further disadvantaged because they shed their feathers during winter (ToN 2019b; 2019c).

When it comes to animals being killed for food or other reasons, permaculturists again make significant effort to do so in a 'humane' manner. One of the interviewees described their process:

> "*Killing the rooster…[involves] you catching it and sitting with him basically until he goes to sleep and then you hold him upside down and 'chik' you slit the throat very gently. And there's none of the kind of 'waah', splattering and... that's often associated with killing chickens.*" ('M')

Another interviewee said this about killing animals in permaculture:

> "*…eventually the chicken is going to die, and you might have to kill it or maybe you kill it as humanely as you can, but what do you do, you break its neck. It's not nice, not my kind of bag, but people do it and they're not squeamish about it.*" ('C')

While these examples are clearly an improvement upon industrial practices, the act is still inherently harmful because killing them for food is unnecessary (Abbate 2019b). Indeed, the larger theme here is that permaculture evidently offers far better conditions for animals than industrial animal agriculture, but despite all of this, there is an intrinsic level of harm that cannot be circumvented when it comes to exploiting animals. However, in the case of natural beekeeping and 'M's hens, where the animals are largely self-determining, no harm is necessarily being done when an unused egg is eaten, or small quantities of honey are harvested (Fischer and Milburn 2019). Though, obtaining food from animals in this way cannot be translated to larger, commercial production without making ethical compromises.

Attitudes of Permaculturists

> "*I suppose maybe the way I put it is that there are some words I invite people to lose if they want to go on this permaculture pathway. Two of the words are good and bad.*" ('G')

As noted earlier in this chapter, the inclusion of domestic animals in permaculture systems is commonly done to add practical value to the system, thereby benefiting the human. In line with this, permaculturists frequently objectified animals, discussing them in relation to what they can provide for humans:

> "*A few chickens make good use of the kitchen scraps, activate the compost heap and can save you work in the garden by clearing ground after crops have been harvested or bringing new ground into cultivation – the 'chicken tractor' so beloved of permaculturists.*" (Whitefield 2010:24)

> "*Our pigs, who fulfil the traditional permaculture 'chicken tractor' role on a larger scale, are a key part of our vegetable rotation as weeders, pest-controllers, ploughers and fertilisers*" (Smaje 2010:49)

> "*In 2003 he [Charlie Pinney] expressed so eloquently my concerns and frustrations: 'Living horse power is cheap and readily available. We can breed horses, without*

> *limit, without endangering the planet. We know a lot about them and how to use them. They can pull things for us, carry us, and help support our society, feed it and enable it to function.* "' (Lant 2013:51)

This objectification of animals could work to obfuscate their exploitation, especially where their lives otherwise appear pleasant (Wrenn 2013). In some cases, it seems that animals were anthropomorphised, such as when a permaculturist described their ducks as "…action-ducks who love to work." (Ashley 2010:49). This projection onto animals may further blind permaculturists to their exploitation. Furthermore, some permaculturists seemed to imply that the attention and care given to animals justifies their exploitation (Thorogood 2018; 'A'). One interviewee criticised the cruelty in factory farming and then went on to say that they could keep chickens and consume their eggs only "…because we treat them in like a really respectful way." ('M').

Another frequently occurring attitude in permaculture was ecocentrism; the prioritisation of collective life like ecosystem communities over individuals (Lynn 1998). This is not to say that individual lives are completely disregarded, more so that harm done to individuals can be justified provided the larger community or ecosystem is relatively unaffected. The following quote is exemplary of ecocentric thinking:

> "*In many 'hunter gatherer' cultures, while the species is sacred and revered, the individual animal is sacrificed...There is a clear ecological function underpinning this belief, as "by pursuing the individual and worshipping the species, the hunter guarantees the eternal recurrence of his prey".*" (Filippi 2019:47)

'M' echoed this view, stating that because anything we eat, both animals and plants is "stopping life" and causing suffering, we should aim to do this in a conscious way where the "…whole ecosystem works". Another permaculturist contends that modestly consuming "…animal products is not only sustainable but may actually be beneficial to the ecology of the landscape" (Whitefield 2010:22).

My findings seem to align with Puig de la Bellacasa's (2010) contention that permaculture counters anthropocentric attitudes and certainly, permaculturists are very attentive of ecology as Hathaway (2016) claims. But while anthropocentrism is non-existent, ecocentrism instead is dominant. In this sense, there are many improvements for animals in moving towards

permaculture. Permaculture's foundations of sustainability mean far less animals overall are being exploited and the treatment of animals who are exploited is likely superior to other food systems. For permaculture to be more considerate of non-human animals, I argue that permaculture needs to challenge its objectification of animals and to reflect on what harm is unnecessary and can thus be avoided. In this way, the flourishing of individual animals in addition to the rest of the geographic community can be achieved and it seems there is already progress in this regard when it comes to permaculture's attitude towards bees.

While permaculture may traditionally view domestic animals as integral to food systems, there is not necessarily any conflict between the philosophies of veganism and permaculture as one veganic-permaculturist suggests:

> "*Permaculture and veganic growing are fully compatible. Neither permaculture nor veganic is a specific 'technique': both are based on ideas and principles, and veganic permaculture involves the merging of these two sets of ethics.*" (Kelly 2011:28).

There may in fact be much overlap between the ethical principles of each movement as Burnett notes that permaculture's three guiding ethical principles; Earthcare, Peoplecare and Fairshare are somewhat parallel to the "compassionate concern for 'Animals, People and Environment'" (2014a:9). Although Burnett also suggests that veganic-permaculture may encompass a fourth principle, that of "Do Least Harm", meaning non-human animals should be able to "exist free from unnecessary harm" (2015:12). Perhaps uncoincidentally, this idea of unnecessary harm underpins Abbate's (2019b) conceptualisation of veganism and so I would suggest that this is the defining logic that leads to veganism. It may then follow that if permaculture were to adopt this fourth ethic and follow it to its logical conclusion, they would arrive at something resembling a veganic food system. Indeed, that is veganic-permaculture's one key difference:

> "*In veganic permaculture, the role of animals as part of the ecosystem and as part of the permaculture system is still considered and valued, though in the form of free-living animals, not in the form of domesticated animals.*" (Kelly 2011:28).

6 – Veganic Permaculture: A Food System for the Whole Geographic Community

Research Question 3: What would be the potential implications of Scotland adopting a veganic permaculture mode of food production?

A Veganic-Permaculture Imagining of Scotland

> "*...for many people permaculture is about designing for human needs. Many people think it's about gardening and it isn't really, …gardening is just one of the easiest ways of expressing it because it's something that most people can do.*" ('G')

Whilst gardening may be the most realistic way through which people can actualise their permaculture visions, this has not limited them to imagining the possibilities of permaculture on a much larger scale. Notably, there was much common ground in the direction of veganic and permaculture visions. One shared aim was for the nation to be almost entirely self-sufficient in food (Burnett 2014a; Hall 2008; Whitefield 2012; 'C'; 'G'). Certainly, there was agreement that domestic food production should be focused on growing staple human foods, decreasing our dependence on imports. Imported food would instead be comprised of primarily luxury foods (Embleton 2011; Burnett 2014a).

The resulting landscape configuration of a food secure Scotland would still follow the broader pattern of the East-West divide due to the more favourable agricultural conditions in the East (Harper 2019; 'C'; 'A'). The East would still be focused on producing mostly annual crops, though grains might not yield as high and other food groups could become staples of our diet (Harper 2019; Filippi 2013; Sugden 2017; 'A'). However, to maintain good fertility and avoid the precarity of monocultures, the arable land in the East should also include some perennials and simple polycultures of annuals too. Alley cropped polycultures could be an effective way of doing this on a large scale (Burnett 2014b) and Figure 6.1 shows how their design blends arable farming with food forests. To keep it manageable, the polyculture would not be tremendously diverse (Anderson 2014), but "…fortunately the first step away from monoculture is the biggest" (Whitefield 2013:18), and therefore, benefits like over-yielding, higher biodiversity, and economic and climate resilience are still being gained. Using Hall's (2008) estimation that ~0.12 hectares are needed to feed one person using veganic methods,

this means 8 people can be fed per hectare which is the same as Fairlie's (2010) estimations. Consequently, ~5 million people can be fed just from Scotland's prime land (Appendix III). Feeding the rest of the population then could be comfortably achieved by using improvable land too. Despite it being less suitable for agriculture, there would still be surplus land left over for other uses (Appendix III). Furthermore, if these predictions considered alley cropping, perhaps more food could be produced per hectare due to the over-yielding principle, in addition to the other benefits from alley cropping (Wolz *et al*., 2018).

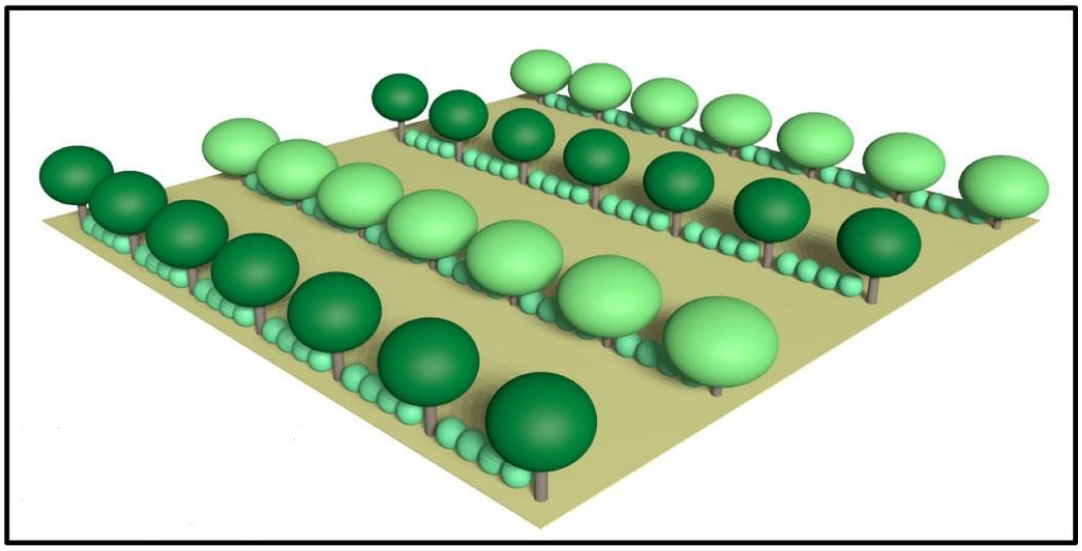

Figure 6.1 – The graphic model provides an example of how large-scale alley cropping could be designed. In the tree rows, understories of shrubs can also make efficient use of the space and there is also diversity between each tree row. Diverse tree species could also be used within the tree rows. Between the tree rows, annual crops can be grown. Adapted from Wolz et al. (2018).

With the East providing food security, the more marginal lands in the West could be devoted to wildlife conservation, rewilding and forestry ('C'; Hall 2008; Darlington 2010; Harper 2019). Though, using some of this vast area to grow perennials in food forests may be sensible in case sea-level rise impacts low-lying farmland (Hall 2008). By allowing the restoration of native forests, huge quantities of carbon could be sequestered according to Harwatt and Hayek's (2019) calculations. Turning over so much land to wilderness would greatly improve biodiversity and it provides ample space for existing predators like Scottish wildcats to multiply or for absent ones to be reintroduced (Hall 2008; Hall 2015). Subsequently, attracting the right predators for pest control becomes easier, because they have more habitats (Jacke and Toensmeiser 2005).

Cities would also undergo a transformation. Given they are a challenging growing environment due to shade, pollution and the lack of green space, cities would be limited in what and how

much food can be grown there ('C'; Griggs 2013). However, garden spaces present a great opportunity for growing fruit and vegetables or more exotic foods in glasshouses, and utilising these spaces frees up land elsewhere (Embleton 2011). Regardless, there was a consensus that most food will be produced in peri-urban and rural areas (Griggs 2013; Whitefield 2012) by large numbers of smaller scale farms, with much more human labour ('M'; 'G'; 'C'; Whitefield 2012; Smaje 2010).

Barriers to this Imagining

One obvious barrier to this vision is the fact that it embodies veganism which itself encompasses many changes that would be met with resistance. Of these changes, diet is perhaps the one most resisted, and when this is considered in conjunction with permaculture where grains will be less prevalent (Filippi 2013; 'A'), this could reinforce people's aversion. Moreover, relying less on imports like "…bananas, chickpeas, chocolate or olive oil" could be met negatively (Burnett 2014a:155). A drastic shift in how the population thinks about their diet is therefore required ('A'; Burnett 2014a).

With the radical change to our diets outlined in this vision, adequate nutrition needs to be ensured. This not to say the diet itself is inadequate but if the population is depending on locally produced food, then "…the mineral levels in your food will be entirely dependent on their availability in the soil in which they are grown" (Sugden 2017:29). Consequently, we need to consider that food will be low in minerals which are traditionally scarce in British soils like selenium, and other minerals where it has been grown on land degraded by previous industrial practices (Lloyd 2010; Aranya 2018). Farming seaweed along Scotland's coasts could help address the geological scarcity of nutrients (especially selenium and iodine) by applying it to farmland soils, although this would require further labour (Robertson 2018; Sugden 2017). Green manures and humanure would also help to accumulate and recycle nutrients, but this does not address localised nutrient deficiencies in the geology. Designing our landscapes then, so that wildlife, particularly large herbivores, can roam widely means nutrients are continually being transported from place to place, potentially replenishing soils deficient in specific nutrients (Aranya 2018). But, to design out barriers could be very laborious and detrimental to controlling pests.

Such a shift to veganism would have profound repercussions for domestic animals and the livelihoods of people dependent on them. Hence, convincing people of the need to repurpose this use of land is a significant challenge. Hill farming for example, is arduous and precarious work, being subsidised as a result, so providing an economic incentive to change this land-use which also grants security to hill farmers is needed (Darlington 2010; Shepherd 2013). Yet, even with economic compensations, hill farming retains a sentimental value:

> "*The end to hill farming would be very distressing to those whose families had been involved in it for generations, so there would be a considerable short-term social cost*." (Darlington 2010:122)

Assuming a consensus among the population could be reached for abolishing animal agriculture in Scotland, it remains to be determined what will happen to the liberated animals? There is a conflict between enabling these animals to live out natural lives, including being able to mate freely and multiply, and the environmental cost of such large numbers of these animals. Indeed, one of the prime advocations for veganism is to alleviate the pressure caused by artificially high numbers of domestic animals. While there will be far fewer domestic animals with the cessation of humans systematically breeding them, a significant number of them will remain. Thus, to house them all in animal sanctuaries might be ethical, but it simultaneously prolongs their environmental impact (Daly 2017). Perhaps this is an inescapable consequence if we want to avoid sterilising or culling them.

Another obstacle to this vision is the need for a larger agricultural workforce. These employment opportunities would need to provide a reasonable income, but currently veganic and permaculture food systems are economically challenging ('S'; 'M'; Darlington 2010; Hall 2008). This might then be addressed by subsidising veganic-permaculture farms, or even increasing food prices along with equitably distributing wealth across the entire population (Darlington 2010). In addition, a large agricultural workforce would see more of the population spread throughout the country and settlement infrastructure would need to accommodate for this ('A'; 'C'). This workforce also requires training:

> "*…how do you undo the clearances, how do we bring people back to the land and that needs to be education of course, training...you can't just expect to put people on the land and have them know what to do.*" ('A')

Despite the mobilisation required from Scotland's population, one of the interviewees viewed this positively:

> "*That of course is a much more intensive rate of human intervention than [current agricultural practices] …Where one guy will do a 10-acre field in a day, then leave it and might visit it for a few more hours or two then they'll spend the day harvesting. But in the present climate you actually need meaningful work for people*." ('G')

Lastly, access to land and the severely unequal land ownership in Scotland is a major barrier for those who are currently trying to implement this vision ('C'; 'A'; 'S'). Presently, there are already a lot of people wanting to live a land-based life and grow food but are unable to do so because of the expensive entry barrier ('A'). And those who get past this often struggle to stay afloat financially and mentally ('C'; 'G'). Moreover, it may not be in the interests of some wealthy elites for more equitable land-access or even land redistribution:

> "*As Bill Mollison describes in his Permaculture Designer's Manual, 'To let people arrange their own food, energy, and shelter is to lose economic and political control over them."*" (Vosper 2012:34).

But it is precisely this freedom that would lead to widespread flourishing for people in Scotland.

7 – Conclusion

Concluding Remarks

In concluding this research, I first want to revisit each research question before tying the broader themes of this research together. Concerning the ways in which permaculture adds value to veganic farming, it is not that permaculture offers any novel growing techniques, for veganic growing already utilises many of the same methods (Hall and Tolhurst 2015). What permaculture offers is a framework of ethical and design principles against which we can the measure the extent that veganic systems have successfully implemented these. For example, taking the design principles 6. 'produce no waste' and 8. 'integrate rather than segregate', we can observe that veganic systems could be improved by recycling humanure and re-integrating absent predators back into Scotland so barriers can be relied on less. Essentially, permaculture can help ensure veganic food systems are deeply sustainable. By thoroughly questioning the true sustainability of veganic practices, veganism enables other members of the geographic community to flourish in unity with us as we learn how to live more lightly.

Regarding the second research question, permaculture is as inclusive to non-human animals as it can be within the mindset and ethical principles it currently operates in. Permaculture generally fosters ecocentric attitudes that confer greater concern for collective lifeforms whereas individual animals retain their status of exploitability for human utility. Utilitarian logic was often employed to justify the exploitation of individual animals, be that the larger systemic benefits this exploitation serves and/or the overall quality of that individual's life. Only once permaculture by itself or in conjunction with veganism, challenges the use of domestic animals themselves can the unnecessary harm caused in using them be realised and acted upon (Wrenn 2013; Abbate 2019b). Upon reaching this point, permaculture becomes fully inclusive of non-human animals, taking on a geocentric outlook.

Imagining the possibilities afforded by the employment of veganic-permaculture in Scotland sparks hope against the tide of crises caused by industrial agriculture. Most significantly, we could reduce GHG emissions and sequester carbon, produce the majority, if not all of our own food sustainably, and vastly improve the lives of Scotland's non-human animal co-inhabitants, wild and domestic. This vision is geocentric, ensuring that the human population can flourish in a way that allows non-human individuals and populations, and the wider ecosystem to do

the same. Yet, the changes this vision requires on our part are tremendous, spanning geographic, political, social, economic and cultural spheres. It could be criticised that these changes are antithetical to human flourishing and progress given the aspects of abstinence (e.g. no animal products and less imports) and descendance (e.g. more agrarian living). But progress in its present conceptualisation portrays human flourishing as comfort, convenience and consumption. It contends that our standard of life is always improving and therefore disregards those features of the past that would be beneficial to replicate in modern life. This vision then requires altruism on our part, sacrificing some modern pleasures whilst enabling humans to flourish in the ways that matter like restoring our relationship with the land and wildlife and the sustainable provision of health promoting foods.

Throughout this dissertation, geocentrism has been thoroughly referenced. In conducting this research, I have become aware of how imperative this perspective is as an analytical tool for measuring the inclusiveness of positive actions. It is a framework that encourages ethical and sustainable behaviours without placing these at odds with each other. Applying geocentrism to veganism and permaculture helps us assess their performance and envisage how they could become more sustainable and ethical respectively.

A key takeaway from this research is that large-scale vegan food systems are not bound to a 'lesser evil' status compared to industrial animal agriculture. This criticism may stem from the supposed unnatural-ness of veganism, which implies inferiority:

> "*…there is no record of a completely vegan society or tribe having existed anywhere in the world*" (Fairlie 2019:11)

> "*[veganic farming] …is always and inevitably incomplete and generally does not fully meet the basic premise of permaculture: it is not a system entirely modelled on nature*" (Filippi 2013:34)

But, the findings of this research demonstrate that veganic permaculture food systems can be sustainable and integrated with the ecosystem without compromising on their ethical principles. This matters because:

> "*…sustainability is of fundamental importance. You could devise the best and most ethical system of agriculture in the world, but, if it was not sustainable, it would be worthless.*" (Darlington 2010:168).

Through the integration of permaculture and veganic approaches then, veganism is made more geocentric, giving reassurance that the pursuit of veganism can be entirely sustainable and worthwhile. The question I then turn to: how do we actualise this vision?

Limitations and Opportunities for Further Research

Knowledge sources used in this research were primarily experiential and so the real-life impacts and implementation of the prescribed solutions will be variable. But food systems are inherently context dependent and so what these alternative solutions do offer is a direction for more specialised, and perhaps more quantitative inquiries into the different aspects of veganic-permaculture food systems.

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Appendix I – Coding Tallying

Code	The Land	Growing Green International	Permaculture Magazine	M'	A'	G'	C'	Tap o'Noth Vlog	Growing Sustainability	Edible Forest Garden Vol 1	The Vegan Book of Permaculture	Growing Green	Total
AI-1			14	2				5					**21**
AI-2	4	3	23	1		1		5					**37**
AI-3	4	2	20					9					**35**
AI-4	2	2	17	3	1	2		2					**29**
AI-5	2	1	9	4	1	1		7					**25**
AI-6	1		15	2				2					**20**
Total	**13**	**8**	**98**	**12**	**2**	**4**	**0**	**30**	**0**	**0**	**0**	**0**	**167**
AII-1	4		1										**5**
AII-2	1	3		1									**5**
AII-3	11	1	41	2	1	4	2	4					**66**
AII-4	1	3	3	1			1						**9**
AII-5	10	3	7	4		1							**25**
AII-6		7	5		1				2		1		**16**
AII-7		6	4	1					2				**13**
AII-8		5	17	4	3	1	3	1	2		1		**37**
AII-9		6							2			1	**9**
Total	**27**	**34**	**78**	**13**	**5**	**6**	**6**	**5**	**8**	**0**	**2**	**1**	**185**
BI-1	22	13	21	1		2			5	8	7		**79**
BI-2	2	3	10	1		1				1	1	1	**20**
BI-3	19	18	12	2	3	1	1		3	4	3	4	**70**
BI-4	10	32	2	2	1	5	2	2	6	5	5	12	**84**
BI-5	10	45	13	2	5	7		2	14	9	7	8	**122**
BI-6	5	17	16	1		2			1	6	2		**50**
BI-7	10	7	2			1			1			2	**23**
BI-8	9	33	34	3	5	1	1	3	4	9	4	1	**107**
BI-9	15	9	7			2	1		5	2	3	2	**46**
BI-10	38	24	19	4	2	1	2		10	2	2	9	**113**
BI-11	13	23	13	3	1		1		6	2	3	6	**71**
BI-12	4	32	12	5	5	8			12	3	4	4	**89**
BI-13	9	10	5	6	2	2	2	2	2		6	3	**49**
Total	**166**	**266**	**166**	**30**	**24**	**33**	**10**	**9**	**69**	**51**	**47**	**52**	**923**
BII-1	20	17	16	1	3	3	8			2	3		**73**
BII-2	19	20	6			1	2		1	5	3	2	**59**
BII-3	24	12	8	1		1					4	1	**51**
BII-4	2	3	1				1				1		**8**
BII-5	7	14	22	3	1	3	3		5	1	10		**69**
BII-6	3	10	17	5	1	3	2		1	2	2	3	**49**

BII-7	3	6	3	1	1	2	1				2	1	**20**
BII-8	10	14	17	3			1	1	1	2	2	2	**53**
BII-9	4	21	7		2	2			1		1		**38**
BII-10		6	3						1				**10**
Total	**92**	**123**	**100**	**14**	**8**	**15**	**18**	**1**	**10**	**12**	**28**	**9**	**430**

Appendix II – Interview & Documentary Analysis Coding Specimens

Interview Transcript Example

S: So how far can the chickens roam?
M: The whole village, I mean they don't go but they're free to go where they want. They raid our neighbours bird feed quite often. We fence our vegetables in to keep the chickens out...but no, they can go wherever they want really. And at the moment they live in a chicken shack so they naturally go in there at night and we close the door because there are foxes around. But otherwise they are living in a trees, there is a forest there

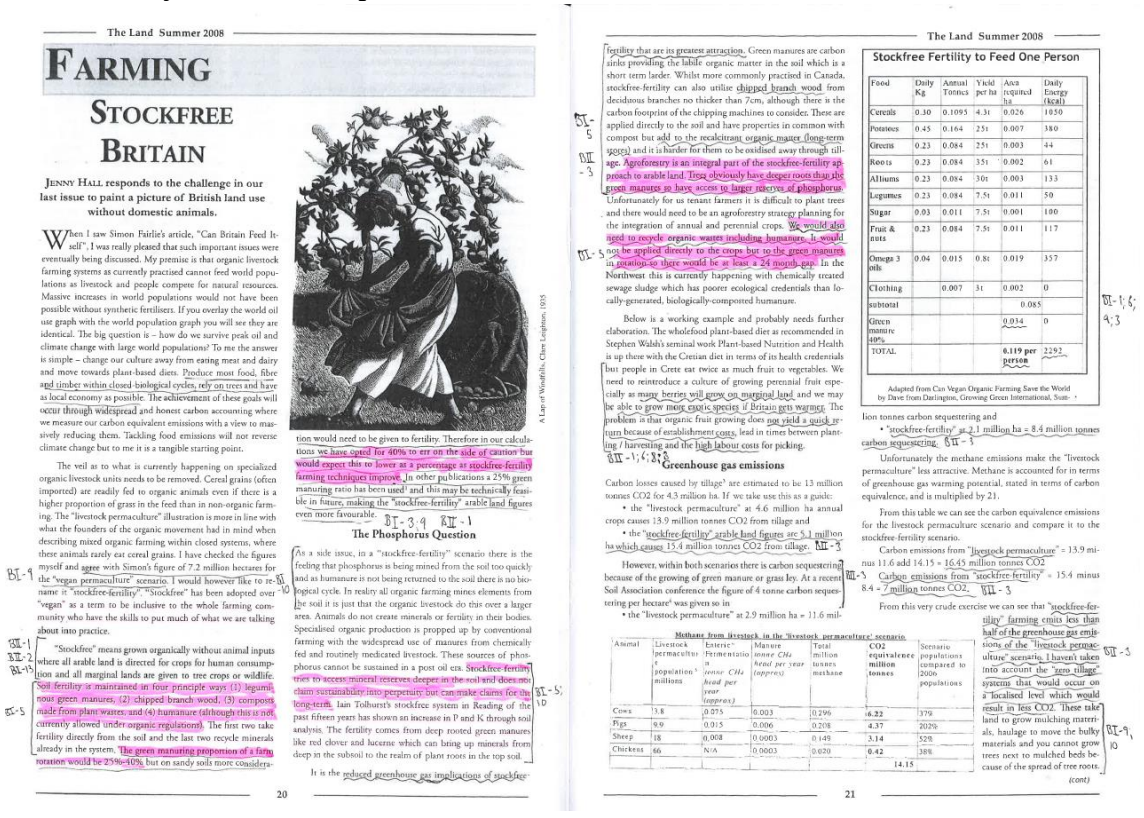
S: In terms of their wellbeing, do you think there is much that could be improved or is it pretty much perfect?
M: I think they are pretty okay. Sometimes I see...like their egg shells are a bit thin and I wonder about the diversity of nutrients they manage to find so sometimes I'm thinking should I be giving them a supplement but at the same time this is their natural habitat. And craig who is around and has a kiln over there, sometimes they like to eat in the clays over there and its fair enough if thats what they want to eat. I think actually they're doing fine. And our neighbours have ducks and in the same way they are allowed to go wherever they want to go. And the chickens and the ducks don't mix so ducks never come into this back garden and the chickens never go into their back garden cause they have like their different territories but thats beyond our understanding of how they're communicating, how they've agreed this or whatever. I think the main thing is that they have a full lifecycle and a natural life cycle so they're not speeded up in any way, the chicks all hatch naturally out in the garden somewhere with their mum and its up to them...like we have a little one somewhere at the moment whos four days old or something at the moment and can be taken by a sparrow hawk at any point but we're not keeping her contained or anything, so its completely natural in that sense. Most of them we let die naturally as well, definitely the hens, they die naturally then we compost them, we don't eat them. The exception is the roosters, we...in a

Sam Eccles
14:30 3 Oct
Resolve
AI-1;5

Sam Eccles
14:31 3 Oct
Resolve
AI-2 AII-8

Sam Eccles
14:32 3 Oct
Resolve
AII-7

Documentary Source Example



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FARMING

STOCKFREE BRITAIN

JENNY HALL responds to the challenge in our last issue to paint a picture of British land use without domestic animals.

When I saw Simon Fairlie's article, "Can Britain Feed Itself", I was really pleased that such important issues were eventually being discussed. My premise is that organic livestock farming systems as currently practised cannot feed world populations as livestock and people compete for natural resources. Massive increases in world populations would not have been possible without synthetic fertilisers. If you overlay the world oil use graph with the world population graph you will see they are identical. The big question is – how do we survive peak oil and climate change with large world populations? To me the answer is simple – change our culture away from eating meat and dairy and move towards plant-based diets. Produce most food, fibre and timber within closed-biological cycles, rely on trees and have as local economy as possible. The achievement of these goals will occur through widespread and honest carbon accounting where we measure our carbon equivalent emissions with a view to massively reducing them. Tackling food emissions will not reverse climate change but to me it is a tangible starting point.

The veil as to what is currently happening on specialized organic livestock units needs to be removed. Cereal grains (often imported) are readily fed to organic animals even if there is a higher proportion of grass in the feed than in non-organic farming. The "livestock permaculture" illustration is more in line with what the founders of the organic movement had in mind when describing mixed organic farming within closed systems, where these animals rarely eat cereal grains. I have checked the figures myself and agree with Simon's figure of 7.2 million hectares for the "vegan permaculture" scenario. I would however like to re-name it "stockfree-fertility". "Stockfree" has been adopted over "vegan" as a term to be inclusive to the whole farming community who have the skills to put much of what we are talking about into practice.

"Stockfree" means grown organically without animal inputs where all arable land is directed for crops for human consumption and all marginal lands are given to tree crops or wildlife. Soil fertility is maintained in four principle ways (1) leguminous green manures, (2) chipped branch wood, (3) composts made from plant wastes, and (4) humanure (although this is not currently allowed under organic regulations). The first two take fertility directly from the soil and the last two recycle minerals already in the system. The green manuring proportion of a farm rotation would be 25%-40% but on sandy soils more considerable tion would need to be given to fertility. Therefore in our calculations we have opted for 40% to err on the side of caution but would expect this to lower as a percentage as stockfree-fertility farming techniques improve. In other publications a 25% green manuring ratio has been used[1] and this may be technically feasible in future, making the "stockfree-fertility" arable land figures even more favourable.

A Lan of Windfalls, Clive Leighton, 1935

The Phosphorus Question

As a side issue, in a "stockfree-fertility" scenario there is the feeling that phosphorus is being mined from the soil too quickly and as humanure is not being returned to the soil there is no biological cycle. In reality all organic farming mines elements from the soil it is just that the organic livestock do this over a larger area. Animals do not create minerals or fertility in their bodies. Specialised organic production is propped up by conventional farming with the widespread use of manures from chemically fed and routinely medicated livestock. These sources of phosphorus cannot be sustained in a post oil era. Stockfree-fertility tries to access mineral reserves deeper in the soil and does not claim sustainability into perpetuity but can make claims for the long-term. Iain Tolhurst's stockfree system in Reading of the past fifteen years has shown an increase in P and K through soil analysis. The fertility comes from deep rooted green manures like red clover and lucerne which can bring up minerals from deep in the subsoil to the realm of plant roots in the top soil.

It is the reduced greenhouse gas implications of stockfree-

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fertility that are its greatest attraction. Green manures are carbon sinks providing the labile organic matter in the soil which is a short term larder. Whilst more commonly practised in Canada, stockfree-fertility can also utilise chipped branch wood from deciduous branches no thicker than 7cm, although there is the carbon footprint of the chipping machines to consider. These are applied directly to the soil and have properties in common with compost but add to the recalcitrant organic matter (long-term stores) and it is harder for them to be oxidised away through tillage. Agroforestry is an integral part of the stockfree-fertility approach to arable land. Trees obviously have deeper roots than the green manures so have access to larger reserves of phosphorus.

Unfortunately for us tenant farmers it is difficult to plant trees and there would need to be an agroforestry strategy planning for the integration of annual and perennial crops. We would also need to recycle organic wastes including humanure. It would not be applied directly to the crops but to the green manures in rotation so there would be at least a 24 month gap. In the Northwest this is currently happening with chemically treated sewage sludge which has poorer ecological credentials than locally-generated, biologically-composted humanure.

Below is a working example and probably needs further elaboration. The wholefood plant-based diet as recommended in Stephen Walsh's seminal work Plant-based Nutrition and Health is up there with the Cretian diet in terms of its health credentials but people in Crete eat twice as much fruit to vegetables. We need to reintroduce a culture of growing perennial fruit especially as many berries will grow on marginal land and we may be able to grow more exotic species if Britain gets warmer. The problem is that organic fruit growing does not yield a quick return because of establishment costs, lead in times between planting / harvesting and the high labour costs for picking.

Greenhouse gas emissions

Carbon losses caused by tillage[2] are estimated to be 13 million tonnes CO2 for 4.3 million ha. If we take use this as a guide:

- the "livestock permaculture" at 4.6 million ha annual crops causes 13.9 million tonnes CO2 from tillage and
- the "stockfree-fertility" arable land figures are 5.1 million ha which causes 15.4 million tonnes CO2 from tillage.

However, within both scenarios there is carbon sequestering because of the growing of green manure or grass ley. At a recent Soil Association conference the figure of 4 tonne carbon sequestering per hectare[4] was given so in

- the "livestock permaculture" at 2.9 million ha = 11.6 million tonnes carbon sequestering and
- "stockfree-fertility" at 2.1 million ha = 8.4 million tonnes carbon sequestering.

Unfortunately the methane emissions make the "livestock permaculture" less attractive. Methane is accounted for in terms of greenhouse gas warming potential, stated in terms of carbon equivalence, and is multiplied by 21.

From this table we can see the carbon equivalence emissions for the livestock permaculture scenario and compare it to the stockfree-fertility scenario.

Carbon emissions from "livestock permaculture" = 13.9 minus 11.6 add 14.15 = 16.45 million tonnes CO2

Carbon emissions from "stockfree-fertility" = 15.4 minus 8.4 = 7 million tonnes CO2.

From this very crude exercise we can see that "stockfree-fertility" farming emits less than half of the greenhouse gas emissions of the "livestock permaculture" scenario. I haven't taken into account the "zero tillage" systems that would occur on a localised level which would result in less CO2. These take land to grow mulching materials, haulage to move the bulky materials and you cannot grow trees next to mulched beds because of the spread of tree roots.

(cont)

Stockfree Fertility to Feed One Person

Food	Daily Kg	Annual Tonnes	Yield per ha	Area required ha	Daily Energy (kcal)
Cereals	0.30	0.1095	4.3t	0.026	1050
Potatoes	0.45	0.164	25t	0.007	380
Greens	0.23	0.084	25t	0.003	44
Roots	0.23	0.084	35t	0.002	61
Alliums	0.23	0.084	30t	0.003	133
Legumes	0.23	0.084	7.5t	0.011	50
Sugar	0.03	0.011	7.5t	0.001	100
Fruit & nuts	0.23	0.084	7.5t	0.011	117
Omega 3 oils	0.04	0.015	0.8t	0.019	357
Clothing		0.007	3t	0.002	0
subtotal				0.085	
Green manure 40%				0.034	0
TOTAL				0.119 per person	2292

Adapted from Can Vegan Organic Farming Save the World by Dave from Darlington, Growing Green International, Sum- -

Methane from livestock in the 'livestock permaculture' scenario

Animal	Livestock permaculture population millions	Enteric Fermentation tonne CH4 head per year (approx)	Manure tonne CH4 head per year (approx)	Total million tonnes methane	CO2 equivalence million tonnes	Scenario populations compared to 2009 populations
Cows	3.8	0.075	0.003	0.296	6.22	379
Pigs	9.9	0.015	0.006	0.208	4.37	202%
Sheep	18	0.008	0.0003	0.149	3.14	52%
Chickens	66	N/A	0.0003	0.020	0.42	38%
					14.15	

21

Appendix III – Yield Calculations for Scotland

For estimating the potential yield of food Scotland can grow using veganic-permaculture, a figure for the number of people fed per hectare was determined. Fairlie (2010), Hall (2008) and Darlington (2010) all estimated that approximately 8 people can be fed per hectare using veganic methods, and Fairlie estimated the same amount for veganic-permaculture methods. Considering also that 6-10 people fed per hectare of temperate food forest was cited in Nytofte and Henriksen's (2019) study, this backs up Fairlie's assertion that veganic-permaculture can similarly feed an average of 8 people per hectare. These estimations take into account the land needed for green manures.

Scotland population = ~5.44 million (https://www.nrscotland.gov.uk/news/2019/scotlands-population-at-record-high-but-population-growth-has-slowed)

Scotland has 625,800 hectares of prime/arable agricultural land. Improvable agricultural land is comprised of 1,541,100 hectares of mixed agricultural land and 1,405,700 hectares of improved grassland. Together this makes 2,946,800 hectares. Unimprovable land takes up 4,035,800 hectares (The James Hutton Institute 2010).

People fed by land classification
Prime Land:

8 x 625,800 = 5,006,400 people fed

Improvable Land:

8 x 1,541,100 = 12,328,800 people fed (on mixed agricultural land)

8 x 1,405,700 = 11,245,600 people fed (on improved grassland)

These figures are however very likely overestimations due to the poorer quality of land and climatic conditions. But it is probable that more than enough food can be produced on these lands to feed the remainder of the population since most of the population is already covered by food production from prime land.

Appendix IV – Logbook

DISSERTATION LOGBOOK

Rm. 509

Student Name: Sam Eccles Supervisor Name: Emma Cardwell

Meeting (duration 30-45mins)	Date	Student signature	Supervisor signature	Additional information on meeting:
1st group meeting after supervisor allocation	14/02/2019	Sam Eccles		
Individual meeting to approve research topic and proposed research	23/05/2019	Sam Eccles		
Group meeting after the summer break	25/09/2019	Sam Eccles		
Individual progress meeting after the summer	4/10/2019	Sam Eccles		
Speed-read meeting (can be split into two shorter meetings)	5/12/19	Sam Eccles		
Additional meeting A				
Additional meeting B				

This logbook is to be printed, brought to every meeting with your supervisor and finally scanned and attached to your dissertation