Environmental Management of Outdoor Pigs for Protein, Plough and Pest Control

A report for

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Executive Summary

In the 21st century the environment is at the forefront of decision making with the worldôs resources becoming increasingly depleted and with the demand on those resources increasing daily, we need to be constantly looking out for alternative methods of maintaining our soil fertility and even regenerating soil that has been depleted of life.

Pigs have the ability to do this. A combination of manure and rooting activity combined with periods of vegetative growth and cropping slowly brings back life to dead soils.

Consumers are pushing for a higher welfare pork product and as a result there is an opportunity to develop farming systems that use the full potential of the pig in a way that fulfils the consumerôs desire for higher welfare and at the same time provides added benefits to the farm.

Combining pig production with various types of cropping can increase the value of the crop by increasing the soil biology and available nutrients with fewer inputs and the ability the pigs have to break the cycle of pests and disease.

The benefits of outdoor pig production can be quickly lost if the production system is not managed correctly. If pigs are not rotated adequately or kept on unsuitable land there is potential for greater damage than good.

Outdoor pig production will never equal the efficiency of confinement pigs but the total benefits, including the benefits to cropping through weed suppression, increased organic matter and the availability of nutrients, can be greater than the industry realises.

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Foreword

Twelve years ago my wife Sue and I took over the lease on the family farm. We had inherited the remains of a rundown citrus orchard on the banks of the Hawkesbury River west of Sydney, where old-school farming practices had left the soil stripped of nutrients and organic material. The soil type could be summed up in a single word - ñsandò. There was little soil structure left after almost a century of ploughing as a method of weed suppression within the orchard. After deciding very quickly there was no future in the citrus, we set out to diversify into gourmet potatoes and other organic seasonal vegetables which were marketed directly into Sydney. Several seasons of potatoes had passed and we found there were more residual potatoes growing from the previous crops than we had planted. As our paddocks were now certified organic there was no opportunity to use chemical herbicide to remove the residual potatoes and the problem was getting worse.

It was because of this potato problem that we got our first few pigs. The intention was that they would be released into the paddocks after harvest to find and remove any left-over potatoes. It was estimated as much as 20% of the crop would be discarded during harvest which meant a possible three tonnes of potatoes per hectare would now have to be eaten by pigs. In the first season, the pigs did an incredible job and basically solved our residual potato problem.

After only a few short years our pig herd had grown to a point where we could market free range pork directly to butcher shops and restaurants within the Sydney Basin. Pork very quickly became the focus of our business and potatoes became a secondary crop.

At the same time, there was disagreement throughout the industry on how to best manage the environmental aspects of free range pigs and how far best practice management should go. With that in mind and after observing an increase in soil fertility and weed suppression after each rotation of pigs, it was evident that there was more to be gained from outdoor pigs than merely consumers of old potatoes. It was also evident that unless we managed these pigs very carefully they had the potential to do more harm than good.

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- my wife Sue who took care of the farm while I was gone, without you I would never have been able to go on this amazing journey.

Thank You

Abbreviations

Kg/hd/yré é é é ...kilograms per head per year.

Haé é é é é é .hectare

NPKé é é é é ..nitrogen, phosphorus, potassium

Kgé é é é é é .kilograms

N é é é é é é ..nitrogen

SPUé é é é é ...standard pig unit

Objectives

The main objectives for this study were to investigate:

- The potential for outdoor pigs to be used as a tool for regenerating depleted agricultural land.
- The importance of natural organic manure in revitalising soil biology.
- The relationship between outdoor pig activity and its impact on weed and disease burden and the benefits to rotational cropping.
- Minimising the environmental risk associated with an outdoor operation.
- Value adding to an outdoor pig operation.

Introduction

There is no other farmed animal, plant or fish that generates as much emotion and ignorance as the modern commercial pig. The worldôs need for cheap protein, coupled with the farmers need to remain profitable and productive and societiesô need for food safety has pushed a once entirely outdoor product to become more intensive, productive and efficient. Now in the 21st century, we see the need for individual consumers to feel morally responsible for the food they eat. As a result, many variations of what was once a standard method of pork production have resurfaced, creating niche markets with products which generally earn a premium for what is seen as a high welfare, environmentally sustainable product. But is it?

In a world running out of space, particularly good arable land, and a limit to grain production yet increasingly more mouths to feed, can we return to a method of raising pigs that is generally less productively efficient and potentially even harmful to the very environment we seek to protect? On the other hand, can we afford to continue down the path of excessive use of chemicals, antibiotics, growth promoters and an increasing reliance on grain production which could be used to feed the growing population?

Pigs were traditionally seen by farmers as a way to convert farm by-products into a saleable product. Although unproductive and inefficient, compared to the modern pig they were cheap to keep and useful for things other than protein. In fact, pigs were seen as an integrated part of the farm and not just a single commodity. Although agriculture has progressed since then, there is still an opportunity to explore the potential to utilise outdoor pigs, their manure and natural behaviours to improve the fertility and the productivity of degraded land through an increase in soil fertility stemming directly from the activity of pigs.

The modern outdoor piggery

The modern rotational outdoor piggery has moved forward a long way since the day of housing sows in small pens (sties) for an indefinite length of time. The pigsty of old was a disgusting place, smelly and muddy; pigs were fed a traditional feed of scraps, whatever was left over on the farm.

Today outdoor piggeries are made up of movable hutches and shelters; feeders and watering points are also often movable. With advances in vaccines and parasite control outdoor pig herds can have as good or even better health status than indoor herds.

There are many benefits to farm pigs outdoors but there are also many negatives associated with outdoor production.

The benefits of free ranging pigs are:

1. Cheaper setup costs for the pig-farming enterprise.
2. An increase in soil biological activity.
3. Provide an increase in soil fertility which could be particularly valuable in third world agricultural systems.
4. Assist in the removal of some soil weeds and pests.
5. Increase in overall crop yields.
6. Potential to use pigs as a way to regenerate overcropped land.
7. Decrease feed costs for pigs.
8. Open new marketing opportunities.

Negative effects of free ranging pigs:

1. Growing pigs experience a decrease in feed conversion and overall efficiency.
2. A very real potential for environmental degradation.
3. An increase in labour cost.
4. The land required is much greater.
5. Piggery staff are required to work in all weather conditions.

Using pigs to regenerate depleted land

For thousands of years pigs have been kept as a paddock animal much the same as sheep and cattle, although they may have been brought inside to farrow before being let out again into pasture. In the age of hand tools a farmer would have been more than happy to have a herd of sows partly turn over his soil. This natural behaviour has never been fully bred out of the modern pig and even within modern genetics the desire to root and dig with the snout still exists. You cannot ignore this behaviour and left unmanaged can be very destructive. The only thing left to do is put this behaviour to good use.

Rooting and Digging

Many farmers around the world are now making use of this instinct to partially prepare a paddock for planting. Sows or gilts are best used for this job; gilts in particular have the strength and youthfulness to be very active diggers. Gestating sows are also well suited to digging and many farmers run small groups of 20 sows/ha over their gestational period or until the paddock has been totally turned over. The roots of the weeds are eaten and a substantial amount of manure evenly spread across the paddock. For an organic farmer this is perfect as herbicide and pesticide cannot be used to chemically remove the grass cover. After the sows have done their job of digging they are moved to a fresh paddock. The paddock is finished with a conventional method of ploughing before a crop is planted. After the crop is harvested the sows are placed back in to the paddock to further remove crop residue and generally start the digging process all over. This form of rotation is widely accepted and practiced within the organic community as a valuable means of removing excessive ground cover, adding manure to the soil and cleaning up crop residue. It has also been noted by these farmers that the disease and pest burden within the paddock is considerably lower after a rotation of pigs.

Free-ranging pigs on pasture, (Melanda Park, Australia, 2012)

Using sows in this way should not be seen as merely an organic method and dismissed by conventional farmers. When managed correctly there is a strange beneficial relationship between the soil and the activity of pigs. This could be due to the stimulation of soil microbes feeding off the manure and other organic material that is being constantly turned over by the pigs. There is no scientific evidence to back up this claim but the proof is in the soil and the changes the farmers have seen over several years.

"The rooting action of the pigs constantly turning the soil over does not destroy soil structure like a mechanical plough would".

Chris Walton from Peelham Farm, U.K., believes this is probably due to the fact that rooting is slow and carried out over several weeks as opposed to ploughing which is completed in hours.

ñ*It's a bit like a giant compost pile, you turn it weekly and the microbes slowly composts into down."*

- *This picture shows how extensively pigs can dig and remove ground cover. (Peelham Organic Farm, Scotland, 2012)*

Combining green manure crops

A key aspect of regenerating soil is the adding of organic material or humus. This is easily done by growing a green manure crop. Planting green manure crops immediately after the pig phase of the rotation has three benefits:

- Adding organic plant material to the soil
- Breaking down raw manure and converting nutrients making it accessible to plants
- Establishing ground cover.

Adding humus to the soil is vital in regenerating soil. Without humus there is nothing to hold the nutrients released from the manure. Nitrogen in particular is lost very quickly through natural decomposition unless it can bind to the soil particles. Growing a green manure crop can add large amounts of organic material to the soil. Once the crop has reached a set point and before flowering it is simply ploughed and incorporated back into the soil. This again helps to disperse the nutrients from the previous rotation of pigs.

Paddocks should never be left bare during the pig phase. Once the existing ground cover is depleted to minimum level, approximately 30%, the chance of excessive run off increases dramatically (APL National Environmental Guidelines, 2010). Ground cover protects the soil and prevents nutrients leaving the paddock through run off. Green manure crops are a must if the main crop is still way off being planted.

Value-adding green manure crops

Grazing the green manure crop periodically with sheep or cattle several times prior to incorporating it into the soil can also fill seasonal gaps in pasture for other grazing livestock. Oats, ryegrass and clover make excellent green manure; they also make excellent forage crops for winter spring shortfalls. Considering these forage crops can be grown without any additional inputs of fertiliser and can be grazed several times before ploughing and incorporating into the soil, green manure crops can make up a valuable fodder source for other livestock. If cover crops of oats or barley, for example, are managed correctly, hay or straw can be harvested, adding further value to the manure left behind from the pig phase (Honeyman, 2001).

-Grazing sheep or cattle is also helpful in spreading the nutrients around, especially if strip grazing is used and the animals are taken out of the paddock after each feed. This will spread nutrients to paddocks set aside for grazing stock only and not pigs.

Breaking the cycle of weeds and disease

Weed management is an ever increasing problem with chemical resistance growing as fast as new chemicals are developed. The last two decades have seen a trend towards separating animal production and cropping. Where sheep or cattle were once used as part of a rotation between crops, now the reliance on chemicals alone to control in-crop weeds has led to this increase in chemical resistance.

Although not every block of land will be suited for pig production it is safe to say that, where suited, pig production can make an incredible difference to the amount of weeds present in a crop during the growing season. Pigs do favour salad-like broadleaf weeds and younger more palatable grasses like rye, oats, clovers and daisies. The difference between pigs and ruminants is simply the pigs will eat as much below the ground as is available above the ground. Unpalatable weeds like tussock grasses and thistle are still no match for pigs. Where ruminants will not touch them, pigs are happy to root them over and eat the roots whilst killing the weeds and turning the leaf into compost. It has been noted that one of the first weeds a sow will eat upon entering a new paddock, if present, is stinging nettle (Chris Walton, Peelham Farm, 2012).

Example of weed control (Castle Mine Farm, Ireland, September 2012)

This photo shows the ground on the left taken over with invasive iris. On the right of the fence the paddock is clean as the pigs have removed the entire iris. Brendan Allen from Castle Mine Farm in Ireland only farms a small herd of 50 sows, producing free range pork for a niche market within his family-owned butcher shop. The land that the pigs run on is rented from local farmers; it was once valuable productive land with peat-like soil. However, in recent years, the land has fallen out of favour for grazing as it has been taken over with an invasive iris-like weed. Due to the regulations on chemical use and the nature of the weed, farmers have not been able to successfully control the weed with the use of herbicides. The ability of pigs to eat practically anything and the fact that they favoured the tuberous roots proved fatal for the iris and over a short 12 month period the pigs had removed 100% of the weed. Combined with the natural digging behaviour, these paddocks were restored to good grazing land without the use of chemicals. As a result the pig farmer now has other farmers asking him for the use of his pigs.

Maintaining Pasture Cover

If denuding the paddock of vegetation for the benefit of the cropping phase is not the desired outcome and the cropping phase is still a way off, it is then most important to maintain pasture cover. The methods of pig rearing in the past have led to the environmental concerns that we face today. Generally paddocks were over-stocked and the use of a cropping rotation was absent from the system with pigs inhabiting the paddock continually. This led to a rise in diseases and the burden of parasites and environmental problems with increased erosion, nutrient runoff, leaching, and of course, smell. Under no circumstance should the production system be allowed to be managed in this way. These conditions gave outdoor production systems a bad name in the past and were a deciding factor in the industry going indoors.

Buffer Strips

Grass buffer strips can be used as an important tool to slow down water running off the paddock. They also catch sediment acting like a coarse filter. Maintaining the grass buffer strip at the lower end of paddocks is an extremely important feature of good environmental management.

A good example of a grass buffer strip between paddocks (Peelham Organic Farm U.K, 2012)

The benefits of pasture cover are:

- reduces erosion and soil movement, holding nutrients within the paddock and reducing nutrient leaching.
- reduces the overall soil temperature.
- adds fibre to the pigôs diet and in the case of gestating sows can replace 65% of her diets (Honeyman, 1995)
- provides an overall image of good environmental management, which is what the public want to see.
- reduces the severity of parasite infestations.

Public perception

Consumers are now gaining knowledge of indoor systems leading to a rise in demand for outdoor raised pork. It is also perceived by consumers that there is a higher welfare associated with outdoor pigs and that outdoor production systems, or ñfree rangeò, are pasture based and that the pigs have access to pasture of some description at all times. Discounting the environmental benefits of pasture, the public perception alone requires it and as they are paying a premium for the product, it is without doubt of significant importance to maintain pasture cover.

In the market place, the consumer does not rely solely on science to determine what is environmentally or humanely right.
In the words of Lori Lyon, field operations manager, Niman Ranch, U.S.A.,

"Perception is nine tenths of the truth."

Nose Rings

The use of nose rings is controversial from a welfare point of view. They restrict the sowôs ability to dig as they cause pain to the nose. As the sow roots with her nose the ring is pulled causing pain and discomfort. From an environmental management point of view nose ringing could be a valuable tool for maintaining pasture.

As pasture has proven to be valuable for both the sow and the environment it may be more important to maintain pasture than to give the sow 100% liberty in exhibiting natural behaviour, remembering that grazing pasture is also a very natural behaviour for pigs. The use of nose rings is controversial especially amongst welfare activists and if outdoor pigs become more common in Australia, nose ringing could become an issue for activists.

Whatever the welfare argument is, the nose ring does reduce the sowôs ability to root and therefore provides many benefits associated with increased pasture. Increasing the life of the pasture can also increase the time between rotations. With or without the use of a nose ring, once there is only 30% pasture cover it is time to rotate.

Picture showing sow with nose ring (BQP, U.K, 2012)

Pasture types

Pasture can be broken into four distinctive groups:

- Running grasses
- Sod forming grasses
- Planted forage
- Weeds

Sod Forming Grasses

Sod forming grasses like tussock and African love grass are generally unpalatable and have very low nutritional value for pigs but withstand grazing much longer. Tussock grasses also provide shelter and material for the sows to gather for bedding, hence allowing them to exhibit natural behaviours.

Running Grasses

Fast growing running grasses like couch and kikuyu are great for being able to grow back as fast as the pigs can uproot them. They hold light soils together and even though there is very little nutritional value, catch soil particles during rain and give a visually appealing ñgreen lookò.

Planted Forage

Tall cropping grasses such as sorghum and millet or even maize are extremely beneficial in providing shelter during the hot months. The temperature at ground level of a 2 metre high crop of sorghum can be 10 degrees Celsius cooler than the outside temperature. Planted forage pastures like lucerne or winter oats can also make up a considerable portion of the sowôs diet. Even young pigs will eat vast amounts of rye grass, barley or oats.

Weeds

Weeds that grow back after harvest or in a paddock left fallow are quite often great for pigs. Pigs will quite often eat weeds that sheep and cattle are reluctant to eat and if they do not eat them, they will root them up and eat their roots or make nests out of them. As long as the weeds are not poisonous there is no reason pigs should not eat it.

Weaner pigs in a sorghum crop, grown for sun protection (Melanda Park free range pork, 2012)

Increasing Soil Fertility

Manure is a valuable fertiliser for any farming operation and has been used for centuries to supply needed nutrients for crop growth. The use of manure has generally declined on many farms over the past 50 years due to farm specialisation with increasing separation of crop and livestock production. This is also due to the cost of transporting manure, which is bulky, and a relatively low analysis nutrient content compared to synthetic fertilisers which are increasingly available and can provide a cheaper source per unit of nutrients than manure. On the other hand, manure produced on farm by rotationally grazed pigs requires no transport and little spreading and pig manure contains higher amounts of nitrogen, phosphorus and potassium (NPK) than most other farmed animals.

Manure not only supplies many nutrients for crop production, including micronutrients, but it also is a valuable source of organic matter. Increasing soil organic matter:

- Improves soil structure
- Increases the water-holding capacity of coarse-textured sandy soils
- Improves drainage in fine-textured clay soils

- Provides a source of slow release nutrients
- Reduces wind and water erosion
- Promotes growth of earthworms and other beneficial soil organisms.

Soil Type

Light, well-drained and sandy soil is considered a must for outdoor pig production. The soil needs to drain freely to avoid water pooling and large areas of mud developing, making it difficult for both the farmer and the pig. Lighter sandier soils are also generally less fertile with less organic material. These soil types tend to be marginal land producing low yields and requiring greater amounts of fertiliser. On these soils, if managed correctly, outdoor pig production can have a significant positive impact on the soil fertility by increasing available nutrients, organic matter and soil structure.

In the U.K, where units of 2,000-plus outdoor sows have been common for the past 20 years, a vast improvement in soil structure and yield has been seen on this lighter soil. It is not only the volume of NPK coming from the manure that makes the difference, it has been noted by at least two farms, Wrights of Brettenham and Peelham Farm, Berwickshire, that raw pig manure contains organic matter and promotes the growth and spread of soil organisms. Over time, combined with a cropping phase, the microorganisms turn organic material into soil, building structure and fertility; the pigs provide the nutrient base and the plants, during the cropping phase, provide even more organic material. The affects have been slightly different than those seen after spreading confinement pig slurry alone. Although confinement slurry is also excellent fertiliser, in an outdoor system it is the pigs constantly turning the soil over, spreading manure and aerating the soil that seems to make the difference. Much fewer weeds are present in the following crop as a result of outdoor pig activity (Richard Wright, 2012).

If pigs are left in the same paddock for extended periods it can become detrimental as pigs stop digging and soil compaction occurs. Once the paddock becomes totally denuded of vegetation and soil compaction occurs, the chance of nutrient run off with heavy rain increases. This should be avoided at all cost.

In England, the continual benefits and improvements from rotating pigs with cereal crops have proven so beneficial that arable farmers working marginal land now work closely with pig farmers or alternatively, manage their own outdoor pig herd.

Richard Wright (2012), principal of Wright Produce Ltd, U.K, stated ñ*we started in pigs in the 1960's and now run 3,600 sows; the pigs make us money but it's the value of the manure that keeps us in pigs. They have made a tremendous difference to the sandy soils here."*

Working with Arable farmers

A benefit of outdoor production compared with indoor production is the cost of setting up a piggery. One of the biggest hurdles preventing young farmers getting started in pigs is the cost of setting up sheds and feed systems in an intensive system. The cost of land is also a hindrance.

Setting up an outdoor herd of sows can be much cheaper with minimal set up costs as the need for infrastructure is considerably less. There is an opportunity to work closely with arable farmers to lease land and rotate the production unit with arable crops. This provides added nutrient benefits to the arable farmer while giving the pig producer an opportunity to access land. Combining the cheaper set-up cost and access to land through leasing could give a young would be pig farmer a foot in the door.

Consideration has to be given though to the fact that outdoor pig production can be more labour intensive and less productive than intensive indoor production. Although in the current market, outdoor free range pigs fetch a premium in the market place and that premium can offset the extra cost due to inefficiencies in labour and production.

A thousand sow outdoor breeding unit set up on leased land.
(BQP, Environmental Project, U.K, 2012)

Managing Manure and Nutrient Build Up

Managing Wallows

During summer, wallows are essential for keeping the pigs cool. Pigs will roll in the wallow coating themselves in water and mud to regulate their body temperature. Pigs do not sweat, therefore, once the temperature rises above 22 degrees Celsius pigs will look for water to wallow in. If there is no designated wallow available pigs will make one, spilling water from water bowls or breaking taps and pipes to make their own. Without a means of cooling down pigs will be overcome by heat exhaustion on hot days. Heat stress causes sunburn, a decrease in fertility and in extreme cases death.

A wallow need only be centimetres deep; pigs do not need to swim in deep water. A small depression in the ground filled with water will do. The pigs will root up the soil and turn it into mud. This behaviour leads to the small depression growing and over time can turn into a large spreading hole which will need to be filled with outside soil before rehabilitation can occur. Pigs will also readily urinate in the wallow, therefore, wallows can become nutrient hot spots and leaching can occur. Water can become putrid and diseased quickly, spreading diseases like Leptospirosis. Sows can also contract infections from the foul water decreasing fertility and increasing cases of scours.

Tips for good wallow management:

- Move wallows regularly, at least every summer.
- Rip, plough, and fill old wallows to prevent further water pooling.
- Allow wallows to dry up so that water can be replaced.
- Wallows should be placed in a suitable location, away from trees and fences and with clay soil that prevent leaching.

Wallowing pig (Melanda Park, Australia, 2012)

Stocking Density

The stocking density and duration of the rotation can make all the difference when trying to prevent environmental degradation and nutrient overloading. Too many animals in one place will denude the paddock too quickly and give rise to parasites and disease. On the other side of the equation, insufficient stocking rates will fail to remove sufficient weeds and will not provide enough manure to make a difference during the cropping phase. Insufficient stocking rates will also make the production system more expensive. Most outdoor piggery standards around the world set the stocking density at around 25 dry sows to the hectare and 14 lactating sows with piglets per hectare, on a two- year rotation.

The Defra U.K Code of Recommendations for the Welfare of Livestock - Pigs (2003) states the following:

"Field stocking densities must reflect the suitability of the site and the system of management. A guideline of 25 sows per hectare overall is reasonable for suitable sites. You may need to reduce stocking densities on less ideal sites or in extreme circumstances during periods of adverse weather".

In the opinion of many arable farmers and piggery industry professionals the rotation should be no more than 12 months, and they generally recommend that the paddocks are rotated to fit the cropping stage. For example, 12 months for a cereal, and 6 months for vegetable crops. This would greatly assist with nutrient management. Either way, the stocking density really needs to be set according to the land and soil capabilities. Other factors like rainfall or irrigation will also change the duration of the rotation and stocking density.

The paddock above may not be over stocked but it has clearly not been rotated for some time. (U.K, 2012)

A well organised outdoor system will have sufficient room to reduce stocking density or spread sows out in extremes of weather, like excessive rainfall events or droughts. Then intensify stock back to normal rates at times when conditions are good and pasture is growing or just prior to cropping when ground cover needs to be removed or an increase in manure is required for cropping (Defra Pigs, 2003).

Calculating manure output

A Standard Pig Unit (SPU) is a unit of measurement for determining the size of a pig production enterprise in terms of its waste output. One SPU produces an amount of volatile solids (VS) equivalent to that produced by an average size grower pig (approximately 40 kg). **Table 1 below, gives the SPU equivalent for all classes of pigs.**

Pig classification	Mass range (kg)	Age range (weeks)	SPU multiplier
Gilt	100-160	24-30	1.8
Boar	100-250	24-128	1.6
Gestating sow	160-230	-	1.6
Lactating sow	160-230	-	2.5
Sucker	1.4-8	0-4	0.1
Weaner	8-25	4-10	0.5
Grower	24-55	10-16	1.0

(Table 1, National environmental guidelines for piggeries, APL, 2010)

The quantity of total solids produced each year and its nutrient value is shown in Table 2 below. The figures are an approximate only and based on data from conventional shed pigs on a typical diet. To realise the true value of NPK the manure from each site and stage of pig should be independently tested. The environment, feed and genetics can all play a part in changing the total VS produced and the equivalent NPK value.

One SPU produces approximately 90kg of solids per year.

Table 2 below shows the total solids and nutrients produced by each class of pig (kg/hd/yr)

Pig class	Total Solids	Volatile Solids	Nitrogen	Phosphorus	Potassium
Gilts	197	162	12	4.6	4
Boars	186	151	15	5.3	3.8
Gestating sows	186	151	13.9	5.2	3.7
Sow & Litter	442	325	50	13	11
Lactating sows	310	215	27.1	8.8	9.8
Suckers	11.2	11	2.3	0.4	0.1
Weaner pig	54	47	3.9	1.1	1.1
Grower pig	108	90	9.2	3.0	2.4
Finisher pig	181	149	15.8	5.1	4.1

(Table 2, National Environmental Guidelines for Piggeries, APL, 2010)

Some nitrogen will be lost to ammonia volatilisation and further testing of dried outdoor pig manure would be beneficial in ascertaining the true value of nitrogen, but most environmental guidelines suggest a loss of 20% is likely (APL National Guidelines for Piggeries, 2010, New Zealand Animal Welfare (pigs), 2010).

Plant Available Nitrogen

Not all of the nitrogen in pig manure is available immediately for plant use. The nitrogen that is available is called plant available nitrogen. Nitrogen can be present in manure as:

- Ammonium nitrogen
- Organic nitrogen
- Nitrate nitrogen

Ammonium Nitrogen and Volatilisation Losses

A large portion of the nitrogen in pig manure is in the form of ammonium ions. Ammonium ions are charged ions which result from the solution of ammonia in water dissolved in the soil (water soluble) and are readily used by plants. Ammonia is a gas and is not significantly used by plants. Ammonium and ammonia can interchange rapidly depending on the pH. Ammonium will convert to ammonia gas at a pH greater than 6.5. Ammonia gas can be readily lost to the air by volatilisation. Volatilisation losses can occur from the surface of the manure whenever it is exposed to air. As outdoor pig manure can sit on the surface of the paddock for some time before incorporation, large amount of ammonia can be lost to the atmosphere, especially at temperatures above 25 degrees Celsius. Therefore, it is important to have a representative sample of the manure analysed to properly ascertain the true concentration of nitrogen in the soil. Incorporation of the manure into the soil as soon as possible will help reduce the amount lost through volatilisation.

Ammonium nitrogen does not leach from the soil because it binds strongly to soil particles. However, it typically converts in the soil to nitrate nitrogen which leaches easily from the soil.

Organic Nitrogen and Mineralisation

Organic nitrogen is the most abundant form of nitrogen in animal manure. Organic nitrogen is not readily available to plants until it has been broken down by microbes to ammonium. The process of converting organic nitrogen to ammonium is called mineralisation. This process does not occur immediately. Hence, the term slow-release nitrogen because the organic N is made available over time and not all at once. The amount of organic nitrogen that is available during the first cropping phase is typically 60% (Clemson University, Swine manure production & nutrient content).
Organic nitrogen does not leach from the soil. Erosion is the only way that organic nitrogen can be lost from the soil.

Nitrate Nitrogen

Fresh manure contains little nitrate nitrogen, however, nitrate is the most plant available form of nitrogen. Nearly all the ammonium nitrogen and organic nitrogen will eventually be converted to nitrate in the soil. Nitrate nitrogen is easily lost through leaching.

Minimising Nitrogen Losses

Understanding nitrogen is important if the full benefits are to be seen from using pig manure. In a rotation outdoor piggery the paddocks are typically rotated every two years. This may be convenient for the pig farmer with minimal labour spent moving fencing and equipment to new grounds, but not allow for the full utilisation of the nitrogen in the manure. As nitrogen is lost though volatilisation and leaching by the end of the two year rotation only a portion of the nitrogen would remain.

Incorporation

Incorporation is the term for turning the manure on the ground into the soil. The more often this is done the less nitrogen is lost through volatilisation. If pigs are allowed to dig, a significant portion of the paddock will be turned over by this natural behaviour and the manure naturally turned in, otherwise a mechanical implement can be used. The difficulty lies

with once the pigs have turned over the paddock and denuded it of vegetation the possibility for erosion and soil degradation is enhanced.

Shortening the time taken to rotate the paddock into the cropping phase can solve this problem. The paddock is already turned over so minimal weeds will be present. A 6 to 12 month rotation seems to be optimal for the utilisation of the manure, particularly the nitrogen component. Within this time there has been sufficient manure dropped to make a substantial contribution to the nutrient requirement of the following crop, yet the manure is still reasonably fresh.
Stocking density needs to be managed at this point to provide optimum benefits for weed removal and manure dropping but also provide optimum benefits for the following crop.

Table 3 Nutrient Uptake by Various Crops

Crop	**Dry matter nutrient content (kg/t)**			**Average Yield**	**Average Nutrient Removal (kg/ha)**		
	Nitrogen	*Phosphate*	*Potassium*	*Dry Matter (t/ha)*	*Nitrogen*	*Phosphate*	*Potassium*
Grazed Pasture	20	3	15		7.1 - 19	0.9 ï 2.2	0.1 ï 0.6
Dry Land Pasture (Cut)	20	3	15	1 - 4	20 - 80	3 - 12	15 - 60
Irrigated Pasture (Cut)	20	3	15	8 - 20	160 - 400	24 - 60	120 - 300
Lucerne Hay	31	3	25	5 - 15	155 - 465	15 - 45	125 - 375
Maize Silage	22	3	24	10 - 20	220 - 550	30 - 75	200 - 500
Forage Sorghum	*22*	*3*	*24*	*10 - 20*	220 - 440	30 ï 60	240 - 480

Winter Cereal Hay	20	3	16	10 - 20	200 - 400	30 ï 60	160 - 320
Barley (seed)	19	3	4	2 - 5	38 - 95	6 - 15	8 - 20
Wheat (seed)	19	4	5	2 - 5	38 ï 95	8 ï 20	10 ï 25
Triticale	19	4	6	1.5 - 3	29 ï 57	6 ï 12	9 ï 18
Rice	14	3	4	4 - 8	56 ï 112	12 ï 24	16 ï 32
Oats (seed)	15	3	4	1 - 5	15 ï 75	3 ï 15	4 ï 20
Grain Sorghum	20	3	3	2 - 8	40 ï 160	6 ï 24	6 ï 24
Grain Maize	20	3	4	2 - 8	40 ï 160	6 ï 24	8 ï 32
Chickpea	40	4	4	0.5 - 2	20 ï 80	2 ï 8	2 ï 8
Cowpea	30	4	20	0.5 - 2	15 ï 16	2 ï 8	10 ï 40
Faba Beans	40	4	12	1 ï 3	40 ï 120	4 ï 12	12 ï 36
Lupins	45	3	8	0.5 ï 2	22.5 ï 90	1.5 ï 6	4 ï 16
Navy Bean	40	6	12	0.5 ï 2	22 ï 80	3 ï 12	6 ï 24
Pigeon Peas	26	3	9	0.5 ï 2	13 ï 52	1.5 ï 6	4.5 ï 18
Cotton	20	4	8	2 ï 5	40 - 100	8 - 20	16 ï 40-

(Source: *APL National Environmental Guideline for Piggeries, 2010)*

For example, a one ha paddock containing 24 dry sows on a one year rotation will have had 4464 kg of manure spread across it, containing 266.9 kg of nitrogen (20% loss to volatilisation), 124.8 kg of phosphorus, and 88.8 kg of potassium.

The nutrient built up after one year should support a crop of forage sorghum with at least two cuts of silage or hay with only a small amount of nitrogen required as a side dressing or, alternatively, several crops of chickpea, faba beans or lupins.

Cropping

One lactating sow can produce a lot of manure. A mature lactating sow feeding 10 piglets and eating in excess of 8kg feed per day can produce 442kg manure per year (Refer table 2). Multiply that by 14 sows per ha for a period of 12 months could exceed 6188kg of manure per ha per year or 0.6kg/m^2. At this rate the soil quickly becomes overloaded with nutrients. Given that there is a good chance of extensive soil disturbance by the pigs at the same time, nutrient runoff could happen in heavy rain, polluting water ways and causing water quality problems. If the nutrients are allowed to accumulate in large amounts nutrient leaching could also occur polluting ground water.

To prevent this, rotation of cropping is vital to remove some of these nutrients. It has to be noted that nutrients alone do not account totally for soil health and fertility. There has to be a plant in the nutrient cycle taking up NPK and growing organic material and then breaking down through soil microbial activity, building soil and completing the cycle of nutrient recycling.

With such a need for cropping as part of the rotation there is a real opportunity to value add at this stage of the rotation. When choosing a crop several factors need to be considered that benefits both pig and pocket. Consideration needs to be given to factors such as:

1. Local growing conditions
2. Available nutrients
3. Length of time required for the rotation
4. Whether or not the crop will be added to the feed ration.

Cereals

Cereal crops are the first crop thought of in a rotation with pigs as they usually fit the rotation timing well. They are also widely used within pig diets and therefore can go back into the piggery reducing feed input cost. Cereals are annuals so do not hold up the paddock for multiple seasons. The straw produced can be used as a bedding material and the pigs can be

turned out into the paddock after harvest to clean up grain residue. Richard Wright (2012) from Wrights Produce quoted

"It's the value of the manure on our cereal crops that keeps us in pigs".

The problem with this is that it is a closed loop where nothing is leaving the farm. Therefore, the nutrients continue to go round building in volume. This problem is made worse if insufficient grain is produced and additional feed is bought in.

Vegetables

Vegetable cropping is ideal for rotational systems. Vegetable production is usually heavily dependent on high levels of NPK. Leaf vegetables like sugar beets, lettuce or cabbage readily use up soil nutrients and once harvested the nutrients leave with the crop. Profitable vegetable production can generally be carried out on smaller paddocks, therefore, concentrating the effects that the pigs have on that paddock. The challenge in larger paddock is having an even spread of manure. The picture below shows organic corn, grown entirely from free ranging pig manure. Note the nutrient deficiency in the middle of the paddock, most probably caused by an uneven spread of manure.

Organic corn growing entirely on pig manure (Longwood Organic Farm, Suffolk England, 2012)

Hay production

Production of hay or silage is the ultimate in nutrient removal. Crops like sorghum or millet use large amounts of nitrogen and once cut into hay or silage they lock up nutrient to be taken away and fed to ruminants or sold. Growing hay or silage after the pig phase is the best way to reduce the nutrient levels.

Lucerne

Lucerne is also a very versatile crop when combined with pigs. Strip grazing gestating sows on lucerne can reduce their reliance on a grain ration by 65% without compromising the condition of the sow. Studies conducted by the Department of animal science, Iowa State University, found that gestating gilts could have their ration of corn reduced from 1.8kg/day to 0.6kg/day without compromising the sow or the reproduction performance. This alone can lead to a dramatic cost reduction (Honeyman, 1995).

The study was set up with four paddocks containing gilts 25/ha and rotated weekly, gilts were nose ringed to minimise rooting. A slight damage to the lucerne stand was noted with a decrease of 1.6 plants per metre per year.

The nutrient loading problems associated with outdoor pigs is directly related to the amount of bought in feed. Therefore, if the bought in component of the sows daily feed ration was reduced by 65% and replaced with grazed lucerne, the increase in nutrients would be 65% less (kg/hd/yr) than the predicted solids and nutrient output for each class of pig (Table 2). This would assist with the environmental management of nutrient build up.

Care should be taken with attempting to grow and finish market pigs on pasture without providing access to a complete grain ration as fluctuations in protein and energy levels of the pasture can present difficulties in consistently finishing a quality pig. Outdoor sows will remove about 1% of the forage on a one hectare pasture per sow per month when stocking at 12 to 30 sows/ha, assuming sufficient moisture is available for the pasture to be actively growing (Iowa Outdoor Pig Production, 2001).

Following a well-managed grazing rotation a final cut of lucerne can be taken for hay before resting the paddock over winter. With the correct stocking rates a stand of lucerne will remain fully sustainable for many years providing one quality cut of lucerne hay and reducing the feed cost of the sow.

Forestry

There is amazing potential for outdoor pigs to be incorporated into tree farming. Tree plantations provide an excellent habitat to grow pigs. They provide shelter, particularly shade, which in Australia is vital for beating hot summer temperatures. Planted with the correct spacing, trees will use up nutrients from the pigs while still allowing sunlight through to grow pasture or lucerne between the rows. The pigs will keep the undergrowth clear and prevent weeds from taking over. Care would need to be taken to prevent pigôs ringbarking trees.

In an orchard situation, mature trees of oranges or apples could house gestating sows very comfortably. They could be used to clean up residual fruit after harvest. Hence, lowering labour costs and reducing disease from rotting fruit. The use of nose rings may be needed to prevent sows digging within the orchard and exposing tree roots. More research could be done on pigs and tree cropping.

The Danish farm pictured below uses rows of willow trees to draw up excessive water, preventing bogging in the paddock. They also cut and sell the willow, using it for brush box products. The willows also provide shelter from sun and wind making it an ideal crop for pigs.

Danish farm showing pigs grazing between rows of willow trees
(Hestbjerg Økologi, Denmark, 2012)

Conclusion

Despite the ups and downs within the pork industry and farmers constantly battling high grain prices and low pork prices, combined with the constant threat of animal activists, there is still an opportunity to integrate pigs into a production system as part of a rotation. Outdoor pig production should be clean, orderly and strive to be efficient, adopting as many modern management practices as possible while remaining true to the free range ideology of allowing the pig to exhibit natural behaviours and enhancing the customerôs perception of pigs on pasture. Outdoor pig farmers should see their pigs as part of an integrated system where pigs play a role in providing nutrients for crops and helping to minimise the effects of pest and weeds. There are many opportunities where pigs can be kept in conjunction with other agricultural enterprises and provide added benefits to both along the way.

Recommendations

- Housing, feeders and other paddock equipment should be movable and indeed moved regularly to prevent nutrient hot spots around the paddock.
- Pasture should be maintained above minimum levels.
- Paddocks need to be rotated into a cropping phase as soon as minimum pasture cover is reached or nutrient loading becomes evident.
- Conduct soil testing before and after pig phase and set nutrient loading benchmarks.
- Stocking rates need to be adjusted to suit particular operations, rates around 12-14 lactating sows per ha and 20-24 dry sows per ha are workable but only a guide.
- Protect trees from ring barking.
- Maintain vegetative buffer strips below paddocks and alongside water courses.
- Fence off watercourses and sensitive places.
- Select replacement sows from mothers that show good mothering ability, not just good production figures.
- Think of outdoor pigs as part of an integrated farm along with other farm animals and crops.

References

Australian Pork Limited. (2010). National Environmental Guidelines for Piggeries http://www.australianpork.com.au

Butler, J. (March 2012). Personal Communication. Blythburgh Free Range, Suffolk, U.K

British Pig Exchange (BPEX). (2006). British Pig Project

Chastain, J.P. James J. Camberato, John E Albrecht, and Jesse Adams. (1999). Swine Manure Production and Nutrient Content . Clemson University.

Danish Production Standards. (2012). Pig Research Centre

Defra U.K. Site suitability for outdoor pig farming. http://www.defra.gov.uk

Defra U.K. (2003). Code of Recommendations for the Welfare of Livestock - Pigs http://www.defra.gov.uk

Honeyman, M.S.(March 2013). Personal communication. Iowa State University, Research and Demonstration Farms.

Honeyman, M.S. and W Roush (1995). Alfalfa Grazing by Gestating Swine: A Four Year Summary.

Honeyman, M.S. (1991). Sustainable Swine Production in the U.S Corn Belt.

Honeyman, M.S. Outdoor Pig Production. Iowa State University

Kongsgaard, J. (September 2012). Personal communication. Jyden Animal Housing Systems, Denmark

Lyon, L. (2012). Personal communication, Field Operations Manager, Niman Ranch, pork division, Iowa, U.S.A.

Mercer, R. (2012). (Personal communication. Mercer Farming, Staffordshire, U.K

New Zealand Animal Welfare (pigs). (2010). Code of Welfare -(pigs)

Unwin, L. (March 2012). Personal communication. Longwood Organic Farm, Suffolk England

Walton, C. (2012). Personal communication. Peelham Farm, Berwickshire, U.K.

Wright, R. (2012). Personal communication. Wrights of Brettenham & Wright Produce Ltd, U.K.

Plain English Compendium Summary

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Project Title:	**Environmental Management of Outdoor Pigs for Protein, Plough and Pest Control**
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Scholar:	Matthew Simmons
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Objectives	To study the following topics: • The potential for outdoor pigs to be used as a tool for regenerating depleted agricultural land. • The relationship between outdoor pig activity and its impact on weed and the disease burden and the benefits to rotational cropping. • Best practice for environmental management of outdoor pigs.
Background	Outdoor pig production is really in its infancy in Australia. If the industry is to go forward it has to have the best environmental management and produce a pig that is as close to intensive standards as possible while keeping to the publicôs free range expectations. This can be achieved by adopting industry best practice and looking for every opportunity to incorporate free ranging pigs into other agricultural activities.
Research	This scholarship took me to the Philippines, China, U.S.A., Canada, France, Denmark, United Kingdom and New Zealand. During which I visited farms (large and small), universities, demonstration plots, Pork industry bodies and Government Departments.
Outcomes	Outdoor pig production needs to be seen as an integrated part of the whole farm production system and not a single entity. A good rotation is vital in managing manure and nutrients and part of that rotation has to include growing a crop that can be removed from the paddock. Opportunities exist to incorporate outdoor pigs in to many other agricultural activities giving benefits to both operations.
Implications	Unless the outdoor industry gets the environmental side of production right they will fail to appease government departments and the discerning consumer. The industry will also miss a valuable opportunity to capitalise on the benefits of outdoor production.
Publications	Nil