**In the light of the need for greater self-sufficiency through the predicted impacts of CC and PPO, could Powys become self-reliant in food by 2020?**

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**July 2010**

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## Acknowledgements

My gratitude is extended to all those who helped with the research supporting this thesis and the technical, literacy and numeric skills of those who helped with proof reading, mathematics and lay out.

My particular thanks goes to Di Greaves at the Statistical Department of Powys County Council, John Bleasdale from the WAG Agricultural Statistics Department, Roger from Calonwen Organic Dairy Cooperative, Kerrin Buckler from the Centre for Alternative Land use, Simon Fairlie for informed discussion and Ian Sheffner for proof reading and checking maths.

I would like to give special acknowledgement to my tutor Melissa Taylor for guidance and advice throughout the thesis writing process.

## List of abbreviations

| | |
|---|---|
| ASPO | Association for the study of Peak Oil and Gas |
| BMI | Body Mass Index |
| CALU | Centre for Alternative Land Use |
| CC | Climate Change |
| DA | Disadvantaged |
| EU | European Union |
| GHG | Green House Gas |
| ITE | Institute of Terrestrial Ecology |
| LFS | Less favoured Status |
| NAW | National Assembly for Wales |
| PCC | Powys County Council |
| PPO | Post Peak Oil |
| QWFC | Quality Welsh Food Certification |
| SDA | Severely Disadvantaged |
| SFP | Single Farm Payment |
| SSSI | Site of Special Scientific Interest |
| WAG | Welsh Assembly Government |
| WTO | World Trade Organisation |

## List of Figures and Charts

## Executive Summary

This report accepts that much work is being done in the twin areas of climate change and oil depletion with regard to renewable energy generation, energy conservation and awareness raising of low carbon issues in communities. Yet, food production and food security do not seem to be placed very far up the agenda of areas of our lives that need looking at in the context of sustainability.

For the most part the UK's food supply now comes from abroad. Much of what we produce is exported, while we import the foods that we actually consume. This takes responses to climate change on our food supply out of our hands and leaves us dependant on countries to feed us who may no longer have the ability to feed themselves as seasons become erratic and weather patterns destabilise.

Oil depletion will either make food miles so expensive that the cost of our imported foods will soar or that oil based movement of produce actually stops. In either case the risk of hunger and possibly starvation could become a reality for the UK, whereas it's always been seen as something that only happens in other, usually third world, countries.

It has taken many years to deconstruct the UK agricultural system and to reform it as the industry it now is. An industry that produces profit over and above appropriate food for its citizens. It could take almost as much time to reinstate the kind of farming that can feed the population with a rich, varied and nutritious diet.

The early predictions for when we would begin to feel the effects of climate change gave a figure somewhere around the end of this century. The figures have been constantly revised by various panels and government bodies and have crept slowly towards the middle of this century and then as close as maybe 2020. If 2020 is a possibility as a date where we could be in the middle of extreme climate change issues, then that only leaves us ten years to turn our food production systems around.

The main objectives of the research are to establish the population figures for a given area, in this case Powys, by the year 2020,to assess the amount of land available for agricultural production, to decide on a basic minimum diet for the population and discover whether the land available can supply this. There are secondary issues surrounding the research such as how the farming practice would need to change to mirror oil depletion and how communities might need to restructure in order to bring this about.

I have chosen Powys because it is where I live and have had some experience in farm scale crop production on marginal land. Powys is also a unitary authority, which allows the findings from this piece of research to be fed into policy making

This report aims to inform agricultural policy at a County Council, Welsh Assembly Government and European Government levels.

Further research needs to be done on how policy can be influenced at these levels. Farmers, politicians, consumers and retailers all need to be involved in the rapid development of a programme for agricultural reform.

Methodology

This thesis asks a very specific question but it is one with many elements all of which require researching. For the most part the research method is quantitative and draws on a wide range of government statistics and research done by other individuals and institutions.
The thesis questions the ability of Powys to be able to provide the dietary needs of it's population in 2020 in the light of climate change and post peak oil, or oil depletion.
The various elements of the question being asked now begin to emerge.

1. Climate change, how might it affect Powys's ability to feed its population? This has ramifications for what Powys might still be able to import from other countries who may also be feeling the impact of climate change on their abilities to produce food. On the other hand climate change in Powys may make producing certain foods easier.
2. Is 'Peak Oil' a reality? Oil depletion means loss of energy. We import vast amounts of food into the country, this may no longer be possible. How will we grow and harvest our own food with limited fuel for tractors and other agricultural machines that are fundamental to production at the moment? Artificial fertilizers and pesticides come from fossil fuels which may no longer be available or, if they are, prohibitively expensive.
3. Population levels need to be predicted in order to begin understanding the scale of production that Powys may have to achieve. What will the demographics be? Where are centres of population?
4. How much available land does Powys have and what can it produce? Is that land close to centres of population or will food still need to be transported, and if so, how far? Will the available land be sufficient to feed the predicted population and what foods should we be producing?
5. What food is being produced at the moment in the county and where? What has been produced historically and could it be possible to do that again?
6. What are our basic nutritional needs for a healthy, active and disease free life?
7. What changes will we have to make to farming methods and how might that affect our communities?

Not all the questions above can be answered using the same methods of enquiry.  Some can simply be resolved by looking up historical data but how that data can be transposed into the future then becomes conjecture.

Below is a table that illustrates the methods used, where the information is accessed from and comments on the process

| Question | Method of enquiry | Source | Comments |
|---|---|---|---|

| | | | |
|---|---|---|---|
| What are the predicted climate changes for Powys | Quantatitive. Research latest reports from climate change experts | Welsh Assembly Government report, 'Wales, changing climate challenging choices. | Unpredictability seems to be the only aspect predictable which makes crop growing much harder |
| Is Post Peak Oil a reality | Research reports from Government bodies and non Governmental institutions and experts | Association for the study of peak oil and gas.<br>Hubbert Marion K, Anderson B | There is sound science to prove oil depletion so this must be built into any and all future food production scenarios |
| What will the population of Powys be in 2020 | Quantatitive. Access census records for Powys and predicted population growth details | Powys County Council Statistics Department | Future population figures can be based on previous population growth rates but possible pandemics and immigration due to climate change may alter the results |
| Where will population densities be | Quantatitive. Access Powys County Council census records | Powys County Council Statistics Department | Difficulties in producing food in urban areas may se a shift of population back to rural areas |
| What land is available for food production | Quantitative, based on statistics supplied by Welsh Assembly | Welsh Assembly Government report 'Welsh Agricultural Statistics 2008' also 'Farming facts and Figures 2009' | |
| Will the available land be sufficient to feed the predicted population and what foods should we be producing | Quantitative, based on agricultural statistics, nutritional guide lines and personal experience of commercial horticulture in Wales | Welsh Assembly Government report 'Welsh Agricultural Statistics 2008' also 'Farming facts and Figures 2009'. British Nutrition Foundation. | Climate change may well see different foods needing to be grown, depending on what the climatic changes are. |
| What food is being produced at the moment and where | Quantative, based on agricultural censuses | Statistical Directorate 2007, Welsh Assembly Government | |
| What has been produced historically | Quantative, based on historical agricultural censuses | Digest of Welsh Historical Statistics 1700-1974, Chapter 4 Agriculture. | |
| What are our basic nutritional needs | Researching available data | Information based on authors previous vegetarian and vegan nutrition studies | |
| What changes will have to be made to farming methods | Review works by leading authors on sustainable farming methods and food production | Jenny Hall, Ian Tolhurst, Colin Tudge, Sue Stickland, Mike and Nancy Bubel, | |

**Introduction**

There is no doubt that our climate is changing. The only uncertainties left to ponder are how gradually and on what scale of severity the changes will happen.

Climate change prediction is not an exact science, which can give an unequivocal answer. Future changes in our climate will depend largely upon the levels of green house gases, (GHGs), that we continue to emit. Climate change prediction models are run using different scenarios for levels of GHG emissions with the predictable level of climate change being arrived at through the differences in the results. In other words an average across the emissions possibilities is taken as the likeliest level of change.

A report commissioned by the National Assembly for Wales entitled 'Wales, Changing Climate, Challenging Choices', (Dinlle D. and Farrar J 2000) gives the following predictions for Welsh Climate Change up to 2080:

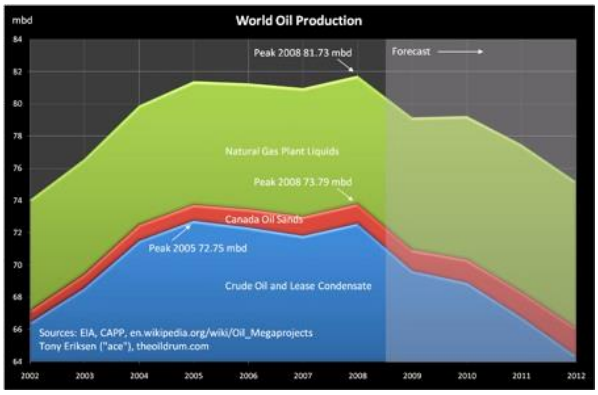
- *Overall temperature up by 1.1 – 2.9$^{0}$c*
- *More precipitation in winter by 7 – 24%*
- *Less precipitation in summer by 7 – 14%*
- *Greater annual precipitation by 2 – 9%*
- *Rise of sea level by 18 – 79cm*
- *Higher wind speeds by 1 – 4%*
- *More variability from year to year, with numbers of extreme years increasing*
- *More frequent and more violent storms, more rain in intense downpours*
- *More drought years by 10%*
- *More severe gales by 10%*

The change in climate will affect how we farm, how we grow, what we grow, and how we harvest and store our food. It will influence what foods we are able to access and import from other countries and in turn what we can produce and hope to sell.

There is a secondary threat to our ability to produce all the above and that is fossil fuel depletion.
"*The peak of oil discovery was passed in the 1960s, and the world started using more than was found in new fields in 1981"* ( Campbell Colin J. 2004)
Like climate change before it, many people remain unconvinced that peak oil is actually happening, or has happened and yet the U.S.A. peaked in 1970, as predicted in 1956 by Marion King Hubbert, renowned American geophysicist, (Sprott, Eric, 2004)

Of the 65 largest oil producing countries in the world, up to 54 have passed their peak of production and are now in decline, including the USA in 1970/1, Indonesia in 1997, Australia in 2000, the North Sea in 2001, and Mexico in 2004. (Anderson.B 2008)

Figure1.Oil and gas depletion profiles




Source: Erikson T.2008 EIA, CAPP, en.wilipedia.org;

So while it becomes increasingly important for individual areas to supply a greater amount of their own foodstuffs it seems that it could become increasingly hard to achieve this as fertilisers, pesticides, animal medications and machinery all become harder to fuel.
To establish whether Powys has the potential to be self-reliant in basic foodstuffs it is necessary to gather information on population density, basic dietary requirements, (calorific and nutritional), land area, land type

and current land use. This information needs to be evaluated in the light of the impacts of climate change, through predictive modelling, and energy depletion.

Many areas in Powys have been designated as Sites of Special Scientific Interest, (SSSI's) or as 'too environmentally sensitive' for agricultural practices. These areas will be taken out of the equation initially but could be introduced into the discussion at a later date depending on how much Powys appears to be able to produce without them.
Discussion on the kind of world a post peak oil world might be often leads to comparisons with life during the Second World War. This imparts images of frugality and rationing. It may be that this will be necessary, or it may be that agricultural methods change to perform more appropriately in the times ahead and we enter a period of self-sufficiency and abundance.

This thesis will look at how we are farming now, what changes will have to be made, if any, and what the changes might be in order to sustain the counties population in 2020
Although Powys is a very rural and under populated county it is hoped that some of the elements contained within the thesis could be transferable to other areas. Adapting to climate change and post peak oil has to be done piece meal, community by community, county by county and region by region and is obviously governed by the demands on the available resources in each of them. There will be the need for 'top down' assistance from government to match this 'bottom up' initiative if the whole thing is going to work. It can no longer be the case that we have a government who is prepared, on the one hand, to advocate such activities as airport expansion and then sign up to a demanding C02 reduction programme. The activities are simple not congruent and undermine faith in leadership at a time when clear, well informed and positive policies should be the corner stone of leading the population through the unavoidable changes to come.
It is hoped that this thesis may go some way to inform county and regional policy, and decision-making.

## Chapter1 Population

### Introduction

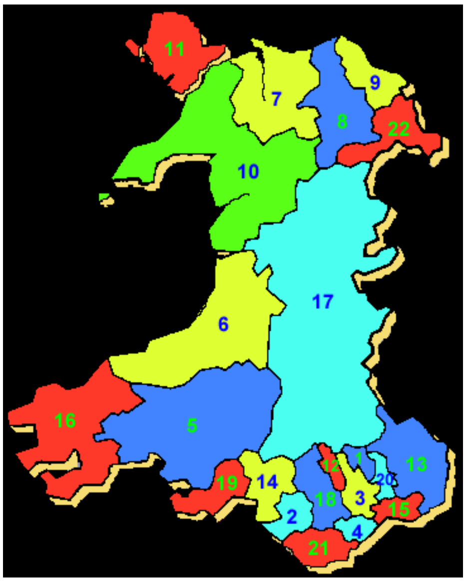
The key to answering the question of whether Powys could feed itself is to know how many people it is likely to have to feed. It is also important to know the predicted age ranges, as different age groups will have different dietary and calorific needs. Where the main centres of population are will inform logistics of production and consumption, although land availability and quality will obviously impact on this too.
The following statistics have been supplied by Powys County Council who carry out a census every ten years, with the next being due in 2010. Each year figures are estimated on previous years trends.

## 1.1 Current population

Figure 2.Map of Wales showing counties.

1. Blaenau Gwent
2. Bridgend
3. Caerphilly
4. Cardiff
5. Carmarthenshire
6. Ceredigion
7. Conwy
8. Denbighshire
9. Flintshire
10. Gwynedd
11. Isle of Anglesey
12. Merthyr Tydfil
13. Monmouthshire
14. Neath Port Talbot
15. Newport
16. Pembrokeshire
17. **Powys**
18. Rhondda Cynon Taff
19. Swansea
20. Torfaen
21. Vale of Glamorgan

22.Wrexham

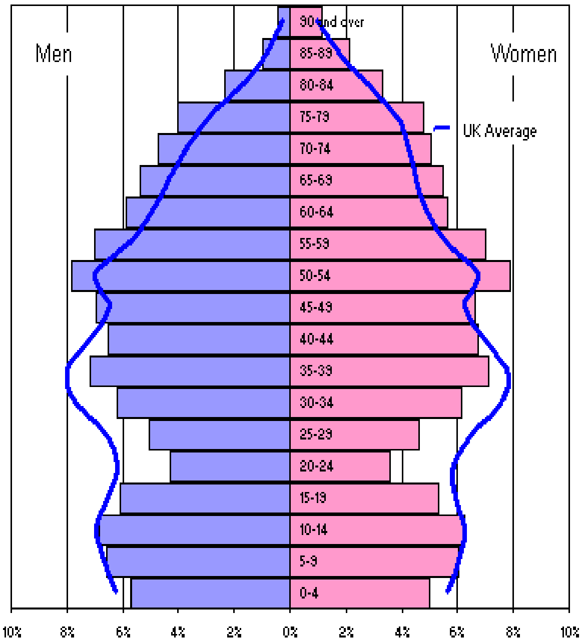



Powys covers 5,181 square kilometres, (518,100 hectares), about a quarter of Wales, and is the most sparsely populated county in England and Wales, with only 25 persons per square kilometre (Wales 143). In 2006 it had an estimated population of 131,141, of whom 64,938 were male and 66,203 were female. In 2006, (date of the last census), there were 1,222 live births to Powys mothers and 1,456 deaths of Powys residents. Despite this apparent decline the population grew by 5.8% (Wales 2.6%) due to UK urban migrants, offsetting both the number moving out and the excess of deaths over births each year.

Working age adults over 30 make up the majority of immigrants, many of whom have young families. Only the18 to 24 age group see more people moving out rather than in. This is primarily due to attending universities and seeking work.

Figure 3. Population average ages.

The average age in Powys sampled by the last
census in 2006 was 43.5 (Wales 40.07)




The percentages on the pyramid represent the percentage of 'all males' (to the left) and the percentage of 'all females' (to the right) that are in that age group.

| | Total | Males | Females |
|---|---|---|---|
| **0 - 4** | 6753 | 3556 | 3197 |
| **5 - 9** | 7957 | 4104 | 3853 |
| **10 - 14** | 8265 | 4291 | 3974 |
| **15 - 19** | 7207 | 3820 | 3387 |
| **20 - 24** | 4950 | 2670 | 2280 |
| **25 - 29** | 6111 | 3145 | 2966 |
| **30 - 34** | 7796 | 3877 | 3919 |
| **35 - 39** | 9039 | 4492 | 4547 |
| **40 - 44** | 8397 | 4085 | 4312 |
| **45 - 49** | 8585 | 4334 | 4251 |
| **50 - 54** | 9939 | 4904 | 5035 |
| **55 - 59** | 8871 | 4380 | 4491 |
| **60 - 64** | 7279 | 3665 | 3614 |
| **65 - 69** | 6859 | 3360 | 3499 |
| **70 - 74** | 6197 | 2955 | 3242 |
| **75 - 79** | 5578 | 2510 | 3068 |
| **80 - 84** | 3578 | 1448 | 2130 |
| **85 - 89** | 1976 | 626 | 1350 |
| **90 and over** | 1017 | 271 | 746 |
| **Totals** | 126354 | 62493 | 63861 |

Percentages converted to population figures

Office for National Statistics. Census 2001. Population Pyramid

Figure 4. Summary of Powys population Projections, 2006 to 2031

| Age Groups | 2006 | 2011 | 2016 | 2021 | 2026 | 2031 |
|---|---|---|---|---|---|---|
| All | 131,141 | 136,138 | 141,136 | 146,107 | 150,133 | 154,263 |
| 0 – 15 | 24,037 | 23,246 | 23,117 | 23,862 | 24,297 | 24,402 |
| 16 – 44 | 41,658 | 40,823 | 40,174 | 40,166 | 41,475 | 42,118 |
| 45 – 64 | 38,190 | 40,551 | 40,551 | 40,236 | 38,360 | 36,554 |
| 65 – 74 | 13,979 | 16,897 | 20,766 | 21,548 | 21,147 | 22,823 |
| 75+ | 13,277 | 14,621 | 16,528 | 20,296 | 25,134 | 28,367 |

WAG, Statistical Directorate, 2006

**1.2 Where people live**

A census is taken in Powys every ten years with the next being due in 2010. Each year figures are estimated on previous years trends.
Powys is a very large rural county with a relatively small head of population. In 2006 it was estimated that 59% of residents lived in isolated dwellings, hamlets and small villages. This is a much greater amount than for the rest of Wales, which averages 17% and England with 11%

There is a steady increase in the housing stock with the latest figures available showing an increase of 62% between 1971 and 2001, from 33,290 to 53,865, (Wales 34%). This is partly due to population growth but also reflects the trend for lower occupancy numbers. The average household size fell from 4.1 in 1931 to 2.3 in 2001. This is mainly due to couples having less children, longer life expectancy; marriages failing and elderly people living alone rather than with families.

Figure 5.Map showing the main urban areas in Powys and their population as of 2001.


| | | |
|---|---|---|
| | Llanfyllin | 1.400 |
| | Llanfair Caereinion | 1.616 |
| | Welshpool | 6.269 |
| | Machynlleth | 2.000 |
| | Newtown | 10.783 |
| | Llanidloes | 2.314 |
| | Rhayader | 2.075 |
| | Knighton | 3.000 |
| | Llandrindod Wells | 5.000 |
| | Presteigne | 2.191 |
| | Builth Wells | 2.352 |
| | Llanwrtyd Wells | 0.700 |
| | Hay on Wye | 1.846 |
| | Talgarth | 1.650 |
| | Brecon | 7.901 |
| | Crickhowell | 2.800 |
| | Ystradgynlais | 2.543 |

Total population living in urban areas = 55,940
Total population for Powys at 2001 =126,354

**Conclusion**

So by 2020 Powys is predicted have an estimated population of 146,107. Just over half the population will be aged between 16 and 65, with a relatively even split between male and female.
There is likely to be the same 60/40 population split between rural and urban dwellers, in favour of urban. Increased fuel prices may see people wanting to be closer to where they work with the likelihood, then, of a small but significant migration into the towns. However, the agricultural sector may well see an increase in the number of people working on the land as oil becomes scarcer and more expensive and the need for manual labour increases. At the same time urban-based fossil fuel reliant jobs may fail, so this may well reverse the rural to urban migration.

Over half the urban population lives in four of the seventeen main towns, Welshpool, Newtown, Llandrindod and Brecon. This information could inform future patterns of food production, as oil depletion will necessitate food being grown as close to where it is consumed as possible.

## Chapter 2   Current land Use

### Introduction

In chapter 1 we established what the head of population was likely to be, based on figures generated from the ten yearly census conducted by Powys County Council. We now know how many people we are going to have to feed, plus what age groups they will fall into and we also know roughly where they are as far as population density goes.

What we need to know now is how much land we have available for producing the food needed for all these people. We also need to know if the land is capable of producing what we need. We can do this by looking critically at what we are producing today and what we were able to produce in the past, coupled with current land classifications.

There are other factors which need to be considered when looking at what we produce at the moment such as subsidies, the Common Agricultural Policy, the 'free market' and rules and regulations laid down by the WTO, (World Trade Organisation), which make protectionism illegal.

### 2.1 How much agricultural land is there in Powys?

Powys is the largest county in Wales, covering a quarter of Wales' landmass. The county stretches from the border of Wrexham and Gwynedd in the north, to the Swansea Valley and Monmouthshire in the south. It borders Ceredigion and Carmarthenshire in the west, Shropshire and Herefordshire in the east. To the south, the county also contains a substantial part of the Brecon Beacons National Park.

Powys covers an area of 5,181 sq kilometres, (518,100 hectares), of which 17.2%, (88,077hectares), is inside the Brecon Beacons National Park. In 2006 4,634 sq kilometres (89%, 463,400hectares), was agricultural land. Of this 463,400, 96% is labelled 'less favoured status, (LFS). When asked for a more comprehensive breakdown of land classification in the county, such as soil types and fertility etc, John Bleasdale, Agricultural Statistics for the Welsh Assembly Government said,
*"The only measure we use is whether land is less-favoured or not. This concept is based on the land's suitability for farming. Most of Wales tends to fall into Less Favoured Areas (LFA). Within this, land is further classified as Disadvantaged (DA) or Severely Disadvantaged (SDA)".* (Bleasdale.J 2008)

When asked whether LFA status was based on the ability of the land to produce anything or was it more about infrastructure, access to markets and population density John Bleasdale went on to say:
*"I'm not sure of the precise factors that determine land as LFA or not but the gist of it is that it defines whether land is suitable for agricultural production or not. Certainly the factors that you list will all play their part, along with the relief of the land (is it flat, hilly, mountainous?) and possibly other factors. Historically the point of defining the LFA was connected with subsidy payments, broadly speaking because the land was more difficult to farm then those attempting to do so would be eligible for subsidy as a sort of "helping hand".* (Bleasdale J. 2008)

Less favoured status offers financial top ups to areas where land is poor or degraded.
There are many schemes, subsidies and payments available to farmers in Powys, which can affect the way land is farmed. For the purpose of this thesis financial skewing of production to fit in with European policy will be looked at later under the title of 'barriers or incentives to implementation'. For now it is sufficient to understand how much land is available for food production and of what type.

So the fact that most of Powys is labelled as SDA would certainly suggest that growing anything other than hardy breeds of sheep could be difficult. By the same token subsidies on sheep rearing have led farmers towards a virtual monoculture of sheep rearing and related grassland management. Most farms exceed their livestock carrying capacity in order to access maximum subsidy payments. This means that all available arable land has to produce grazing, silage and hay for fodder with supplements being bought in, usually from England, to support these numbers.
However, the relatively new 'Single Farm Payment, (a grant scheme introduced in 2005/2006 by the EU to replace the existing Headage/Premia Schemes), effectively de-couples subsidies from production but has typically only been paid on grazed acreage (DEFRA 2007). Land taken out of grazing and used, for instance, in horticultural/grain production would lose its SFP status. This, again, locked farmers into rearing meat and growing grass.
However in 2008 the rules of the SFP scheme changed to allow payment on land under permanent fruit and vegetable (including commercial orchards), nursery crops and vines.

**2.2 Historical production**

Historically Welsh farms were more diverse growing a variety of vegetables, grains and cereals both for animal and human consumption. The charts 1,2 and 3 in the appendix cover production in the three shires within Powys from 1867 to 1972.
It's clear from these figures that Powys was capable of producing much more in the way of cereals and root crops than it does today. The chart below aggregates figures from these three charts for wheat, barley, oats, potatoes, turnips and Swedes. There has been a steady decline in all areas with 1942 seeing a sudden increase in production due to the 'War Ag' effort recorded in 1942, with the exception of barley, which is slightly up.

Figure 6. Cereal and vegetable production for Powys in hectares 1867 to 1972

| Shire | Date | Wheat | Barley | Oats | Potatoes | Turnips and Swedes |
|---|---|---|---|---|---|---|
| Radnorshire | 1867 | 7090 | 4863 | 11760 | 1426 | 6280 |
| | 1942 | 3278 | 2617 | 22800 | 1754 | 4685 |
| | 1972 | 1124 | 3447 | 4979 | 357 | 2277 |
| Brecon | 1867 | 9559 | 8896 | 14356 | 1799 | 5494 |
| | 1942 | 5414 | 4825 | 21295 | 2727 | 4115 |
| | 1972 | 1146 | 3723 | 5133 | 470 | 4080 |
| Montgomeryshire | 1867 | 20954 | 12087 | 21344 | 3045 | 8986 |
| | 1942 | 9969 | 4694 | 29109 | 3498 | 3346 |
| | 1972 | 2190 | 8237 | 3765 | 217 | 1032 |
| Total across Powys | 1867 | 37606 | 13771 | 47460 | 6270 | 20760 |
| | 1942 | 18661 | 12136 | 73204 | 7979 | 12146 |
| | 1972 | 4460 | 15407 | 13877 | 1044 | 7389 |
| | | | | | | |

Digest of Welsh Historical Statistics 1700-1974,

More recent statistics taken from the WA's 'Farming Facts and Figures 2008', (Statistical Directorate. Welsh Assembly Government 2008), clearly show that the weakest area of production is in cereal crops and horticulture. The figures are for the whole of Wales and not just Powys. Because of its SDA status it can be presumed that Powys will have more sheep and less milk and dairy products and probably less cattle.

There are also186,597 acres (75,500 hectares) of common land in Powys, most of which are in private ownership. Common land is usually less cultivated than the surrounding farmland and forms an important resource for nature conservation, recreation and agriculture and is characterised by the following habitat types:
Unimproved dry acidic grassland, semi-improved acidic grassland, acidic marshy grassland, bracken, blanket bog, heath land and Improved grassland
Of the 547sq kilometres that are not designated as being of agricultural use at least 50% is in woodland and forestry with just under half this being owned by the forestry commission.

**2.3 What does Powys produce now?**

Powys mainly produces meat in the form of, predominately, sheep, followed by beef and a small amount of poultry and pig production. Land that's not being grazed by these animals is generally given over to producing food for them such as silage and hay, with some root crops for winter-feeds.
There is little or no cereal, vegetable or fruit production for human consumption. Indeed, even with turning over all available land to animal food production, farmers still have to import hay, straw and dried feeds from out of the county and usually out of Wales. Many farmers have to send their sheep away to lower

ground, quite often in England, called ‘tacking off’, in order to keep them fed during the winter months and to keep their weight up for market.
The chart below shows land use for these activities by region and is based on information from The Welsh Assembly Governments Welsh Agricultural Statistics 2007.

Figure 7. Agricultural land by region (a) Powys

| Measured by thousand hectares | Powys |
|---|---|
| Crops and Grass | |
| Arable land | 15.8 |
| Permanent Grass | 149.5 |
| Total | 165.3 |
| | |
| Rough Grazing | |
| Sole Rights | 74.1 |
| Common (b) | 21.2 |
| Total | 95.3 |
| | |
| All other land on agricultural holdings (c) | 16.5 |
| Total area of agricultural land | 464.4 |
| | |
| (a) Figures include both main and minor holdings<br>(b) Estimated<br>(c) Includes both woodland and set aside land | |

Statistical Directorate 2007, Welsh Assembly Government

Nearly all human food, apart from a small percentage of meat and dairy, is imported into the county, this includes the staples like cereals, flours, vegetables and fruits. Although climate change and post peak oil are a serious threat to global food production and transportation the majority of the public do not see them as a particularly relevant threat at the moment.
However, imagine a scenario where the Powys borders were closed, (the same effect that climate change and post peak oil could have on food production and transportation), so that there were no movements of goods out or in and then consider what we would be eating. What would be in the shops? Imagine that there was so little fuel to transport anything any great distance meaning that each community could only source what was produced within, say, a twenty mile radius, about the distance that someone could walk or ride a bicycle in a day. What would be in local shops then?
Imagine also that the fuel crisis had impacted on electricity supplies so that foods could not be effectively stored for any period of time in fridges and freezers. Imagine too that this had happened too suddenly for any long term strategic agricultural planning to have taken place. It takes a very long time to change the European agricultural policies which drive production and which would need to be changed to allow shifts in subsidies away from the monocultural practises now encouraged and towards the diversity most likely needed. Remember, as well, that food production is not instant and needs time to grow, for most horticultural produce this will be a minimum of one growing season and for animals longer.
Let’s see what’s might be on the menu!

**Breakfast.**
Toast? No, we are not producing any cereals for human consumption
Tea? No, imports have slowed to a standstill
Coffee? As above
Cereal? Same as for toast
Fruit juice? No, we do not produce any fruit
Milk? Some is available, but only if you live in Montgomeryshire or in the South of Brecknockshire
Beans on Toast? No. We don’t grow haricot beans or tomatoes, and of course we don’t have any bread for the toast.
Mushrooms? Yes, but only in the autumn
Eggs. Yes, but limited as chicken feed is imported so most hen production is stopping and the chickens themselves are being eaten instead.

Bacon? Yes, In some parts of Powys, but again pig feed is limited
Water? Yes, no problem

**Lunch and Dinner**
Not looking very good either. Basically the only food available is meat, with lamb and mutton being the most widely available, followed by some beef and chicken. Some wild foods may be available like rabbit and river fish such as trout and salmon. Fruit and vegetables are rare with only one farmer, at present, producing any vegetables on any scale and he is located at St. Harmon, just outside Rhayader. There is another smaller producer in the Brecon area just outside Libanus. The lucky folk who live near these two producers may be able to source fresh vegetables, for the majority fresh produce will be almost impossible to find.

So it looks as if the diet for Powys folk would be very limited and based almost entirely on meat. Of course slaughterhouses are few and far between and oil depletion means that transporting animals any long distance could be prohibitive. As regulations stand on home slaughtering this could mean that even meat would not be very readily available.
What we are starting to see is an alarming picture emerging of food shortages, malnutrition and starvation. At present we live in a rural, agricultural county, which, without imports of food, is ironically virtually a desert. The rural landscape is wholly pastoral with a mixture of permanent grass and rough grazing. Arable land is given over to fodder production for livestock in the form of hay and silage. Almost no cultivated ground is producing food for direct consumption by humans.
Through its designation as a SDA (seriously disadvantaged area), and distorting subsidies from Europe, Powys has an image of only being able to produce sheep, and some cattle. In buying into this image all land is given over to lamb, mutton and beef production with whatever good arable land there is being grazed or used to produce fodder. The scenery is essentially green with white dots, a monoculture of meat production.

**Conclusion**

We have established that the present population of Powys is around 131,141 and that by 2020 it will have risen to around 146,107. Powys covers approximately 5,181sq kilometres with 59% of the population living in isolated dwellings, hamlets and small villages. Of the total area of the county there exists 4,634 sq kilometres of agricultural land.
We know that 96% of this available agricultural land is classed as SDA (severely disadvantaged area) and that farming statistics point to Powys predominately producing sheep, lamb and cattle.
Yet historically Powys has been capable of producing a much wider range of foods such as cereals, grains, fruits and vegetables. For the most part it appears that subsidies have altered how Powys has farmed as opposed to changes in demands from consumers or the inability of the land to support this more diverse production.
What we need to establish now is exactly what crops we will need to grow for a balanced diet.

## Chapter 3 Diet

**Introduction**
The two previous chapters have established what the head of population will be in 2020 and given a breakdown of the expected head count in the different age groups. This is necessary to inform calorific and dietary needs. We have also discovered how much land is available to us for producing the food to fulfil these needs. What we need to do now is look more closely at diets so that we can inform our producers. Some considerable work has already been done on basic diets by Kenneth Mellanby in his book, 'Can Britain Feed Itself'?, ( Mellanby K. 1975*.).* Simon Fairlie has taken Mellanby's basic diet and embellished and adapted it to show how much land UK agriculture would need to produce food under six different agricultural regimes, (Fairlie S. 2007-8*)* These will be reproduced in this chapter to show the most efficient farming regime and therefore the optimum type of diet for human health and sustainable production.

### 3.1 Energy/Calorie needs

Diet consists of calorific intake for energy and nutrients for body health.

The average adult female leading a normal active life requires around 2,000 calories a day, for a similar male it rises to 2,500.

Children need an increasing amount from birth to maturity ranging from 900 to 2200 calories.

Figure 8. Calorific needs for children aged 1yr to 18yrs.

| Age | 1yr | 2 to 3yrs | 4 to 8yrs | 9.to 13yrs | 14.to18yrs |
|---|---|---|---|---|---|
| Girl | 900 | 1000 | 1200 | 1600 | 1800 |
| Boy | 900 | 1000 | 1400 | 1800 | 2200 |

Based on figures from the American Heart Foundation 2009
http://www.americanheart.org/presenter.jhtml?identifier=3033999

The average daily energy requirement for people 65 and older with a normal body mass index (BMI) should be, men 2,300 calories and women, 1,800, *(Swiss Association for Nutrition 2003)*

Based on the figures above a new table can be developed to indicate the amount of calories needed to maintain health in the predicted population of Powys in 2020. For the 0 – 15 age group it's not possible to give the incremental increase in calorie demand as a breakdown of the age group isn't apparent. Therefore the calorific need is averaged out over the group and is 1,120. Also, where the gender split is not explicit an average is taken

Figure 9. Projected calorific needs for Powys in 2121

| Age Groups | 2006 | 2011 | 2016 | 2021 | Calorific need daily |
|---|---|---|---|---|---|
| All | **131,141** | **136,138** | **141,136** | **146,107** | **295,991,360** |
| 0 – 15 | 24,037 | 23,246 | 23,117 | 23,862 | 33,325,440 |
| 16 – 44 | 41,658 | 40,823 | 40,174 | 40,166 | 88,366,520 |
| 45 – 64 | 38,190 | 40,551 | 40,551 | 40,236 | 88,519,200 |
| 65 – 74 | 13,979 | 16,897 | 20,766 | 21,548 | 44,173,400 |
| 75+ | 13,277 | 14,621 | 16,528 | 20,296 | 41,606,800 |

Adapted from Summary of Powys population Projections, 2006 to 2031, Source, WAG, 2006 – based population projections for Welsh Local Authorities

So with a mixed age and gender population of around 146,107 by 2020, Powys would need to produce something in the region of 296 million calories a day to feed it's population. To maintain health these calories need to come from a balanced nutritional source.

### 3.2 Nutritional needs

Nutrients are usually divided into five classes: carbohydrates, proteins, fats (including oil), vitamins and minerals. We also need fibre and water. All are equally important to our well-being, although they are needed in varying quantities, from about 250g of carbohydrate a day to less than two micrograms of vitamin B12. Carbohydrate, fat and protein are usually called macronutrients and the vitamins and minerals are usually called micronutrients.
Most foods contain a mixture of nutrients (there are a few exceptions, like pure salt or sugar) but it is convenient to classify them by the main nutrient they provide.
Meat supplies protein, fat, some B vitamins and minerals (mostly iron, zinc, potassium and phosphorous). Fish, in addition to the above, supplies vitamins A, D, and E, and the mineral iodine. All these nutrients can be easily obtained by vegetarians from other sources.

## Protein

Proteins are the building blocks of the body, used for making and repairing cells, hormones and anti-bodies. The recommended daily amounts are:
Age 1 – 3 yrs – 14.5g /day
4 – 6 yrs – 19.5g /day
7 – 10yrs – 28.3g/day

11 – 14yrs – 42g/day
Adult15- 45yrs – 50g/day

Protein is a very large group of organic type compounds consisting of, hydrogen, oxygen, sulphur and nitrogen. Individual molecules are built up of amino acids, which form long polypeptide chains. There are eight recognised amino acids that will combine to form all necessary proteins. Some amino acids may be high in sulphur such as those derived from beans, while others may be low, for example, rice, whose main amino acid is lysine.
A combination of these two ingredients will give the body the correct building blocks to form complete proteins. Most people recognise meat as a form of protein, but the following list contains equally viable sources:

- Nuts: hazels, brazils, almonds, cashews, walnuts, pine kernels etc.
- Seeds: sesame, pumpkin, sunflower, linseeds.
- Pulses: peas, beans, lentils, peanuts.
- Grains/cereals: wheat (in bread, flour, pasta etc), barley, rye, oats, millet, maize (sweet corn), rice.
- Soya products: tofu, tempeh, textured vegetable protein, veggie burgers, soya milk.
- Dairy products: milk, cheese, yoghurt (butter and cream are very poor sources of protein).
- Free range eggs.

There are 20 different amino acids in all. We can make many of them in our bodies by converting other amino acids, but eight cannot be made, they have to be provided in the diet and so they are called essential amino acids. They are:

- Isoleucine
- Leucine
- Lysine
- Methionine
- Phenylalanine
- Threonine
- Trytophan
- Valine

Single plant foods do not contain all the essential amino acids we need in the right proportions, but when we mix plant foods together, any deficiency in one is cancelled out by any excess in the other.

We mix protein foods all the time, whether we are meat-eaters or vegetarians, for example, beans on toast, muesli, or rice and peas.
The body has a pool of amino acids so that if one meal is deficient, it can be made up from the body's own stores. Because of this, we don't have to worry about complementing amino acids all the time, a varied and balanced diet will supply all the building blocks needed, (Robinson D 2001)

## Carbohydrate

Carbohydrates are a combination of starches and sugars that supply the body with most of its energy, they are made up of carbon, hydrogen, and oxygen.

Carbohydrates can be divided into two groups, simple and complex. Simple carbohydrates come from refined foods like cakes, sweets, biscuits, jams and many other processed foods. This is not an ideal form as the sugars are 'fast burn' and very often high in fats as well.
Complex carbohydrates are found in fruits in the form of fructose, naturally occurring unrefined sugar. They are also found as natural starches in rice, pasta, potatoes, bananas, lentils, yams and most root vegetables.
The complex carbohydrates have better food value and release their energy slowly over a longer period than refined sugars, (Robinson D 2001)

### Dietary Fibre

Fibre is a vital part of any diet even though it does not digest and has no particular nutritional value.

It comes in two main kinds, Soluble and Insoluble.
Soluble fibre is found in fruits, vegetables, oats and pulses and enters the bloodstream where its presence helps to prevent cholesterol build up and controls the levels of blood glucose.
Insoluble fibre is found in all other plant foods and cannot enter the blood stream. Instead it works in the digestive system to encourage digestion and the formation of soft easily passable stools. These stools stimulate the bowel walls encouraging excretion.
Both types of fibre protect the body from illness and diseases such as heart disease and bowel cancer.
Vegetarian and vegan diets have the richest sources of fibre, ( Robinson D 2001*)*

## Fats & Oils

Fatty acids make up fats. The two essential fatty acids that we must get from our food are linoleic and linolenic. Fats provide energy, protect the organs, help the body use the fat-soluble vitamins, A,D,E and K and help hormone balance.
The important thing is to eat unsaturated as opposed to saturated fats. Most fats from animal origin are saturated fats. The easy way to decide if a fat is saturated or not is to see whether it becomes solid when cold, or cool, like butter, cheese, lard, cream etc.
Vegetarians as well as meat eaters can be in danger of consuming too much saturated fat but a vegan diet should be virtually free of it.
Unsaturated fats can be found in vegetable oils, green vegetables, grains, nuts and seeds. The best oils to use are cold-pressed virgin olive oils as they contain the highest nutrients, ( Robinson D 2001)

**Vitamins**

Vitamin is the name for several unrelated nutrients that the body cannot synthesise either at all, or in sufficient quantities. The one thing they have in common is that only small quantities are needed in the diet

**Vitamin A** (or beta carotene): Vitamin A is a fat soluble vitamin as opposed to Vitamins B and C which are water soluble. This means that Vitamin A can be stored in the body. It is one of a group of vitamins popularly known as ACE vitamins. These are three vitamins, which, along with Selenium and zinc, make up five powerful antioxidants. Antioxidants have many roles in the body but are lately accredited with the ability to help reduce the risk of cancer and coronary heart disease through the control of free radicals. Free radicals are a result of the natural oxidation, or 'rusting' process of the body. The ACE vitamins also help to condition the immune system.
Good sources of Vitamin A are:
Red, orange or yellow vegetables like carrots and tomatoes, leafy green vegetables and fruits like apricots and peaches. It is added to most margarines.

**B Vitamins:** There are 8 B vitamins all together. B1, Thiamin, B2 Riboflavin, B3 Niacin, B5 Pantothenic acid, B6 Pyridoxine, B7 Biotin, B9 Folic acid and B12 Cobalamin. B vitamins are water-soluble which means they cannot be stored in the body and must, therefore, be taken in every day. B vitamins, support and increase the rate of metabolism, enhance the nervous system combating stress and depression, promote cell growth and division including red blood cells.
Good sources of B Vitamins are:
Brewer's yeast, blackstrap molasses, brown rice, sunflower seeds, brazil nuts, eggs, wheat germ, beef liver, meat, poultry, fish, soybeans, potatoes.
Vitamin B12 is the only one that may cause some difficulty for vegetarians or vegans as it is not present in plant foods. Only very tiny amounts of B12 are needed and vegetarians usually get this from dairy produce

and free-range eggs. It is sensible for vegans and vegetarians who consume, few or no, animal foods to incorporate some B12 fortified foods in their diet.
Vitamin B12 is added to yeast extracts, soya milks, veggie burgers and some breakfast cereals. However, there is usually at least a six-month supply of Cobalamin in the average liver and in a lot of cases, although not all, B12 can be manufactured within the body.
Good sources of B12 are:
Beef liver, algae, canned tuna, eggs, cottage cheese, milk, bee pollen, fermented products such as tempeh and yeast extract.

**Vitamin C:** Is water-soluble and like the B vitamins must be taken everyday. It's main functions are: Bone and tooth formation; collagen production; digestion; iodine conservation; healing; red blood cell production; blood vessel strength; iron absorption, diuretic.
Good sources of Vitamin C are:
Guava, red pepper, cantaloupe, oranges, grapefruit, papaya, strawberries, kiwi, tomatoes, broccoli, cauliflower, parsley, all fresh fruit, salad vegetables, all leafy green vegetables and potatoes.

**Vitamin D:** The main functions of vitamin D are: Calcium absorption in the intestine; phosphorus metabolism; bone formation; heart action; blood clotting. It can be beneficial against bone and intestinal tumours.
Good sources of Vitamin D are:
Fish, halibut liver oil, eggs, beef liver, butter, sunlight. This vitamin is not found in plant foods but humans can make their own when skin is exposed to sunlight. It is also added to most margarines and is present in milk, cheese and butter. These sources are usually adequate for healthy adults. The very young, the very old or those with limited access to sunlight may need a supplement.

**Vitamin E:** is also fat-soluble and is one of the ACE vitamins. Vitamin E also benefits the reproductive system and slows down the ageing process. It's important for proper growth and development, healthy blood and good blood clotting and plays an important part in the development of scar tissue and wound healing. It also aids proper brain and nerve function, cholesterol reduction, protects fat-soluble vitamins and scavenges free radicals.
Good sources of Vitamin E are:
Wheat germ oil, soybean oil, sunflower seeds, walnuts, whole grains, eggs, peanuts safflower/sunflower oil, oatmeal, beef liver, dark green leafy vegetables, avocados, tomatoes, all seeds and nuts, peas, beans and corn, (Robinson D 2001)

## Minerals

Minerals perform a variety of jobs in the body. Details of the some of the most important minerals are listed below.

**Calcium:** Important for healthy bones and teeth and the absorption of calcium. Found in dairy produce, leafy green vegetables, bread, tap water in hard water areas, nuts and seeds (especially sesame seeds), dried fruits, cheese, almonds, figs, beans, carrots, pecans, raisins, brown rice, apricots, garlic, dates, spinach, brazil nuts, cashews, papaya, avocados, celery

**Iron:** Needed for red blood cells. Found in leafy green vegetables, wholemeal bread, molasses, eggs, dried fruits (especially apricots and figs), lentils and pulses, kelp, raisins, figs, beets, soy beans, bananas, asparagus, carrots, cucumbers, sunflower seeds, parsley, grapes, watercress. Vegetable sources of iron are not as easily absorbed as animal sources, but a good intake of vitamin C will enhance absorption.

**Zinc:** Plays a major role in many enzyme reactions and the immune system. Found in green vegetables, cheese, sesame and pumpkin seeds, lentils and wholegrain cereals, mushrooms, liver, seafood, soy beans, sunflower seeds, brewers yeast.

**Iodine:** Important for thyroid health, skin, nails and hair. Iodine helps in metabolic rate maintenance and cell metabolism. It's found in vegetables, but the quantity depends on how rich the soil is in iodine. Dairy products also have plenty of iodine, as does kelp, dulse, beets, celery, lettuce, Irish moss, grapes, mushrooms and oranges. Sea vegetables are a good source of iodine for vegans, ( Robinson D 2001)

The list of vital nutrients above can now inform us, not only of the calories that the county must produce to feed it's population, but also the types of food that they will need to come from. The vast majority of nutrients come from plants and plant based products, which, looking back at earlier chapters, Powys fails to produce at the moment.

### 3.3 Selecting a basic diet

A lot of work already exists on the impact on human support per hectare of different diets. Six different diets and agricultural regimes are reproduced here to allow an appropriate basic diet to be arrived at for the population of Powys in 2020. Remember that these figures are for the UK as a whole, but the land use per diet ratio will be the same.

**Figure 10 Chemical with Livestock. Population 60.6 million. Agricultural land 18.50 million hectares. Forestry etc, 3.69 million hectares**

Table A

| | Consumption | Calories in diet | Uk production | Yield | Arable land | Perm' pasture | Rough pasture |
|---|---|---|---|---|---|---|---|
| | gms/person/day | Kcal/person/day | Million tons per yr | Tonnes/ha | 1000 ha | 1000 ha | 1000 ha |
| Cereals for human food | 500 | 1700 | 11.06 | 7.3 | 1515 | | |
| Potatoes | 453 | 300 | 10 | 44 | 227 | | |
| Sugar | 32 | 100 | 0.707 | 9 | 78 | | |
| Vegetables and Fruit | 500 | 150 | | | 400 | | |
| Milk (inc butter, cheese etc) | 568 | 330 | 12.5 | 7.0/cow | 1252 | | |
| Beef | 56 | 150 | 1.24 | 0.43 | | 2758 | |
| Cereals for animal feed | | | 6.69 | 7.1 | 917 | | |
| Sheep | 14 | 37 | 0.31 | 0.084 | | | 3690 |
| | | | | | | | |
| Land available (Total Calories) | | 2767 | | | 6335 | 5711 | 6462 |
| Spare land | | | | | 1946 | 2953 | 2772 |
| Land used | | | | | 4389 | 2758 | 3690 |
| | | | | | | | |

Fairlie S. 2007 -8

Table A uses: 4.4 million hectares arable, 6.4 million hectares pasture, and has 7.6 million hectares spare.

**One hectare of arable plus 1.5 hectares of pasture feeds 14 people**

**Figure 11 Chemical Vegan. Population 60.6 million. Agricultural land 18.50 million hectares. Forestry etc, 3.69 million hectares**

Table B

| | Consumption | Calories in diet | Uk production | Yield | Arable land | Perm' pasture | Rough pasture |
|---|---|---|---|---|---|---|---|
| | gms/person/day | Kcal/person/day | Million tons per yr | Tonnes/ha | 1000 ha | 1000 ha | 1000 ha |
| Cereals for human food | 500 | 1700 | 11.06 | 4.3 | 2572 | | |
| Potatoes | 453 | 300 | 10 | 25 | 400 | | |
| Sugar | 32 | 100 | 0.707 | 7.5 | 94 | | |
| Rape oil | 35 | 310 | 0.774 | 0.8 | 968 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Dried peas | 80 | 207 | 1.77 | 3 | 590 | | |
| Vegetables and Fruit | 500 | 150 | | | 450 | | |
| Green Manures | | | | | 2242 | | |
| | | | | | | | |
| Land available (Total Calories) | | 2767 | | | 6335 | 5711 | 6462 |
| Spare land | | | | | -981 | 4730 | 6462 |
| Land used | | | | | 7316 | | |
| | | | | | | | |

Fairlie S. 2007 -8

Table B uses: 7.3 million hectares arable and has 11.2 million hectares spare.

**One hectare of arable feeds 8 people**

**Figure 12 Organic vegan. Population 60.6 million. Agricultural land 18.50 million hectares. Forestry etc, 3.69 million hectares**

Table C

| | Consumption | Calories in diet | Uk production | Yield | Arable land | Perm' pasture | Rough pasture |
|---|---|---|---|---|---|---|---|
| | gms/person/day | Kcal/person/day | Million tons per yr | Tonnes/ha | 1000 ha | 1000 ha | 1000 ha |
| Cereals for human food | 500 | 1700 | 11.06 | 4.3 | 2572 | | |
| Potatoes | 453 | 300 | 10 | 25 | 400 | | |
| Sugar | 32 | 100 | 0.707 | 7.5 | 94 | | |
| Rape oil | 35 | 310 | 0.774 | 0.8 | 968 | | |
| Dried peas | 80 | 207 | 1.77 | 3 | 590 | | |
| Vegetables and Fruit | 500 | 150 | | | 450 | | |
| Green manure | | | | | 2242 | | |
| | | | | | | | |
| Land available (Total Calories) | | 2767 | | | 6335 | 5711 | 6462 |
| Spare land | | | | | -981 | 4730 | 6462 |
| Land used | | | | | 7316 | | |
| | | | | | | | |

Fairlie S. 2007 –8

Table C uses: 3 million hectares arable and has 15.6 million hectares spare.

**One hectare of arable feeds 8 people**

**Figure 13 Organic with Livestock. Population 60.6 million. Agricultural land 18.50 million hectares. Forestry etc, 3.69 million hectares**

Table D

| | Consumption | Calories in diet | Uk production | Yield | Arable land | Perm' pasture | Rough pasture |
|---|---|---|---|---|---|---|---|
| | gms/person/day | Kcal/person/day | Million tons per yr | Tonnes/ha | 1000 ha | 1000 ha | 1000 ha |
| Cereals for human food | 500 | 1700 | 11.06 | 4.3 | 2572 | | |
| Potatoes | 453 | 300 | 10 | 25 | 400 | | |
| Sugar | 32 | 100 | 0.707 | 7.5 | 94 | | |
| Vegetables and Fruit | 500 | 150 | | | 450 | | |
| Milk (inc butter, cheese etc) | 568 | 330 | 12.5 | 5.8/cow | 1898 | | |
| Beef | 56 | 150 | 1.24 | 0.29 | | 4100 | |
| Cereals for dairy cows | | | 2.936 | 4 | 657 | | |
| Cereals for beef cows | | | 1.656 | 4 | 328 | | |
| Sheep | 14 | 37 | 0.31 | 0.084 | | | 3690 |
| Land available (Total Calories) | | 2767 | | | 6335 | 5711 | 6462 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Spare land | | | | | -1760 | -149 | 2623 |
| Land used | | | | | 8095 | 4100 | 3690 |

Fairlie S. 2007 -8

Table D uses: 8.1 million hectares arable, 7.8 million hectares pasture, and has 2.6 million hectares spare.
**One hectare of arable plus one hectare of pasture feeds 7.5 people**

**Figure 14 Livestock Permaculture. Population 60.6 million. Agricultural land 18.50 million hectares. Forestry etc, 3.69 million hectares**

Table E

| | Consumption | Calories in diet | Uk production | Yield | Arable land | Perm' pasture | Other land |
|---|---|---|---|---|---|---|---|
| | gms/person/day | Kcal/person/day | Million tons per yr | Tonnes/ha | 1000 ha | 1000 ha | 1000 ha |
| Cereals for human food | 448 | 1526 | 9.9 | 4.3 | 2302 | | |
| Potatoes | 453 | 300 | 10 | 25 | 400 | | |
| Sugar | 32 | 100 | 0.707 | 7.5 | 94 | | |
| Vegetables and Fruit | 500 | 150 | | | 100 | 50 (100) | |
| Hemp and flax | 5 kg/year | | 0.303 | 3 | 100 | | |
| Horse or bio fuel | | | | | 463 | | |
| Green manure | | | | | 430 | | |
| Milk (inc butter, cheese etc) | 568 | 330 | 12.5 | 3.7/cow | 2825 | 1765 | |
| Beef (grass reared) | 33 | 86 | 0.735 | 0.4 | | 1740 | |
| Cereals for pigs | Bacon 36 | 180 | 1.2 | 4.3 | 279 | | |
| Cereals for hens/eggs | Egg/chicken 30 | 50 | 2 | 4.3 | 465 | | |
| Sheep | 9 | 24 | 0.2 | 0.084 | | | 2372 |
| Leather & sheepskin | 1.46kg/yr | | | | | | |
| Wool | 750kg/yr | | | | | | |
| Fish | 11 | 11 | 0.243 | | | | |
| Timber, firewood | | | | 3 | | | 6000 |
| Wild meat | 5 | 10 | 0.11 | 0.031 | | | |
| Land used (total calories) | | 2767 | | | 8095 | 4100 | 3690 |
| | | | | | 7458 | 3555 | 8372 |

Fairlie S. 2007 -8

Table E uses: 7.5 million hectares arable, 5.9 million hectares pasture, 6 million hectares woodland and has 2.8 million hectares spare.

**One hectare of arable plus 0.8 hectare of pasture supplies 8 people**

**Figure 15 Vegan Permaculture. Population 60.6 million. Agricultural land 18.50 million hectares. Forestry etc, 3.69 million hectares**

Including extra veg, textiles, tractor power and timber.

Table F

| | Consumption | Calories in diet | Uk production | Yield | Arable land | Orchard | Other land |
|---|---|---|---|---|---|---|---|
| | gms/person/day | Kcal/person/day | Million tons per yr | Tonnes/ha | 1000 ha | 1000 ha | 1000 ha |
| Cereals for human food | 491 | 1670 | 10.9 | 4.3 | 2534 | | |
| Potatoes | 453 | 300 | 10 | 25 | 400 | | |
| Sugar | 32 | 100 | 0.707 | 7.5 | 94 | | |
| Rape oil | 35 | 310 | 0.774 | 0.8 | 968 | | |
| Dried peas | 80 | 207 | 1.77 | 3 | 590 | | |
| Hemp and flax | 7kg/yr | | 423 | 3 | 146 | | |
| Vegetables, fruit, nuts | 666 | 180 | | | 150 | 150 | |
| Bio-fuel | | | | | 725 | | |
| Green manure | | | | | 1646 | | |
| Timber/firewood | | | 18 | 3 | | | 6000 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Wildlife / spare land | | | | | | | 8803 |
| Land used (total calories) | | 2767 | | | 7253 | 150 | 6000 |

Fairlie S. 2007 -8

Table F uses: 7.2 million hectares arable, 6 million hectares woodland and has 8.8 million hectares spare.

**One hectare of arable feeds 8.5 people.**

If we accept Simon Fairlie's calculations then we can examine the meaning of the 6 charts and arrive at a suggested diet and agricultural model for Powys for 2020, (the model will actually need to be implemented much earlier, however, if it is to be in place by 2020).

In order to calculate quantities of produce an average healthy diet has to be decided on. People's ideas on what constitutes a healthy diet can vary enormously. At one extreme chips and take-aways are considered to be a suitable staple. At the other end of the spectrum nothing short of a macrobiotic, organic vegan diet will do. Somewhere in between is a balance that could be accepted as a 'model'.

When trying to decide on which of Simon Fairlie's models would be the best one for Powys it should be remembered that fossil fuel depletion will mean an end to chemical fertilizers and pesticides, or at the very least make them so expensive that they are no longer viable. It would seem reasonable, then, to ignore Table A, 'Chemical with Livestock', even though it appears to feed a lot of people per hectare. Equally, Table B must be eliminated for the same reasons.
It is extremely unlikely that the population of Powys would accept being completely vegan, even though Tables C and F, clearly show that vegan diets can support between 8 and 8.5 people per hectare and 3.1 and 3.2 above clearly show that dietary needs can be met without animal inputs.
This leaves Table D, 'Organic with Livestock', and Table E, 'Livestock Permaculture'. Table E will feed 0.5 more people than Table D and does it on less land, leaving more for wilderness, recreation or simply in reserve. Table E also includes fuels in the calculations. It must be remembered that Simon Fairlie's figures are for the UK as a whole and may not allow for production on land classed as SDA. It may be necessary to revisit this should Powys's ability to provide for its population prove to be marginal.

So will it be possible to persuade the majority of the population away from a heavy meat based diet?

### 3.4 Arguments for accepting less meat in the diet

The government is aware of the need to drastically improve the nations diet and is actively encouraging more fruit and vegetables to be included in the daily diet. It says,
*"The Government recommends an intake of at least five portions of fruit or vegetables per person per day to help reduce the risk of some cancers, heart disease and many other chronic conditions."* ( Department of Health 2008)

Many scientific bodies also highlight the increased risk of cancer and coronary heart disease through eating too much meat, particularly red meat and processed meats.
Eating red meat increases a woman's chance of developing breast cancer, according to new research from the University of Leeds, (Science Daily, 2007)

A study of the eating habits of half a million people throughout Europe found that eating above recommended levels of beef, veal, pork and processed varieties like ham, bacon, salami increase the risk of bowel cancer, (Bingham S 2008)
High-risk groups eat more than 160g of meat per day, (British Nutrition Foundation 2008). An average steak weighs around 140g, a burger around 100g and sausages varying between 20g and 40g each.
The study, found that the risks of eating red meat were less in people who ate a lot of fibre from vegetables, fruit and wholegrain cereals as well. Eating any sort of fish on a regular basis had a protective effect, reducing the bowel cancer risk by 30% over those who ate fish less than once a week.

Professor Bingham goes on to say, " *It is the way we now eat meat that is the problem, and even though man has been eating red meat for thousands of years, meat used to be the relish and still is in Mediterranean countries, and the bulk of the meal comes from the other things like carbohydrates and vegetables*".

So busting the preconception that meat has to be the main focus of a meal means that it could be eaten less. Land could therefore be freed up for producing a lot more of the foods we currently rely on, but don't produce.

There are other reasons for consuming a lot less meat than we do and they are directly related to GHG, (green house gas) emissions and consumption of limited resources. In January 2008 Rajendra Pachaur, the head of the UN's scientific panel on climate change, asked the world to stop eating meat. He explained that meat is a very carbon-intensive commodity. United Nations research supports this by stating that livestock production creates more greenhouse gases than all forms of transport combined, ( United Nations Report, 'Livestock's Long Shadow', 2006)

Water consumption by the meat industry is another issue. Meat produced in different parts of the world requires different amounts of water due to variations in species, rainfall, hygiene standards, drinking needs, slaughter, butchering, cleaning, packaging and also the water required to grow the animals feed. As a result, estimates of the water required to produce a kilo of beef vary from 13,000 litres to 100,000 litres. *(*Vegetarian Society 2008*)*

Here in Powys the bulk of meat produced is not consumed locally. For a long time welsh lamb has travelled as far a field as Greece and Turkey where they prefer the texture and flavour of welsh mountain reared meat. Wales, and the UK as a whole import their lamb from New Zealand. In 2006 the Middle East opened a market exclusively for Welsh lamb:

"A potentially lucrative market for Welsh lamb has opened up in the oil-rich Gulf states. The United Arab Emirates has agreed to lift its long-term ban on European sheep meat exclusively for Wales." (Dube S. 2006)

Eating home produced lamb and mutton is a fairly new idea with the public still preferring New Zealand lamb.

This has led to the absurd situation where we export nearly everything we produce and import nearly everything we need. In 1998 the UK imported 61,400 tonnes of poultry meat from the Netherlands. In the same year it exported 33,100 tonnes of poultry meat to the Netherlands. Britain also imported 240,000 tonnes of pork and 125,000 tonnes of lamb, while exporting 195,000 tonnes of pork and 102,000 tonnes of lamb. ( Dr Lucas C. MEP 2002).

The massive swapping of foods around the globe is a major emitter of CO2. UK air freight of imports and exports grew by 7 per cent a year in the 1990's and is expected to increase at a rate of 7.5 percent a year to 2010 (12). (Dr Lucas C. MEP 2002).

The only way that this system can survive is if we totally ignore the need for CO2 emission reductions and have a guaranteed continuous supply of cheap fossil fuels to drive the machinery, fly the planes and power the ships that produce and transport the millions of tonnes of traded goods each year. Knowing what we do, now, about fuel depletion and the predicted famines and crop failures linked to climate change, it seems not just unwise, but positively suicidal, not to drastically examine how we farm, what we produce and why we produce it.

**Conclusion**

We are looking at the frightening picture of a world in crisis through climate change and oil depletion. Added to these two catastrophes are the demands of an ever increasing population with ever higher expectations of what they can own and consume. We have all got used to eating produce out of season, and from the other side of the world, with hardly a second thought. However, as we can see from the previous chapters, our ability to sustain this consumerism and to hold these expectations is being seriously challenged. Powys will have a population of over 146,000 in 2020 with a calorific need of just less than 296 million calories per day. If all we are able to produce at the moment is meat and that is mainly exported, then we are staring a potential disaster in the face. The sections on nutrition show the wide variety of foods we need to include in our daily diets for good health. Not one of these foods is being produced in Powys on any scale large enough to feed the population. The skills and knowledge needed to produce these foods has been lost. To move from the agriculture we practice now to an agriculture that can support the population with limited fossil fuel inputs and resilience to the vagaries of climate change will need a quantum leap in understanding, a total shift of focus and a great many more people involved with the land.

No tweaking of the way we work now will be enough. No half measures or believing that food will come rolling in from somewhere else will do. We are having to wake up to the reality that we have mismanaged our land

and farmed for profit not to feed people. Combined with climate change and oil depletion is the sad truth that most UK soils are depleted and fertilizer dependant, (Soil Association 2008). Mineral depleted soils mean mineral depleted food with research showing that today's vegetables and fruits are on average 70% lower in nutrients than they were 40 years ago. Nothing short of a complete overhaul of current practises will be sufficient to turn the impending crisis round. If viewed in a more positive light this crisis could be the most wonderful opportunity to restore health to both the land and the people dependant on it.

With Table E, Livestock Permaculture, being the diet and agricultural regime of choice, as it fulfils low carbon and fossil fuel depletion criteria, the next questions are, " Can it produce enough, how will it be implemented and what are the fringe benefits to the wider community and countryside?"

## Chapter 4 Livestock Permaculture as a sustainable agricultural model for Powys

### 4.1 Is there enough land?

Going back to Simon Fairlie's Table for Livestock Permaculture his calculations state that using this method of production, 1hectare of arable and 0.8 hectare of pasture will feed 8 people, and go someway towards providing fuel and cloth.

If Powys's population will be 146,107 in 2020 then a 'back of the fag packet' calculation should tell us if we have enough land.
146,107 divided by 8 = 18,263.375 units needing land at a rate of 1.8 hectares per unit.
1.8 x 18,263.375 = 32,874.07 hectares of mixed arable and pasture.
Chapter 2, (2.1), says that Powys covers 5,181 sq km with 4,634 sq km of agricultural land.
5,181 sq km = 518,100 hectares
4,634 sq km = 463,400 hectares
Taking simply the available agricultural land in hectares, 463,400, then dividing it by the required 32,874.075 hectares to support the 2020 population, 60,848.512, it seems that we have potentially 14 times the minimum amount of land required to sustain us. So far it looks as though we could even help feed more densely populated counties on our borders or use the spare land for forestry, energy production and wildlife.

### 4.2 What to grow and how to grow it?

At some point in the calculations we will have to commit to an example of a basic diet in order to actually decide what we need to grow, See Table 12. We have arrived at what seems to be a good basic plant based diet with greatly reduced meat, fats and sugars, all the dietary advice recommended by the medical profession and health experts supports this. Because of depleted fuel and its impact on fertilizers, coupled with the need to greatly enhance soil quality, most of the produce will be grown organically. Some exotics may be possible using protected cropping methods but, for the most part, produce will be seasonal and native, or at least will have been naturalised.

We need to grow all the basics for a healthy diet and we can start with the staples which can be found in any allotment or back garden veg' patch. The scale of production is addressed later on and will obviously have an impact on current land use.

Figure 16. Suggested range of produce for good nutrition

| Roots + | Brassicas | Salads | Cereals & Grains | Pulses | Others | Fruits + |
|---|---|---|---|---|---|---|
| Onions | Cabbage | Radish | Oats | Broad beans | Courgettes | Apples |
| Garlic | Cauliflower | Lettuce | Spelt | Haricot beans | Pumpkins | Blackcurrants |
| Leeks | Broccoli | Tomatoes | Rye | Runner beans | Squash | Redcurrants |
| Carrots | Kale | Cucumbers | Barley | | Rhubarb | White currants |
| Potatoes | Brussel Sprouts | Rocket | | | | Gooseberries |
| Parsnips | Oriental Salads | | | | | Pears |
| Swede | | | | | | Plums |
| Celeriac | | | | | | |

, Robinson D 2001, Based on authors study of vegetarian and vegan nutrition

In order to establish the quantities that will be needed to feed the population in 2020 I have created a weekly diet for 1 person based on a calorific need of 2,250 per day, (Table 8). The weekly amount per person is then calculated up for the whole population. The diet contains a wide enough range of fruits, vegetables, pulses, grains, fats and meats to be balanced and nutritious. Whether it's to everyone's taste is another issue and one that needs to be addressed later, as moving away from what is known and comfortable can be difficult and stressful.
For all the reasons given in previous chapters the diet in 2020 will need to be less meat orientated. It will also probably not include any imported foods that we take for granted now like orange juice, tea, coffee, rice, or any products made from cereals, grains and pulses which only grow abroad, such as pasta, chick peas and

lentils. It also needs to be remembered that with more self-reliance in food production menus will be increasingly seasonal.
It is also fair to say that the land may well dictate the diet as opposed to the diet making demands on the land, which it might not be able to meet. It could be said to be a ‘chicken and egg’ situation!

Figure 17. An average weekly menu for one person.

| | Mon | Tues | Wed | Thurs | Fri | Sat | Sun |
|---|---|---|---|---|---|---|---|
| B’fast | 2 Scrambled eggs on 2 slices of toast | Toast, butter and a fruit preserve | Bubble and squeak. | Porridge | Mushrooms on toast | Pancakes with fruit preserve | Mushrooms, potato cakes, tomatoes, toast |
| Lunch | Chicken soup and bread | Broad bean pate, toast and seasonal salad | Ploughmans | Onion tart and seasonal salad. | Parsnip and apple soup | Sweetcorn pasties. | Roast chicken Seasonal vegetables |
| Dinner | Vegetable chilli with spelt rolls and seasonal salad. Apple crumble | Cauliflower pie with roast potatoes and seasonal raw salad. Stewed pears | Raw nut savoury pudding with steamed seasonal vegetables and spelt rolls Blackberry and apple pie | Mutton stew with potatoes and kale. Jam sponge | Bean layer pie with cabbage, potatoes. Plum cake | Homity pie with kale and seasonal vegetables Rhubarb crumble | Jacket potatoes with cheesy leek. |

Figure 18. The weekly menu broken down in to weights and quantities for one week and then for one week for the total predicted population in 2020 of 146,107.

| Ingredient | Quantity | Weight | Weight/Quantity for 2020 population |
|---|---|---|---|
| Eggs | 4 | | 584,428 |
| Bread | 2 x 500g loaves | 1kg | 146,107kg |
| Butter | 1 | 250g | 36,526 kg |
| Jam | | 100g | 14,610kg |
| Oats | | 200g | 29,221kg |
| Potatoes | | 2kg | 292,214kg |
| Cabbage | 1 | | 146,107 |
| Mushrooms | | 500g | 73,053kg |
| Milk | | 1litre | 146,107ltrs |
| Tomatoes | | 500g | 73,053kg |
| Chicken | .25 | | 36,526 |
| Mixed salad leaves | | 200g | 29,221kg |
| Broad beans | | 300g | 43,832kg |
| Cheese | | 100g | 14,610kg |
| Onions | | 2kg | 292,214kg |
| Garlic | 2 bulbs | | 292,214 bulbs |
| Parsnip | 2 | 500g | 73,053kg |
| Cooking apples | | 1kg | 146,107kg |
| Sweetcorn | | 50g | 7,305kg |
| Swede | .25 | | 36,526 |
| Leeks | | 400g | 58,442kg |
| Spelt rolls | 4 | 500g | 73,053kg |
| Flour | | 500g | 73,053kg |
| Cauliflower | .50 | | 73,053 |
| Chilli pepper | .25 | | 36,526 |
| Carrots | | 400g | 58,442kg |

| | | | |
|---|---|---|---|
| Kale | | 500g | 73,053kg |
| Pears | 1 | 150g | 21,916kg |
| Rhubarb | | 150g | 21,916kg |
| Blackberries | | 50g | 7,305kg |
| Plumbs | | 75g | 10,958kg |
| Mutton | | 100g | 14,610kg |
| Pork | | 100g | 14,610kg |

So already we are starting to get an idea of the scale of production needed to support a basic low meat high fruit and vegetable diet for the predicted population of Powys.
If chilli appears on the menu for one day of the week for everyone then in one week the population would use 36,526 individual peppers. That is a huge amount of produce probably requiring around 3,652 plants. Chillies need protected cropping in the form of polytunnels or greenhouses. With an average plant needing about 2 sq ft of space the total crop would need 679 sq metres of protection.
This would be the equivalent of 20.28, 32ft x 12ft polytunnels and would cover an area of 0.679ha. This is not a huge amount of land and providing the tunnels were in constant use could arguably be a more productive use for the land than grazing sheep. Land carrying capacity is usually measured in units. One unit of sheep equals 5 to 6 individual animals, 0.8092ha can support 2 units, or 10 to12 animals, although the sheep need moving periodically for grass to regrow and to reduce parasitic burdens. This means that other land needs to be available from time to time. If 0.8092ha can support 10/12 animals then the predicted land outtake of 0.679ha for protective cropping would displace 1.19 sheep.
This means that on just under 0.7ha of land we can have 20 polytunnels producing chillies or 1.19 sheep. Of course the polytunnels could and would be used to produce a much wider range of crops all year round, but the chilli calculation helps to get the land use for meat production into perspective.

**4.3 How much land would we need?**

To calculate the area of land needed to produce the crops in Table 9 I have taken the average weight produced per square foot and multiplied by the sq feet in an acre. An allowance has to be made for wastage from crop failure and damage which I am calculating at 20%, (I've used 20% as a rough guide based on personal experience of field scale vegetable production.). This is 20% of the crop not being either fit or available for human consumption, although it is possible to use animals to 'clean' a field after the harvest. This has a three fold benefit in that it helps feed and fatten stock, clears the ground of the old produce and aids soil fertility with animal manure.
Therefore there has to be 20% added to land area needed to bring the crop size up to the predicted required amount.
Calculations are based on 1 acre = 43,560 sq ft, 1 hectare = 107,639.104 sq ft. 1 sq kilometre = 100 hectares (247.105381 acres).

Vegetable production
Powys covers 5,181 sq kilometres, which equals 518,100 hectares with 4,634 sq kilometres designated as agricultural, which equals 463,400hectares.
Not all of these 463.400 hectares are suitable for horticulture but considerably more of it could be used for horticultural production than is being used at present. The next series of tables calculate land area needed for vegetable production, cereals and dairy.

For horticultural calculations a cropping plan is necessary as the land can produce more than one crop in a season through under planting and intercropping. It is also necessary to consider land available within towns and villages and the contribution these plots can make to the overall production of the county.

Figure 19. Land area needed for predicted vegetable crop requirements for one week

| Ingredient | Quantity | Weight | Weight/Quantity for 2020 population | Land area needed in acres/ha |
|---|---|---|---|---|
| Potatoes | | 2kg | 292,214kg | 3.22/1.30 |
| Cabbage | 1 | | 146,107 | 4.02/1.62 |
| Tomatoes | | 500g | 73,053kg | 0.3/0.12 |
| Mixed salad leaves | | 200g | 29,221kg | 0.16/0.064 |
| Broad beans | | 300g | 43,832kg | 0.10/0.040 |
| Onions | | 2kg | 292,214kg | 8.04/3.252 |
| Garlic | 2 bulbs | | 292,214 bulbs | 1.42/0.404 |
| Parsnip | 2 | 500g | 73,053kg | 2.13/0.860 |
| Sweetcorn | | 50g | 7,305kg | |
| Swede | .25 | | 36,526 | 1.42/0.574 |
| Leeks | | 400g | 58,442kg | 0.12/0.048 |
| Cauliflower | .50 | | 73,053 | 4.02/1.626 |
| Chilli pepper | .25 | | 36,526 | 0.16/0.040 |
| Carrots | | 400g | 58,442kg | 1.42/0.485 |
| Kale | | 500g | 73,053kg | 4.02/1.618 |
| Rhubarb | | 150g | 21,916kg | 0.40/0.161 |

The table above indicates that to feed the population of Powys with basic staple vegetables for one week will require 12.21 hectares (30.17 acres) of land. To feed the population for a year would take a maximum of 634.92 hectares, (30.17 x 52), but as already pointed out, the land would be able to produce more than one variety in a year if careful crop planning and rotations are observed, so the actual land use could be slightly less in reality. For many of the root crops to be available all year round appropriate storage methods will be needed. Storage needs to happen without the use of fossil fuels to be sustainable, which precludes freezing.

**So, land take for vegetable production = 634.92 hectares**

We now need to look cereals and dairy production and their respective and collective land area usages.

**Cereal production**
The Centre for Alternative Land Use is based at Bangor University's Henfaes Research Centre. They are supported by ADAS, Bangor University, Coleg Llysfasi, the Welsh College of Horticulture and Planed and Mabis; and deliver the Farming Connect Knowledge Transfer Development Programme for Land Management.
One area of their research has been cereal production in Wales and looks at appropriateness of variety and crop yields, which indicate that Oats and Rye are the best options for wide use across Wales with options for Barley (CALU 2008).

Simon Fairlie's figure for cereal consumption per capita is 484 grams per day. My calculations indicate 143 grams per day for bread, (2 x 500g loaves per person per week), and another 200 grams a day as breakfast cereal which comes to 383 gms. Given the use of flour in cooking it would be fair to add another 100grams a day bringing the daily total to 483. For the sake of easier calculations I think it reasonable to round the 483 grams up to 500 grams.

The rate of cereal consumption in 2020 will then be:
146,107 (head of population) x 500 grams = 73,053.5 grams per day, = 730kg per day, =266,645kg per annum, = 266.645 tonnes per annum.
We now need to go back to Table 15 to convert the tonnage into land area needed for production.
The average across the three most suitable grains for Wales, (Oats, Barley and Rye) is 6 tonnes per hectare.
To gauge the amount of land needed we divide 266.645 tonnes by 6, = 44.44 hectares.

**So, land take for cereal production for direct human consumption = 44.44 hectares**

**Cereal production for animal consumption**

However, even within a livestock permaculture system some cereal will be produced for animal feeds. Table 15
Indicates 30 grams per day for chicken feed. My recommended weekly diet includes a quarter of a chicken per person per week. That amounts to 36,526 chickens a week or 1,899,391 chickens per year. In one year a chicken will need 30 grams x 365 = 10,950 grams of cereal, = 10.95 kg.
Annually for total chicken production, if everyone has a quarter of a chicken a week the cereal demand will be
20,798,331kg = 20,798 tonnes. Converting this to land use we need to divide 20,798 by 6, as there is an average yield of 6 tonnes to the hectare, which gives a land use of 3,466.388 hectares for feeding chickens. This is a huge amount of land for simply feeding poultry.

**So, land take for cereal production for chickens = 3,466 hectares**

This does not factor in land taken up for housing poultry as in a permaculture system they would most likely be free range. However all poultry needs housing by night so it is worth looking at what area housing would use in order to get a clearer picture of land use for chicken production. An average hen house 4ft sq or 0.371msq will house about 8 average sized hens, (P and T Poultry 2009). It's not suggested in this thesis that hens are kept in numbers of 8; it simply enables the calculation for total flock coverage, which is:
total flock = 1,899,391 birds, divide by 8 = 237,423.87 4ft sq/0.371msq henhouses which = 949,695.48 sq ft/88,084.255msq of cover. 1msq = 0.0001ha, which gives a total of 8.808ha for housing chickens.
If this were done in the current agricultural climate of mass production it would take a large chunk of land out of production, However permaculture means many small hen houses dotted throughout towns, villages, orchards, backyards, etc, where the land take is barely noticed against the background of diverse production

**So, land take for housing chickens = 8.808 hectares**

**Pig Production**
The average pig weighs 100kg at slaughter, (Dr O'Connell N. 2009), with a quarter of it's body weight being lost through unusable parts such as bone and intestines, giving 75kg of usable flesh.
If each person eats 100g of pork per week then the weekly consumption of pig meat will be 14,610kg, which equates to 194.8 pigs each week. Annually the population would consume 10,129 pigs. If each pig needs 36g of cereal per day it will consume 13kg of feed in a year. It must be remembered that these are pigs being produced within a permaculture system and as such are predominately free range, probably woodland, and getting much of what they need by foraging.
Total land take for cereal production for pigs would be 10kg x 10,129 (number of pigs) = 101,290.0 kg per year, which is 10,129 tonnes. To calculate land area needed divide 10,129 tonnes by 6, (average yield per hectare in tonnes) = 16.88hectare

**So, land take for cereal production for pigs = 16.88 hectares**

Woodland pigs still need housing, usually in the form of arks and, like chicken housing, it is interesting to see how much land would need to be given over to this.
An average sized shelter for 4 pigs is 8ft x 8ft = 16sq ft, = 1.48644mtr sq, (The Traditional Pig Ark Company. 2009) If the total annual pig population for Powys is 10,129 then we divide this by 4 to find out how many arks we need, 10,129 dived by 4 = 2,532.25. Each ark uses 1.48644mtr sq of land so the total pig population will need 2,532.25 arks x 1.48644mtr sq, which = 3,764.0376mtr sq, which = 37,640 hectares. As with chicken housing, should the pigs be reared industrially then this is a large amount of land use. However, with individual arks dotted throughout woodland the land take has less impact. In both cases the less intensive approach also means no issue with pollution from droppings and dung as it's returned to the soil in a manageable way where it actually becomes part of the natural soil fertilization process.

**So, land take for housing the pigs = 37,640 hectares**

**Dairy**
Live stock in the permaculture model are not reared intensively but are included as a bonus on the margins of horticultural production. Modern dairy farming places high demands on cows for maximum production meaning high inputs to match the expected yields. For the dairy industry this means cows are grazed on premium land where rich grass fodder can be produced and the cows diet is supplemented with cereals and grains, again, grown on premium land where maximum yields to the hectare can be expected. Dairy cows in this system can be expected to produce around 6,933 litres per annum, (DEFRA. 2009).
The average age of modern dairy cows is five years, compared with twenty for the same cow in a non-intensive system. So although each cow would be giving considerably less milk on a daily basis she would probably give more over her lifetime.
Table E, 3.3, suggests a daily intake per person of 568grams of dairy products, this includes milk, cheese and butter. For the sake of easy mathematics it would be helpful to reduce this to 500 grams per day as 1ltr of milk = 1kg. This is 3.5ltrs per week per person and is congruent with statistics gathered from Calonwen Organic Dairy cooperative who kindly supplied the data used in this section.
Based on the figures above then, you need approximately 3.5litres/person/week (allowing for production waste - filling pipes, etc) therefore you would need about 182 litres per year per person. That would give a total requirement of 26.8M litres
An organic cow will produce between 5,000 - 5,500litres per year so at 5,000 litres per year this would give an overall need for about 5,400 cows. However, it would be necessary to set aside land for replacements so overall there'd be an extra need for land and feed for another 1600 animals, based on a 15% replacement rate, if half were under 1 year old and half were under 2 years old. This gives a total of 7000 animals.
In an intensive dairy system you could work on 1 cow per acre but in organic systems it needs to be nearer 1.8 acres, (0.7284 hectares) per cow depending on the land and how much extra feed is needed

plus grass conversation for winter feed. Calonwen recommend 1.5 - 1.8 acres (0.6070 to 0.7284 hectares) per cow
Supplementary feed depends on how much milk you want the cow to give and how much feed you want to bring in. If you worked on a less intensive system the cow would calve in the spring, produce milk all summer and autumn and through the beginning of winter and then go dry after Christmas ready for next year. In that case she would not really need much supplementary feeding. The ruminant evolved to take low-grade prairie grass, and by fermenting it in the rumen produces huge quantities of microbes, which the cow then digests, and that is where she derives her protein. In reality, therefore, she does not really need supplementary feeding unless you want fresh milk in the Winter If you do want milk in the winter then you will need about 1tne of additional feed, which is made up of cereals and legumes. Organic land would produce about 1.5 - 2tne of wheat per acre so to feed a cow a tonne of feed would need maybe another acre of land for the growing of these crops, assuming some of the land is down to cereals and some to legumes. The replacements would need about 400kg, (just under half a tonne) of concentrate over the two years that they were growing. For the 5400 milking cows this would need another 2700 acres plus 400 acres for the replacement animals, giving a grand total of 10,100 acres, which is 4087.324 hectares.

**So, land take for dairy production = 4087.324 hectares**

Like pigs and chickens, the dairy herds will need protection from the elements even if they are a hardier breed better adapted to living outdoors for most of the year on marginal land.
You can comfortably accommodate 4 cows in a barn measuring 300sq ft, which is 27mtr sq. If we have a total of 7,000 animals then we will need 1,750 x 27mtr sq of cover, which = 82,687,500mtr sq, which =8,268.75ha

**So, land take for housing all dairy cattle = 8,268.75 hectares**

**Sheep production**

Currently, (2009), Powys predominately produces sheep and lamb. With the need for large scale production halted through the inability to export the large numbers which leave the county at the moment, due to oil depletion and transportation issues, it’s suggest that farmers revert back to indigenous species which can tolerate living out all year on the uplands which cannot be brought into horticultural production. For this reason sheep are not included in these calculations but would obviously be a fringe benefit to the overall food production strategy.

Figure 20. projected figures for land take based on vegetable, cereal, poultry, pig and dairy production

| Occupation | Land area needed in hectares |
|---|---|
| vegetable production | 634.92 |
| cereal production for direct human consumption | 44.44 |
| cereal production for chickens | 3,466.0 |
| housing chickens | 8,808.0 |
| cereal production for pigs | 16.88 |
| housing pigs | 37.640 |
| dairy production | 4,087.324 |
| housing for dairy cattle | 8,268.75 |
| **Total** | **25,363.954 hectares** |

With Powys having a total for agricultural land available of 463,400 hectares the activities above leave a surplus of 438,036.05 hectares. Which rather beggars the question. “ What on earth are we doing with the land at the moment if stepping up production for an increased population and diversifying into wider production can leave us with so much spare land"?

**Conclusion**

Although the above calculations are for a limited range of agricultural activities they do cover the main ones and the ones that we will need to concentrate on to deliver a reasonable diet for everyone. This chapter proves that it is possible to deliver an acceptable and healthy diet for the population of Powys in 2020, and with land to spare for other activities such as orchards, bee keeping, goats, specialist sheep for wool production, forestry and fuels.

## Chapter 5 Changes to agricultural methods

### Introduction

It seems, from the results so far in this piece of research, that farming is going to have to change quite radically if it is to switch from growing for profit to feeding local communities. By it's very nature farming cannot operate a rapid response mechanism. Changing production takes time, vegetables and fruits take a season to grow, livestock takes longer. We need to have a very clear idea of the changes that are necessary and we need that knowledge as soon as possible in order to implement change at an acceptable rate.
A plentiful supply of relatively cheap fossil fuel over the last one hundred years has meant that food can be grown some distance away from where it will eventually be consumed. Planes, boats, trains and lorries regularly transport food for thousands of miles every day, quite often from the other side of the planet. At one point during the winter of 2008 it was possible to buy carrots from Australia, in Mid Wales. Depleted fossil fuel reserves will mean that food must be grown closer to the places where it is to be consumed.
Field sizes and scale of production have both increased over the last one hundred years. Farm machinery has become standard on most farms. Farm machinery has got larger and more efficient, but has also meant that fields have had to become larger to accommodate them, with resulting hedgerow losses.
The Woodland Trust says,
"Surveys by ITE and by the Countryside Commission showed that the net loss of hedgerows due to removal, lack of management and development accelerated rapidly after the Second World War across Great Britain, rising from 2,600 miles per year in the period1947-1969 to an estimated 5,378 miles per year in 1984-1990. Since 1990 hedgerow loss has continued, although a further survey showed that, largely as

a result of public concern and changes in Government subsidies, the rate of removal had more than halved to an average of 2,235 miles per year in the period 1990-1993", (woodland trust 2009)
Although hugely valuable as habitat, hedgerows also play a large part in soil retention and protection from weather.

So two significant changes to the where and how we farm will be a massive reduction in mechanisation and ensuring that maximum production takes place in and close to centres of urbanisation.

### 5.1 Where we farm

Figure 5, page 6, (adapted below), shows the main urban areas in Powys and their population as of 2001. We can recalculate the population figures to reflect the overall predicted rise in population for 2020. Having done this we can apply the ratio of people to hectare support for 'Livestock Permaculture', (I.8 hectare supports 8 people), to find the land area needed around each town.
In 2001 the total population for Powys was 126,354 with 55,940 living in urban areas. The total population for Powys in 2020 is estimated at 146,107, a difference of 19,753 this is about a 15% increase if we now apply the 15% increase to the urban figures above we can estimate the land needed to feed each of the major towns in Powys in 2020.

Figure 21. Population figures by town for 2001 and 2020 based on predicted population growth rate and land needed to support that population.

| **Town** | **2001** | **2020** | **Land needed in hectares** |
|---|---|---|---|
| Llanfyllin | 1,616 | **1,858.4** | **418.14** |
| Llanfair Caereinion | 1,400 | **1,610** | **362.25** |
| Welshpool | 6,269 | **7,209.35** | **1622.09** |
| Machynlleth | 2,000 | **2,300** | **517.50** |
| Newtown | 10,783 | **12,400.45** | **2790.00** |
| Llanidloes | 2,314 | **2,661.1** | **598.74** |
| Rhayader | 2,075 | **2,386.25** | **536.89** |
| Knighton | 3,000 | **3,450** | **776.25** |
| Llandrindod Wells | 5,000 | **5,750** | **1293.75** |
| Presteigne | 2,191 | **2,519.65** | **566.91** |
| Builth Wells | 2,352 | **2,704.80** | **608.58** |
| Llanwrtyd Wells | 0,700 | **0.805** | **181.25** |
| Hay on Wye | 1,846 | **2,122.90** | **477.65** |
| Talgarth | 1,650 | **1,897.50** | **426.93** |
| Brecon | 7,901 | **9,086.15** | **2044.37** |
| Crickhowell | 2,800 | **3,220** | **434.70** |
| Ystradgynlais | 2,543 | **2,924.45** | **365.55** |

The calculations above reveal a land need of 14,021.55 hectares to feed the major towns in Powys in 2020, which will have a total predicted population of 64,101,805. However there are another 82,052 people living in rural areas who will need another 10,631 hectares, giving a total land need of 28,043.1 hectares. Powys's available agricultural land is presently 4,634 Km sq, which equals 463,400 hectares.

Because farming will be less mechanised and there will not be the fossil fuels available to transport food over long distances it becomes clear that food production will need to happen as close to the point of consumption as possible. This means that all available farmland surrounding centres of population will have to diversify into cereal production and horticulture, producing as much of the range of staple foods as possible.

**5.2 How we farm**

As already stated, farming will have no choice but to change as oil reserves become depleted and fuel prices, for the reserves that remain, rise to the point where the resulting food produced via these limited resources becomes too expensive.

In Cuba, before its ‘special period’ when fossil fuel supplies were cut off by Russia, less than 1% of the population worked on the land. Farming was highly mechanised and chemical based, with most produce being grown for the export markets, coffee for example. This is much the same form of agriculture as is practised in Wales, and the rest of the UK, at the moment.

The ‘special period’ of oil scarcity saw 40% of the population working the land and nearly all produce being grown for the home market. Cuba was a ‘trial run’ for a world agriculture without oil and tells us quite clearly that there will need to be a massive shift of labour back onto the land and rapid and extensive diversification into vegetables, fruits and cereals with livestock being kept as part of the horticultural process, e.g. chickens free ranging in orchards.

Because Cuba had to make a rapid transition in it’s agricultural practises there wasn’t the luxury of debate with farmers as to what and how they grew, instead, the state dismantled farms and replaced them with production cooperatives, run by the people, (Quinn M. 2006)

With peak oil being predicted for 2010 there is time to prepare and avoid farms becoming state owned as in Cuba. Cuba, of course, has a very different climate from Mid Wales; it is possible to grow fruit and vegetables all year round in the Cuban climate. Wales, however, has a very short growing season with most planting happening as late as the end of April, beginning of May, and all but over wintering vegetables like brassicas and roots, needing to be harvested by September.

The report from the National Assembly for Wales, ‘Changing Climate, Challenging Choices’, predicts that Wales will have an overall temperature rise of 1.1 – 2.9$^{0c}$ with winter rain up by between 7 and 24%. The summers will be drier and wind speeds will increase. Overall the weather will become more unpredictable and with greater extremes. In a climate that can be challenging to begin with, with a short growing season and not known for extensive horticultural production, there will be an obvious need for some kind of control over production through protective cropping. The most obvious and well know forms of protective cropping are polytunnels and glass houses, but it can also mean strategically grown shelter belts, preferably from fruiting bushes and shrubs; fleecing, mulching, companion planting, under sowing, etc

Because food production surrounds the community, getting the food into the towns is a relatively simple task. Infrastructures, such as supermarkets, can easily adapt to receive the local produce, although extensive fossil fuel use in keeping produce chilled and frozen may well have to be reviewed and other storage methods developed. Ideally produce arrives fresh and is sold almost instantly, this may well be more labour intensive but again, the lack of fossil fuels will mean more people working manually in food production and factored into these costs must be the savings from not purchasing large machines and vast quantities of oil to run them.

The majority of the population in the UK have given up producing their own food. Instead they rely on the trucks to keep rolling and the supermarket shelves to stay full of all the rich varieties of foods available, right now, from all over the world. Having food security gives a ‘feeling’ of security as does the empowerment of being able to provide some, if not all, of ones own needs. To that end it seems wise to encourage as much production as possible within the towns and villages. Many small gardens lend themselves to crop production, as do parks, south facing walls and window ledges.

### 5.3 Seed Saving

Climate change and post peak oil impacts on seed germination and the ability of plants to grow to fruition.
It was not so long ago that every gardener in the world saved his or her own seed for the following year. They saved seeds from plants that did particularly well or which had qualities that they liked such as flavour, colour or scent. This made for a healthy and resilient gene pool of plants. If one plant failed in an area there was another variety that would have done well. People swapped seeds. There was no patenting or ownership. Seeds were viable and open pollinated; they all had a slightly different gene pool, building resilience into communities through their adaptability.
Over the last forty years, due to EU legislation and the seductive offers from large seed companies, almost all local plant strains have been lost and the knowledge of how to save seed has all but disappeared. (Gabel B. 2008).

Many vegetable varieties have been bred to 'breed true' which allows for uniformity of growth and harvest. This has mainly been for the benefit of large-scale producers who want to harvest an entire crop in one go making the crop more profitable because the process is streamlined. They are also able to fulfil very large orders for large purchasers like supermarket chains. Because these seeds are identical the environment they are grown in must be uniform also. This has meant literally 'bludgeoning' the environment into a standard growing medium through the use of chemical fertilizers and pesticides, all of which come from cheap oil and all of which we will soon have to learn to live, and grow, without. About 90% of the calorific value in crops comes from oil, instead of sunlight and water, so great is it's input to the success of the plant and on the produce reaching it's final destination.

These varieties, usually known as F1 hybrids do not have the ability to make viable seed. The seed they produce cannot be saved to sow again, instead a whole new seed order has to be placed with the major companies each new season. The EU has compounded this by declaring a list of 'official' vegetable varieties. Seed that is not on this list cannot be sold to the public even though it is perfectly legal to plant and grow it. The difference between the plant requirements of commercial growers and back garden growers is massive. Commercial growers need varieties that fruit at the same time, respond to certain chemicals and stand up to transport and packaging. Home growers look for flavour, tenderness and nutritional value. Nearly all commercial seed companies will produce for the biggest market and that is why it gets harder and harder to find non F1 seed and why it is becoming a serious issue that individuals can no longer save seed from their plants for the next year.
Seed saving will be a very necessary skill in the new agriculture.

### 5.4 Post Peak Oil and Soil Fertility

There has been a long held belief that the fertility of our soil is directly linked to animal by-products and that without animal manure we will have no way of replenishing the nutrients taken from the soil by crops. Chemical fertilizers were specifically designed to replace these nutrients artificially and it has been various organic certification bodies such as the Soil Association and QWFC UK 13, that have worked hard to return/project agriculture towards more sustainable and less polluting methods of production, banning most artificial chemicals and fertilizers.
However most organic systems still rely heavily on animal input for soil fertility. This may come directly from manure from animals kept on the land but may also come in the form of organic fertilizers comprised of blood and bone from abattoirs. However, in 2007 The Soil Association developed a set of standards for complying with stockless horticultural production, called The Stockfree Organic Standard'.
The development of this standard by the soil association gave credibility to the belief, albeit by a minority, that soil fertility could be maintained and enhanced without animal input. This was widely welcomed by both the vegetarian society and the vegan society and, although they still might be viewed, even collectively, as a minority group, does mean that when/if we have to greatly reduce the amount of livestock we keep on the land, we have a practical and sustainable alternative for enhancing our soil.
In the early 1990's stockless trials were conducted by Elm Farm in Norfolk and Lincolnshire where arable farms were suffering from a lack of farmyard manure, the land being given over to cereal production. Farmers had a heavy reliance on chemical fertilizers and were reluctant to convert to organic having no other way of feeding their soil. The trials proved, (later backed up by the ADAS Terrington trials and the Co-operative Wholesale Society) that it was possible to grow good crops of grain without either animal or

chemical input. Fertility was provided by the growing of green manure leys, such as red and white clovers, cocksfoot grass and chicory, mustards and phacelia, (Hall J and Tolhurst I 2006)

### 5.5 The permaculture model and land use

Powys covers 5,181 sq kilometres, which equals 518,100 hectares with 4,634 sq kilometres designated as agricultural, which equals 463,400hectares. This thesis proves that a very basic, but healthy, diet can be achieved for the predicted population off Powys in 2020 on just 25,363.954 hectares. But how will the land be used?

The suggested permaculture style of agriculture uses 'zoning', ( Mollison B 1979):

**Zone 1:** This is usually the area closest to your home or community, but it also includes frequently travelled paths. Everything that needs a lot of attention should be placed in zone 1. Examples would be seedlings that require daily watering, frequently used herbs, salad vegetables, polytunnels, glass houses and is also the area where you collect compost, place your anaerobic digester, etc

**Zone 2**: This is still an area needing a lot of attention. It is usually fully irrigated, if the climate requires it, regularly composted and mulched. It contains fruit bushes and trees, shrubs and trellised fruit, bramble berries, edible hedges, ponds and windbreaks. It might also feature hardy perennial plants that are not used on a daily basis, and vegetables that take a long time to mature and need occasional attention such as weeding. Usually they are only picked once or twice, potatoes, carrots, cauliflower, onions, etc

**Zone 3**: Still managed, but neither mulched nor irrigated, this area features larger permanent fruit or nut trees and is where chickens, dairy cows and some pigs can free-range.

**Zone 4**: Only semi-managed, this is an area for gathering wild foods and for growing timber for building and fuel.

**Zone 5**: Natural, semi-wilderness, uncultivated where some hardy cattle and sheep can graze. In Wales this would be where wind power could be generated.

This zoning builds a picture of how the new countryside might look and perform. Most labour intensive crops and work are close to the communities with livestock becoming integrated in zones 3,4 and 5. The livestock is free ranging, non-intensive and, for the most part, unsupported by supplementary feeding. The use of local traditional breeds is essential for this to work.

With Powys having approximately 463,400 hectares of land available and the population in 2020 needing only 25.363.954 hectares in cultivation to give an acceptable basic diet for everyone, there are approximately 438,036.05 hectares left over. Adopting the permaculture style of agriculture and using zoning means that zones 4 and 5 could play a very important role in energy production for the county. Of course Powys could extend zones 1,2 and 3 beyond it's own needs and become a net exporter to less rural communities such as Birmingham, Bristol and Manchester, all of whom will find it much harder than Powys to feed it's population.

### Conclusion

This thesis asks whether Powys could be self-reliant in food by 2020. The figures all say that it can be, although a change in farming practise will be essential in bringing this about. The preferred model of farming is livestock permaculture which allows a wide range of food production with greatly reduced fossil fuel input and which, by it's nature, improves soil fertility, animal welfare and self-reliance.

However, as previously stated, there is not much time left in which to begin implementing these changes and action needs to be taken on several fronts to enable a smooth transition from the current model of agriculture to the new, which will help to eliminate fear and aggression as climate change and post peak oil begin to impact on available food supplies.

Reskilling and education will be essential for the majority of farmers who have been encouraged to only farm sheep for generations. Almost all will have no knowledge of horticultural production, seed saving and stock free fertility.

It is essential that Europe, responsible for the Common Agricultural Policy, which affects all European agriculture, prioritise policies for change as rapidly as possible. All levels of Government must see food security and local production as key to their county's and country's viability as we move into the coming period of radical change. How this happens is a subject for further research.

Overall, Powys has enough land to feed its population with land to spare. More land could be put into cultivation with spare food being exported to the nearest cities who may well struggle to feed their population. On the other hand Powys may choose to use the spare land for large-scale timber production for fuel and construction, thereby sequestering C02 and reducing its overall carbon footprint.

The change needs to happen from the top down with government and from the bottom up with communities making the appropriate changes for themselves such as in the Transition movement. It is gaining the knowledge and skills to be self-reliant which will eliminate the fear of change and possible deprivation. The research in this thesis actually points us to a world of bounty and well being, not of hunger and despair. There is much to be said for the benefits to communities and society as a whole as we all re learn to look after one another again. The changes that are coming are unstoppable, though they can be minimised if we act quickly to reduce the damage we are inflicting on the planet at present. However, the changes can be looked on as positive rather than negative as they give us a golden opportunity to review what we have been doing for the last two hundred years and to put right some of the disastrous mistakes we have made that have brought us to this point. Welcome the change and make it the best thing that has happened to our society, our agriculture and our natural world in a very long time.

The human race could be staring at it's own extinction or it could be looking at a utopia waiting to be created.

The choice is ours and ours alone, but for agriculture we must make that choice now.

As an initial piece of research this thesis is valuable in having identified the need for greatly increased self-sufficiency in Powys and has gone some way to suggesting how this might come about. However, it can only be an overview based on available data for expected population growth, climate change and oil depletion. The work is limited by a lack of detailed information, which needs to be the basis of further research. To date there has only been limited research data available on alternative land use issues in Wales. More information is needed on plant varieties, soil types, disease resistance etc. There also needs to be a series of trials into food crops which may never have been grown in the county before, but which may become appropriate as the climate changes. Further research into the social and economic implications of a more agrarian society could help to clarify and prepare for the changes that are likely in those areas.

This thesis has asked the questions that had to be asked about how Powys will feed its population in 2020. The resulting answers act as signposts for further discussion and should form the basis for a wider programme of research to include all stakeholders.

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Figure 16. Figure 16. Robinson D. 2001 based on personal nutritional research for vegetarian/vegan nutrition diploma. Stoneybridge College. Available as hard copy on request.

Figure 17 Robinson D. 2009 An average weekly menu for one person.

Figure 18. Robinson D. 2009. The weekly menu broken down in to weights and quantities for one week and then for one week for the total predicted population in 2020 of 146,107.

Figure 19. Robinson D. 2009. Land area needed for predicted vegetable crop requirements for one week

Figure 20. Robinson D. 2009. Projected figures for land take based on vegetable, cereal, poultry, pig and dairy production

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Appendix
Montgomeryshire 1867 to 1972

Digest of Welsh Historical Statistics 1700-1974, (http://new.wales.gov.uk/topics/statistics/publications/dwhs1700-1974/?lang=en)

| June | Total Farming Area | Rough Grazings | Total Cultivated Area | For Grazing | For Hay | Total | Total Arable | For Grazing next | For Hay | Total | Total | Wheat | Barley | Oats | Potatoes | Turnips & Swedes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1867 | | | 229.2 | .. | | 128.7 | 100.5 | .. | .. | 25.7 | 74,754 | 20,954 | 12,087 | 21,344 | 3,045 | 8,986 |
| 1872 | | | 243.3 | 96.9 | 35.5 | 132.5 | 110.8 | 13.7 | 22.2 | 35.9 | 74,903 | 22,735 | 12,879 | 21,785 | 3,208 | 7,490 |
| 1877 | | | 249.2 | 113.7 | 39.0 | 152.7 | 96.5 | 10.0 | 18.2 | 28.2 | 68,274 | 19,242 | 10,822 | 21,918 | 2,801 | 8,119 |
| 1882 | | | 256.1 | .. | .. | 163.4 | 92.6 | .. | .. | 23.9 | 68,761 | 18,655 | 9,970 | 23,937 | 2,728 | 7,761 |
| 1887 | | | 259.9 | 121.4 | 47.0 | 168.4 | 91.5 | 12.0 | 17.0 | 29.0 | 62,465 | 14,173 | 8,647 | 25,008 | 2,634 | 8,031 |
| 1892 | 362.9 | 90.2 | 272.7 | 138.4 | 47.5 | 185.9 | 86.8 | 13.9 | 17.1 | 31.0 | 55,786 | 11,027 | 9,075 | 22,759 | 2,287 | 7,872 |
| 1897 | 403.8 | 132.4 | 271.5 | 138.9 | 46.0 | 184.9 | 86.5 | 13.9 | 17.9 | 31.8 | 54,780 | 10,952 | 8,359 | 22,800 | 2,143 | 7,729 |
| 1902 | 433.0 | 158.4 | 274.6 | 146.5 | 47.8 | 194.3 | 80.3 | 13.0 | 18.2 | 31.2 | 49,141 | 9,605 | 7,798 | 20,943 | 1,940 | 6,601 |
| 1907 | 437.8 | 163.8 | 274.0 | 149.5 | 48.8 | 198.3 | 75.8 | 12.9 | 17.8 | 30.7 | 45,034 | 8,157 | 6,758 | 19,932 | 1,731 | 6,083 |
| 1912 | 442.1 | 168.7 | 273.4 | 149.7 | 50.9 | 200.6 | 72.8 | 9.7 | 16.8 | 26.5 | 46,245 | 8,391 | 7,234 | 20,496 | 1,590 | 5,980 |
| 1917 | 440.5 | 165.9 | 274.7 | 150.6 | 50.9 | 201.6 | 73.1 | 8.1 | 16.4 | 24.6 | 48,540 | 10,399 | 5,620 | 23,185 | 1,992 | 4,818 |
| 1922 | 442.9 | 182.7 | 260.2 | 140.0 | 50.5 | 190.5 | 69.8 | 9.1 | 17.6 | 26.7 | 43,009 | 8,333 | 4,363 | 19,533 | 1,420 | 4,656 |
| 1927 | 446.7 | 188.4 | 258.3 | 144.8 | 51.0 | 195.8 | 62.5 | 8.7 | 17.6 | 26.3 | 36,219 | 6,002 | 2,727 | 17,511 | 1,263 | 3,978 |
| 1932 | 450.4 | 192.3 | 258.1 | 147.9 | 51.4 | 199.3 | 58.8 | 9.7 | 17.8 | 27.5 | 31,328 | 4,385 | 1,978 | 15,780 | 1,112 | 3,643 |
| 1937 | 452.0 | 195.1 | 256.9 | 150.3 | 52.0 | 202.3 | 54.7 | 8.4 | 17.4 | 25.8 | 28,826 | 3,949 | 1,658 | 14,617 | 963 | 2,551 |
| 1942 | 459.0 | 204.9 | 254.1 | 119.1 | 38.2 | 157.3 | 96.8 | 7.5 | 18.8 | 26.3 | 70,555 | 9,969 | 4,694 | 29,109 | 3,498 | 3,346 |
| 1947 | 462.6 | 209.1 | 253.5 | 113.4 | 35.2 | 148.6 | 103.9 | 19.3 | 27.0 | 46.3 | 57,608 | 5,449 | 4,832 | 23,055 | 3,558 | 2,653 |
| 1952 | 458.5 | 206.7 | 251.8 | 123.0 | 35.8 | 158.7 | 93.1 | 14.2 | 27.2 | 41.4 | 51,426 | 5,237 | 2,768 | 16,831 | 1,625 | 1,866 |
| 1957 | 454.7 | 198.6 | 256.1 | 135.0 | 36.4 | 171.3 | 84.7 | 19.7 | 29.0 | 48.7 | 35,887 | 3,522 | 2,060 | 13,233 | 848 | 1,327 |
| 1962 | 451.0 | 186.9 | 264.1 | 146.4 | 38.0 | 184.4 | 79.7 | 21.8 | 28.6 | 50.3 | 29,237 | 2,695 | 4,399 | 10,350 | 520 | 1,013 |
| 1967 | 451.1 | 181.7 | 269.4 | 156.4 | 39.2 | 195.6 | 73.8 | 21.7 | 25.1 | 46.9 | 26,824 | 2,723 | 9,565 | 6,225 | 354 | 1,222 |
| 1972 | 449.5 | 173.6 | 270.6 | 164.8 | 38.1 | 202.9 | 67.7 | 25.3 | 20.1 | 45.4 | 21,798 | 2,190 | 8,237 | 3,765 | 217 | 1,032 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

Radnorshire 1867 to 1972

Digest of Welsh Historical Statistics 1700-1974, (http://new.wales.gov.uk/topics/statistics/publications/dwhs1700-1974/?lang=en)

| June | Total Farming Area | Rough Grazings | Total Cultivated Area | For Grazing | For Hay | Total | Total Arable | For Grazing | For Hay | Total | Total | Wheat | Barley | Oats | Potatoes | Turnips & Swedes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1867 | | | 135.2 | | | 91.1 | 44.1 | | | 9.7 | 34,403 | 7,090 | 4,863 | 11,760 | 1,426 | 6,280 |
| 1872 | | | 150.0 | 79.3 | 18.6 | 97.9 | 52.0 | 6.4 | 8.9 | 15.3 | 36,736 | 7,689 | 5,302 | 12,678 | 1,454 | 6,734 |
| 1877 | | | 155.0 | 83.5 | 20.5 | 103.9 | 51.1 | 6.6 | 10.8 | 17.4 | 33,669 | 6,803 | 4,675 | 12,067 | 1,504 | 6,399 |
| 1882 | | | 156.4 | .. | .. | 111.5 | 44.9 | .. | .. | 12.5 | 32,333 | 6,407 | 4,196 | 12,289 | 1,212 | 5,536 |
| 1887 | | | 159.4 | 91.6 | 24.6 | 116.2 | 43.3 | 6.6 | 7.1 | 13.7 | 29,565 | 4,717 | 3,449 | 12,820 | 1,083 | 5,776 |
| 1892 | 274.2 | 106.3 | 167.9 | 102.7 | 24.4 | 127.0 | 40.0 | 6.6 | 7.1 | 13.6 | 26,382 | 3,453 | 3,663 | 12,249 | 973 | 5,723 |
| 1897 | 273.9 | 111.1 | 162.7 | 95.8 | 24.2 | 120.0 | 42.7 | 8.1 | 7.7 | 15.7 | 27,006 | 3,285 | 3,455 | 12,507 | 910 | 5,695 |
| 1902 | 287.4 | 124.4 | 163.0 | 97.1 | 23.5 | 120.6 | 42.4 | 8.8 | 8.4 | 17.2 | 25,180 | 2,879 | 3,455 | 11,566 | 858 | 5,535 |
| 1907 | 290.6 | 128.2 | 162.4 | 96.5 | 25.0 | 121.5 | 40.9 | 8.8 | 8.3 | 17.1 | 23,748 | 2,078 | 3,359 | 11,367 | 734 | 5,456 |
| 1912 | 287.4 | 125.6 | 161.8 | 97.3 | 25.2 | 122.5 | 39.2 | 7.0 | 7.9 | 14.9 | 24,307 | 2,187 | 3,769 | 11,583 | 688 | 5,153 |
| 1917 | 282.8 | 121.2 | 161.6 | 96.5 | 25.6 | 122.1 | 39.4 | 6.4 | 8.4 | 14.8 | 24,647 | 3,428 | 3,129 | 11,869 | 840 | 4,545 |
| 1922 | 278.1 | 121.4 | 156.7 | 94.1 | 24.0 | 118.1 | 38.6 | 6.9 | 9.2 | 16.1 | 22,444 | 1,737 | 2,364 | 11,653 | 647 | 4,673 |
| 1927 | 283.2 | 127.5 | 155.7 | 94.4 | 24.2 | 118.6 | 37.0 | 7.7 | 9.5 | 17.2 | 19,760 | 1,058 | 1,456 | 10,659 | 566 | 4,533 |
| 1932 | 283.1 | 128.9 | 154.1 | 93.4 | 24.3 | 117.7 | 36.5 | 8.2 | 9.8 | 18.0 | 18,450 | 690 | 854 | 10,656 | 496 | 4,279 |
| 1937 | 282.1 | 128.7 | 153.4 | 90.9 | 24.6 | 115.5 | 37.8 | 9.2 | 10.6 | 19.8 | 18,078 | 732 | 573 | 10,553 | 483 | 3,701 |
| 1942 | 280.7 | 136.4 | 144.3 | 69.5 | 19.5 | 89.0 | 55.2 | 5.6 | 9.3 | 14.9 | 40,395 | 3,278 | 2,617 | 22,800 | 1,754 | 4,685 |
| 1947 | 280.9 | 139.8 | 141.0 | 61.5 | 16.4 | 77.8 | 62.8 | 14.4 | 15.1 | 29.5 | 33,361 | 2 | 3,053 | 15,958 | 1,895 | 4,162 |
| 1952 | 272.0 | 128.7 | 143.3 | 63.0 | 16.0 | 79.0 | 64.3 | 15.1 | 16.4 | 31.5 | 32,770 | 1,742 | 2,165 | 14,452 | 1,010 | 4,067 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1957 | 270.9 | 121.3 | 149.7 | 69.3 | 16.5 | 85.8 | 63.8 | 20.6 | 17.2 | 37.7 | 26,054 | 1,160 | 1,339 | 10,888 | 577 | 3,861 |
| 1962 | 271.6 | 116.0 | 155.7 | 71.1 | 16.3 | 87.4 | 68.3 | 25.7 | 18.7 | 44.5 | 23,683 | 938 | 1,278 | 10,231 | 445 | 3,396 |
| 1967 | 276.1 | 115.1 | 161.1 | 78.5 | 17.8 | 96.3 | 64.8 | 23.9 | 18.9 | 42.8 | 21,851 | 851 | 3,425 | 7,502 | 393 | 3,079 |
| 1972 | 276.9 | 108.9 | 164.6 | 86.3 | 19.3 | 105.5 | 59.1 | 25.1 | 15.8 | 41.0 | 17,443 | 1,124 | 3,447 | 4,979 | 357 | 2,277 |

**Brecon 1867 to 1972** Digest of Welsh Historical Statistics 1700-1974, (http://new.wales.gov.uk/topics/statistics/publications/dwhs1700-1974/?lang=en)

Brecon 1867 to 1972

| June | Total Farming Area | Rough Grazings | Total Cultivated Area | For Grazing | For Hay | Total | Total Arable | For Grazing | For Hay | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1867 | | | 173.8 | .. | .. | 109.1 | 64.7 | | | 17.9 |
| 1872 | | | 189.9 | 86.2 | 28.3 | 114.5 | 75.4 | 12.8 | 13.0 | 25.8 |
| 1877 | | | 196.5 | 98.5 | 31.0 | 129.4 | 67.0 | 12.1 | 11.6 | 23.8 |
| 1882 | | | 202.4 | .. | .. | 140.4 | 62.0 | .. | .. | 20.0 |
| 1887 | | | 205.3 | 107.5 | 39.1 | 146.6 | 58.7 | 12.4 | 8.8 | 21.2 |
| | | | | | | | | 12.0 | 7.1 | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1892 | 400.8 | 199.2 | 201.7 | 113.0 | 37.4 | 150.4 | 51.3 | 11.3 | 8.0 | 19.1 |
| 1897 | 407.4 | 204.1 | 203.2 | 115.7 | 37.3 | 153.0 | 50.2 | 12.4 | 8.4 | 19.3 |
| 1902 | 409.2 | 205.2 | 204.0 | 118.7 | 37.0 | 155.8 | 48.2 | 11.1 | 7.2 | 20.8 |
| 1907 | 418.6 | 214.5 | 204.1 | 123.5 | 38.3 | 161.8 | 42.2 | 8.8 | 6.3 | 18.2 |
| 1912 | 419.1 | 218.6 | 200.5 | 122.6 | 39.1 | 161.7 | 38.8 | | | 15.1 |
| | | | | | | | | 7.9 | 5.9 | |
| 1917 | 439.3 | 243.0 | 196.3 | 115.4 | 40.5 | 155.9 | 40.4 | 9.1 | 6.4 | 13.8 |
| 1922 | 393.4 | 213.2 | 180.2 | 107.4 | 35.3 | 142.7 | 37.6 | 9.6 | 6.5 | 15.5 |
| 1927 | 394.2 | 217.7 | 176.6 | 105.9 | 35.6 | 141.5 | 35.1 | 10.7 | 6.6 | 16.1 |
| 1932 | 464.9 | 292.9 | 172.0 | 101.2 | 35.9 | 137.1 | 34.9 | 9.9 | 6.3 | 17.3 |
| 1937 | 464.7 | 294.8 | 169.9 | 101.0 | 36.0 | 137.0 | 33.0 | | | 16.2 |
| | | | | | | | | 7.5 | 5.5 | |
| 1942 | 410.3 | 255.6 | 154.7 | 69.2 | 26.6 | 95.8 | 58.9 | 18.8 | 11.7 | 13.1 |
| 1947 | 403.1 | 251.7 | 151.4 | 59.0 | 23.1 | 82.0 | 69.1 | 19.5 | 12.2 | 30.5 |
| 1952 | 430.0 | 275.3 | 154.7 | 65.9 | 24.6 | 90.6 | 64.1 | 21.0 | 12.2 | 31.7 |
| 1957 | 420.7 | 259.6 | 161.1 | 78.9 | 24.2 | 103.1 | 58.0 | 23.4 | 13.3 | 33.2 |
| 1962 | 412.6 | 250.4 | 162.2 | 79.0 | 24.5 | 103.4 | 58.8 | | | 36.7 |
| | | | | | | | | 22.0 | 12.9 | |
| 1967 | 409.2 | 243.3 | 165.9 | 84.7 | 25.0 | 109.7 | 56.2 | 25.2 | 10.9 | 34.9 |
| 1972 | 401.7 | 231.7 | 165.7 | 86.3 | 24.5 | 110.8 | 54.9 | | | 36.1 |

## Calorific values of selected foods

*Calories per 100g (3.5oz approx)*

| **Dairy Produce** | |
|---|---|
| Butter | 770 |
| Cheese (Cheddar) | 420 |
| Cheese (cottage) | 83 |
| Cheese (cream) | 800 |
| Cheese (processed) | 350 |
| Cream (double) | 460 |
| Cream (single) | 200 |
| Eggs (fried) | 239 |
| Eggs (poached) | 160 |
| Milk (whole) | 66 |
| Milk (condensed) | 320 |
| Milk (dried) | 500 |
| Milk (skimmed) | 35 |
| Yoghurt (natural) | 54 |

| **Cereal foods** | |
|---|---|
| Barley (boiled) | 120 |
| Biscuits (plain) | 430 |
| Bran | 311 |
| Bread (white) | 243 |
| Bread (wholemeal) | 228 |
| Cornflakes | 364 |
| Cornflower | 350 |
| Custard powder | 350 |
| Flour (white) | 349 |
| Flour (wholemeal) | 333 |
| Macaroni (boiled) | 112 |
| Oatmeal porridge | 45 |
| Rice (boiled) | 122 |
| Sago (raw) | 355 |
| Semolina (raw) | 350 |
| Tapioca | 357 |

| **Meat and Poultry** | |
|---|---|
| Bacon (Back) | 600 |
| Bacon (streaky) | 530 |
| Beef (corned) | 230 |

*Calories per 100g (3.5oz approx)*

| **Fish** | |
|---|---|
| Cod (fried) | 140 |
| Cod (steamed) | 82 |
| Haddock (fried) | 175 |
| Haddock (steamed) | 100 |
| Halibut (steamed) | 130 |
| Herring (fried) | 235 |
| Kipper (baked) | 200 |
| Plaice (fried) | 234 |
| Salmon (steamed) | 200 |
| Salmon (tinned) | 137 |
| Sardines (tinned) | 294 |
| Sole (fried) | 274 |
| Sole (steamed) | 84 |
| Turbot (steamed) | 100 |
| Whiting (fried) | 193 |

| **Vegetables** | |
|---|---|
| Asparagus (boiled) | 18 |
| Beans (baked) | 90 |
| Beans (broad) | 42 |
| Beans (butter) | 90 |
| Beans (runner) | 7 |
| Broccoli (boiled) | 14 |
| Brussell sprouts (boiled) | 17 |
| Cabbage (boiled) | 10 |
| Carrots (boiled) | 17 |
| Cauliflower (boiled) | 10 |
| Celery (raw) | 6 |
| Cucumber (raw) | 10 |
| Leeks (boiled) | 24 |
| Lentils (boiled) | 96 |
| Lettuce (raw) | 10 |
| Marrow (boiled) | 7 |
| Mushrooms (fried) | 217 |
| Onions (fried) | 355 |
| Onions (raw) | 23 |
| Parsley (raw) | 21 |

*Calories per 100g (3.5oz approx)*

| **Fruit** | |
|---|---|
| Apple (raw) | 47 |
| Apricot (raw) | 28 |
| Banana (raw) | 77 |
| Blackberries (raw) | 30 |
| Blackberries (stewed, no sugar) | 13 |
| Blackcurrant (raw) | 29 |
| Blackcurrant (stewed, no sugar) | 22 |
| Cherries (raw) | 47 |
| Dates (peeled) | 248 |
| Figs (dried) | 214 |
| Figs (raw) | 35 |
| Gooseberries (raw) | 18 |
| Grapes (raw) | 60 |
| Grapefruit (raw) | 22 |
| Lemon (peeled) | 17 |
| Mandarines (peeled) | 33 |
| Mandarines (tinned) | 64 |
| Oranges (peeled) | 35 |
| Peach (raw) | 37 |
| Pear (raw) | 42 |
| Pineapple (tinned) | 63 |
| Plums (raw) | 35 |
| Plums (stewed, no sugar) | 22 |
| Prunes (dried) | 140 |
| Prunes (stewed, no sugar) | 81 |
| Raisins (dried) | 247 |
| Raspberries (raw) | 25 |
| Rhubarb (stewed, no sugar) | 5 |
| Strawberries (raw) | 26 |
| Tangerines (peeled) | 34 |

| **Nuts** | |
|---|---|
| Almonds (shelled) | 598 |
| Brazils (shelled) | 644 |

| | | | | | |
|---|---|---|---|---|---|
| Beef surloin (roast) | 385 | Parsnips (boiled) | 56 | Chestnuts (shelled) | 172 |
| Beef steak (grilled) | 300 | Peas, fresh (boiled) | 49 | Cobnuts (shelled) | 398 |
| Chicken (boiled) | 203 | Peas (tinned) | 84 | Peanuts (shelled) | 603 |
| Chicken (roast) | 190 | Potatoes (boiled) | 80 | Walnuts (shelled) | 549 |
| Duck (roast) | 315 | Potatoes (crisps) | 560 | | |
| Ham, lean (boiled) | 210 | Potatoes (fried) | 245 | **Miscellaneous** | |
| Kidney (fried) | 210 | Potatoes (roast) | 123 | Chocolate | 590 |
| Liver (fried) | 250 | Radishes (raw) | 14 | Honey | 280 |
| Mutton (roast) | 280 | Spinach (boiled) | 24 | Jam | 260 |
| Mutton (stewed) | 315 | Swedes (boiled) | 17 | Lard | 910 |
| Pork (roast) | 455 | Tomato (raw) | 14 | Margarine | 800 |
| Rabbit (stewed) | 180 | Turnips (boiled) | 14 | Marmalade | 260 |
| Sausage, beef (fried) | 280 | Watercress (raw) | 12 | Sugar | 390 |
| Sausage, pork (fried) | 326 | | | Syrup | 300 |
| Sweetbreads (stewed) | 180 | **Alcohol** | | | |
| Veal (roast) | 232 | Beer | 28 | | |
| | | Spirits | 220 | | |
| | | Wines | 70 | | |