Farm Case Study resource
EMAI (Elizabeth Macarthur Agricultural Institute) Beef cattle research property

Elizabeth Macarthur Agricultural Institute (EMAI) is located approximately 75 km south-west of the Sydney CBD at Menangle near Camden. It is a research property run by the NSW Department of Primary Industries. A Department of Education environmental education centre (Camden Park EEC) is located onsite and is where we meet for our class excursion.

From 1805 until 1975 the property was owned by descendants of the first European owners, wool pioneers John and Elizabeth Macarthur. Prior to this it was part of the country of the Dharawal people, who farmed it for food production using fire stick farming to encourage grasslands for kangaroos and emus on fertile plains, while the hills remained wooded for building materials, shelter and foraging. Grass seed was also harvested and ground to make a type of flour for bread. Australian Aboriginals are thought to have made flour and bread 20,000 years before any other cultural group. In addition, the Dharawals maintained extensive yam beds along the river flats, cultivating mostly *Microseris lanceolata* (also known as Daisy yam or Murnong) and also managed eel growing in the natural lagoons beside the upper Nepean river.

The Macarthur family sold 1600 ha of their 2000 ha property in 1975 to a developer (Talga investments) and the NSW government purchased it when that company went into liquidation the following year. Today it is managed by NSW Dept of Primary Industry as an agricultural research institute, including the NSW regional veterinary laboratories.

Enterprises

The farm operates a commercial-scale beef production enterprise involved in long-running research into development of estimated breeding values for cross-breeding programs and for methane production.

Cattle Breeds

Angus, Hereford and Charolais, Wagyu, Shorthorn

The Farm

The farm comprises 1600 ha of land and consists of creek flats and undulating to steeply undulating hills. It is dissected along its length by Navigation Creek, which flows into the Nepean River. Tree cover is remnant Cumberland Plains woodland and includes approximately 20% cover - mostly scattered shade trees of Iron Bark (*Eucalyptus crebrus*) on ridges, Forest Red Gum (*E. teriticornis*), Grey Gum (*E. punctata*) and Grey Box on slopes, and flats. There are also some small patches of bush around the banks of the creek, mostly Native Blackthorn (*Bursaria sp.*) and Black Wattle (*Acacia decurrans*).

Physical Resources of the Farm

Topography

Slope on the farm ranges from flat to 10 degrees, with most slopes around 6 degrees. Appendix A shows the outline of the property and a simplified version of the slope on the property.

Soils

There are a number of soil types on No. 9 and these can be divided into two main groups: Alluvial soils and Duplex (podsolic) clay-loam soils.

Alluvial Soils

These are soils that have developed over many millions of years due to the action of water. They are found on and around riverbeds (whether or not there is a river there now) and on the EMAI they are found either side of Navigation Creek and beside the Nepean river. In the photograph below, the alluvial soil is shown on the left. It shows a uniform soil profile – or a profile of fairly even colour the properties of which don't change much with depth. From a management point of view this is probably the biggest difference between the two main soil types on the EMAI – soil found on the flatter country tends to be deep – up to 6 m deep in places, with relatively little change in fertility. When comparing soils we will use a very broad definition of fertility, i.e.; "the ability of the soil to grow plants". We consider the chemical attributes (such as nutrient levels, pH, cation exchange capacity), structure and texture. While all three are very important management regards soil texture (the relative amounts of sand, silt and clay particles), as the most critical attribute because it is not economically possible to change this characteristic.

Texture of the alluvial soil is a clay loam varying to sandy-clay loam in parts. This is a very good texture because it absorbs water well and that water moves down cracks deep into the sub-soil. It provides plants with nutrients (some soils "hold on" to nutrients restricting their access to plants) and resists structural damage when cultivated. It has a friable, crumbly soil that promotes germination and a dark, alkaline subsoil. As a general statement, this is a highly fertile, safe soil suitable for a wide range of agricultural uses.

Clay-loam Soils

The soils found on the hills of the EMAI are of a type found right across the Sydney Basin, and used to be known as Cumberland clay-loam. It is a sedimentary soil formed from the muddy bottom of an ancient lake that once existed where the greater Sydney area is now found. The most obvious difference between this soil and the alluvial soils found on the property, is the depth of the A horizon (the top-soil layer). There are two types of these duplex soils found on the EMAI – one with a red-coloured B horizon and another, which has a yellow-coloured B horizon. The different colour is caused by naturally occurring irons (haematite and goethite) found in the former, that "rust" on exposure to oxygen, and look red. The red version has a slightly higher natural nutrient load and tends to be more stable but there is little difference.

The texture of the A horizon is similar to the alluvial soil – sandy clay-loam. Like the alluvial soil it provides nutrients to plants well and has good moisture storage. It tends to set hard when dry and is prone to structural damage and sheet erosion when over-cultivated. The B horizon is pure clay, with very poor moisture absorption and a lower pH with depth. It tends to form perched water tables (i.e. Waterlogged soils high in the soil profile) and has a low nutrient content.

As a general statement, this soil has a reasonably fertile topsoil which is vulnerable to erosion if mismanaged. Once this topsoil is lost a highly infertile, unproductive clay remains. Careful, long-term management of this soil is essential for sustainable production.

A more technical description of these soils is found in Appendix E

Alluvial Soil Profile **Clay-loam Soil Profile**

Climate

Rainfall totals approximately 800 mm annually, mostly as Summer storm events: Table 1 shows the average, monthly temperature and rainfall for the EMAI.

Table 2. Average Monthly Temperatures and Rainfall for the EMAI

Month	***Temp* (C^0)**	***Rainfall (mm)***
Jan	22.3	162
Feb	21.9	128
Mar	20.4	61
Apr	17.2	68
May	13,7	33
Jun	11.4	31
July	10.5	26
Aug	11.9	34
Sept	14,7	21
Oct	17.8	115
Nov	18.8	79
Dec	22.2	29

Minimum temperatures can be as low as minus ten degrees (though rarely below minus two) and this can affect pasture growth. There are a number of frosts in June-September though black frosts (where the ground freezes) are rare.

Irrigation and Reticulation

EMAI is fortunate to be on town water. This makes provision of high quality water for cattle troughs, etc, very convenient.

However potable water is too expensive to use for irrigation of crops and pastures. The EMAI has three large dams that can be used for irrigation. Irrigation water is pumped directly from the river, for which the farm has a license to pump while the river flows over the nearest weir. This flow has proved extremely reliable and allows 24/7 irrigation over an area of 60 ha per day. Currently there is approximately 300 ha of EMAI that is irrigable. A secondary source of irrigation is through a contract EMAI has to accept recycled water from the nearby Camden sewerage works. This resource is pumped to a large turkey-nest dam near the centre of EMAI and piped to irrigation hydrants as needed.

Whole Farm Plan

Management's main long term objective at the EMAI is to be sustainable. This means that, regardless of what is done on any part of the farm in any season, it is sustainable – it could be done for the next 100 years without a decrease in productivity.

Before land use is decided, each part of the farm is studied to determine the capability of that land for agriculture. A "Capability class" is then allocated to that area of land and a long term plan is developed according to that capability (rather than what we think might make the most money that year).

Land Capability
This has nothing to do with what is growing there at the time or how close the farm is to markets. It is an indicator of the potential capacity of the land for sustainable, agricultural production. The most important characteristics of land that determine its capability include:

- **Soil type**
- **Slope**
- Aspect
- Climate
- History

Of these five, the first two – soil type and slope, are by far the most important.

Identifying land capabilities -The way capabilities are identified usually involves the following steps.

1. Soil types are surveyed across the farm. Appendix B shows a simplified version of the soils found on No. 9 Dairy. The main characteristic we are interested in here is soil texture, because soil structure and chemistry can be changed, but other properties such as stability, ability to absorb moisture and store nutrients and salinity are very important.
2. A slope map is then developed for the property, showing the broad range of slope patterns on the farm. A simplified version done for the EMAI can be found in Appendix A.
3. These two maps are then put on clear overlays and laid over an aerial photograph of the farm. Boundaries are drawn on a clear cover-sheet showing where the best soil types occur with flat land (the highest capability), the worst soil types with the steepest slopes (the lowest capability) and all combinations in between. If the original soil and slope data is fed into a GIS (Geographic Information System) program, this stage will be done very accurately by a computer,

Appendix C shows these boundaries for the EMAI with the land capability class for each combination. The system used in New South Wales includes capability classes from one to eight, where one is the best land capability found in NSW and eight is the worst. They are usually shown on these maps as roman numerals.

Land Use recommendation

The development of a whole farm plan involves development of a long-term plan of management based on information on the land capability study. On a grazing property like the EMAI, where the paddock is the land management unit (because cattle cannot be managed without a fence), the placement of fences is considered very carefully. Fences have historically been placed for reasons other than land capabilities – to minimise walking distance of cattle, to make best use of watering points, to make a paddock shape that is geometrically appealing and so on. Often, therefore, more than one land capability class can be found in a paddock and that makes it impossible to manage the whole paddock in a way that realises maximum, sustainable production. Several paddocks on the dairy, for example, have a mixture of class II and class IV land. Class II land can be cropped sustainably, but class IV land cannot (though it might yield well under cropping in the short term). The manager is therefore forced to decide between either cropping the paddock and risking long term soil damage to part of it, or growing pasture that might yield less than 10% of the productivity expected from a crop on the same land. The first choice involves risking the long-term productive potential of the land, the second choice could risk the economic viability.

The answer of course is to change the fencing arrangement and encouraging and guiding decisions like this, which have an impact on the long-term productivity of the farm, is the main advantage of Whole Farm Planning.

Pastures

There are two main divisions of pasture types – unimproved (native or natural) pasture and improved pasture.

Native pasture

Native pasture on the EMAI should really be referred to as natural pasture as there is so much foreign seed that has found its way into these pastures over the years. However, these pastures are still dominated by native species.

Advantages – native pastures have a number of advantages over improved species,. The advantages of native pastures include; drought tolerance, good recovery from fire and low requirement for fertilizer. A well-managed native pasture will also have a high diversity of species so that at least one plant type is likely to be productive regardless of season or conditions. They also have some significant limitations. The maximum potential productivity of native pastures, measured in kilograms of dry matter per hectare, (kg DM/ha), is much lower than well managed improved pastures. Other advantages of improved species are that they generally have a higher digestibility, (so cows utilise the nutrients more efficiently), they are more palatable (cows prefer eating them) and the energy and protein levels are generally higher.

Typical fertiliser application for native pasture is 25 kg/Ha/year.

1. Unimproved pastures.
These are found on land classed as class 4 and above. They are composed of native species and naturalised (introduced) species. The most prominent native species are:

- Kangaroo Grass (*Themeda triandra)*
- Common Wallaby Grass (*Austrodanthonia caespitosa)*
- Umbrella Grass (also known as Windmill Grass) (*Chloris truncata*)
- Rhodes Grass (*Chloris gayana*)

The most prominent naturalised species are:

- Buffel Grass (*Cenchrus ciliaris)*
- Rhodes grass *(Chloris Gayana)*
- Paspalum (*Paspalum dilatatum)*

These unimproved pastures are of relatively low nutritional value, grow actively only in the warmer months and are of low productivity in comparison to the improved pastures. They do, however, grow well on poor soils and are quite drought tolerant. They are not used for cows with calves due to their low protein content.

These pastures are fertilised with superphosphate a rate of 20 kg/DM/Ha per year. Care is also taken to ensure that they are not overgrazed as native grasses do not persist well under intensive grazing pressure.


Windmill grass


Kangaroo Grass


Common wallaby Grass


Paspalum

Improved Pasture

This is the term used to describe any pasture that has been established because it is superior to the native pasture that would otherwise be maintained in that paddock. Species used don't have to be exotic (non-natives) but they nearly always are. These species are, as a rule, faster growing with a better resistance to grazing pressure and of higher quality than the native alternatives but will also have an establishment cost and require more resources to maintain than native species. They are also generally less drought tolerant.

Improved pasture usually includes a grass and a legume and the most common summer mix on the EMAI is Kikuyu/white clover. Most of the Class III land is used this way and permanent irrigation outlets have been installed in these paddocks to provide the large amounts of moisture needed for kikuyu to reach its genetic potential. Kikuyu is preferred because of it's high productivity, providing more feed per hectare than most other pastures. It has an aggressive growth habit spreading out from stolons and rhizomes which makes it well adapted to "ripping" grazers like cattle, and to the sod-seeding rotation used to establish a winter pasture in the kikuyu paddocks (see below).

2. Improved pastures
Improved pastures are grown on the higher class land that exists on the creek flats on the farm. The soils here are deep and relatively fertile and the topography makes irrigation of the pastures in times of low rainfall possible. This, combined with the judicious use of artificial fertilisers, maintains high productivity from these pastures throughout the year.

Three species are used in these pastures.

- Kikuyu (*Pennisetium clandestinium)*
- Perennial Ryegrass (*Lolium perenne*)
- White Clover (*Trifolium repens*)

Perennial Ryegrass

White clover

Kikuyu

The kikuyu, being a warm season grass, provides the basis of pasture production from mid spring until mid-autumn. The perennial ryegrass and White Clover, being cool season species, are then direct drilled into the existing kikuyu pasture to provide winter feed.

Chemical fertilisers are applied to these pastures as follow:

Fertiliser type	Nutrients supplied	Application rate	Timing
Hi Fert blend (a compound fertiliser)	N, P, K	150 Kg/ha	Spring
Urea	N only	80Kg/ha/yr	After each grazing

Kikuyu

Kikuyu - fact file

Common names	Kikuyu, Kikuri
Scientific name	*Penisetum clandestinum*
Productive Season	Heavily seasonal, Autumn - Spring
Use	Permanent pasture
Origin	Africa
Moisture requirement	High
NPK fertilizer requirement	High
Typical protein level	8% - 20%
Typical Digestibility	68%

Management of Kikuyu

In highly productive situations such as dairying, kikuyu requires regular slashing to a height of about 5 cm to allow light penetration through the grass canopy to the clover below and to stimulate new growth of kikuyu leaves. On the EMAI, it is best to graze this within 6 weeks as pasture digestibility and protein levels drop markedly after this time.

Kikuyu Factors affecting production

Plant moisture

Fertilizing Kikuyu

Nitrogen and phosphorous application in particular can increase kikuyu production – in fact 130 kg/ha can almost double growth rate in summer. On the EMAI this level is applied in late Autumn and again in early Spring. As a rule of thumb, grazing time is brought forward 5 days for every 20kg/ha N applied and 130 kg is necessary to achieve one grazing every 5 weeks ~~on No. 9 Dairy~~. 40 kg/ha superphosphate is also applied each year, usually in late August.

Haifa White clover

Clover - fact file

Common names	White clover
Scientific name	*Trifolium repens*
Productive Season	Year-round, especially Winter
Use	Permanent and irrigated pasture on coast and tablelands
Origin	Israel
Moisture requirement	Medium
Fertilizer requirement	PKS requirement high. N requirement low
Typical protein level	14% - 23%
Typical Digestibility	High

Management of clover

White clover is the most commonly used legume in pastures of the coast and tablelands of NSW. It is almost always planted with grasses such as kikuyu, ryegrass, phalaris and paspalum. It can be grown alone but strict anti-bloat measures must be taken if such a pasture was used for grazing (seed or hay production would be more common).

On the EMAI, white clover is sown with rye-grass using a sod-seeder in April, after the paddock is intensely grazed and mulched. Seed is very small and seed depth is important – one centimetre and certainly no more than 2 cm. All seed is inoculated with a strain of Rhizobium bacteria and limed and sown at a rate of 2 kg/ha. Phosphorous is the main limiting nutrient for clover at EMAI and the August application of 40 kg/ha is generally sufficient, though clover proportion can be increased over time by increasing superphosphate application and reducing nitrogen fertilizer.

Clover and bloat

Cattle grazing pastures which are clover dominant run the risk of bloat – a condition caused by a foaming of the rumen contents making it difficult for cattle to release gases which build up as a result of normal digestive processes. The rumen swells and pushes on the diaphragm causing death by asphyxiation. Pasture fertilizer regimes should be altered to produce a grass:clover mix of 60:40. Special detergents that prevent frothing in the rumen known as pluronics can be given to the cattle as a drench, rumen capsule, in drinking water or to molasses in a roller drum.

Benefits of clover

A kilogram of legume is higher in protein and digestibility than a kilogram of grass and adding legume to a pasture will increase total feed intake. White Clover also fills feed gaps and promotes growth of grasses through nitrogen fixation and addition of clover to pasture can increase production significantly.

Maize and Sorghum Production

All maize and sorghum is produced under irrigation and it is all used for silage production – mostly pit silage in the case of maize and baled silage for sorghum. Silage is not stored as an emergency feed, it is used to fill an expected feed gap that occurs in winter and spring on the farm.

Management

Paddock preparation is conventional, though the aim is to minimise cultivation as much as possible to preserve soil structure and reduce erosion. The paddock is sprayed with Roundup (glyphosate) and ripped with a Yeoman's plough. This is a deep ripping plough that has bullet or vibrating arrow-like additions to the base of the tynes to create sub-surface tunnels to collect moisture and enhance root growth. Tynes are very narrow to minimise soil disturbance nearer the surface. Yeoman’s ploughs are very effective in reducing soil compaction without compromising soil structure long-term. A Grizzly off-set disc harrow or a Potinger speed tiller is generally used to break up larger soil clumps near the surface. Paddocks are pre-dressed with 15 cubic metres per ha of turkey or chicken manure and seed sown at 80,000 plants per ha with fertilizer (based on soil analysis, but approximately 300 kg/ha Urea and 300 kg/ha potash and lime to increase pH. If necessary it is sprayed post-planting with Primextra Gold herbicide to control grass weeds. The sower used is an 8-row, Kubota VP1600 precision planter. Sowing time is temperature dependant, with most maize varieties requiring 14 deg C soil temp at 2.5 cm depth and sorghum around 16 deg C.

Maize seed variety is a hybrid 118-day variety produced by Pioneer Seeds and is sown from October to early November, depending on soil moisture and temperature. This variety is bred to grow to optimum harvest stage in 118 days from sowing.. Average production is between 25 tDM/ha and 40 tDM/ha.

The sorghum variety used is known as Brown-ribbed sorghum or BMR sorghum and is planted a little later than maize most years. The aim is to cut the crop twice between November and May and if this is achieved yield is similar to maize.

Insect Pests

The most important insect pests of maize are Heliothis and Armyworm. They are both species of moth and tend to affect plants around the outside rows of silage maize, Heliothis caterpillars damage the tops of corn cobs and armyworm caterpillars the leaf and stem.

Integrated control

A number of strategies are used to control these two pests in maize and sorghum

1. Use of hybrid maize seed provides some resistance to Heliothis
2. Maize is planted as early as possible (when soil temp reaches 14 deg Celsius). This allows the crop to become established before infestation (Heliothis is an Australian native and usually migrates to Eastern Australia from inland in Spring/Summer)
3. Crop is monitored for Heliothis and Armyworm regularly to target insecticide application effectively while minimising impacts on natural predators of caterpillars
4. Armyworm is controlled by a biological spray called Fawligen, a virus-based biological insecticide. Fawligen is selective for Armyworm and does not affect natural predators.
5. Heliothis outbreaks are controlled by application of Vantacor which can be effectively applied in low doses, it has a low impact on non-target species and a long residual which reduces impacts on beneficial species further.
6. Weed control – Heliothis can over-winter between crops in lucerne and several weed species. As lucerne and maize are often grown in the same paddock in rotation the control of residual plants can delay infestation.

Calendar of operations:

Jan	Bulls removed
Feb	Pregnancy testing cows Drench
March	
April	Pregnancy testing
May	Weaning Flight and docility scoring Ovary scanning of heifers (test for puberty) Worm egg counts
June	Weighing cows/heifers/steers
July	Weighing C/H/S
August	Bulls weiged, semen tested Calving – weigh/sex, score maternal behaviour, score udder
Sept	Calving
Oct	
Nov	Bulls Fat score heifers
Dec	Turn off steers (average 450 kg), on contract to feedlot.

Calendar of operations: Improved Pastures (kikuyu and ryegrass/clover)

Jan	Fertilize. Irrigate
Feb	Irrigate
March	Graze at very heavy stocking rate Mulch (using a mulcher) Irrigate
April	Sod-sow ryegrass and clover (starter fertilizer included). Irrigate
June - October	Graze and top-dress with urea after each grazing (6 weeks between grazing). Irrigate
October	Fertilize kikuyu. Irrigate
November	Fertilize. Irrigate

Irrigation occurs any month as required

Calendar of operations: Maize/Sorghum

September	Plough/scarify
October	Fertilize (organic material) Scarify Sowing maize Spraying pre-emergent herbicide Irrigate
November	Sowing of BMR sorghum Irrigate if necessary Herbicide treatment if necessary Insecticide application if necessary
December	Irrigate
January	Harvest sorghum Irrigate
February	Irrigate
March	Irrigate
April	Harvest Maize Harvest sorghum

Gross Margin

(Nb – it is too early to present a real GM for this enterprise. The following is based on 550 head breeder herd and 280c/kg sale price. Refer to link below for typical GM estimates for NSW)

VARIABLE COSTS

Purchased feed	000
Veterinary costs	$3,000
Fuel/vehicle costs	$18,000
Electricity	$500
Stock selling costs	$4,500
Employed labour	$50,000
Seed	$35,000
Fertilizer	$71,000
	$0
Clothing	$750
Cattle purchased (bulls)	$4,200
Consumables	$6,000
Farm supplies	$25,000
Equipment maintenance	$10,600
Office/miscellaneous	$1,987
Total	**$230537**

FIXED COSTS

Water rates	$1,600
Insurance	$4,500
Accounting fees	$1,200
Telephone	$800
Depreciation: Vehicles (15%)	$1,500
Depreciation: Machinery(10%)	$13,000
Depreciation: Improvements (3%)	$7,000
Total	**$42,600**

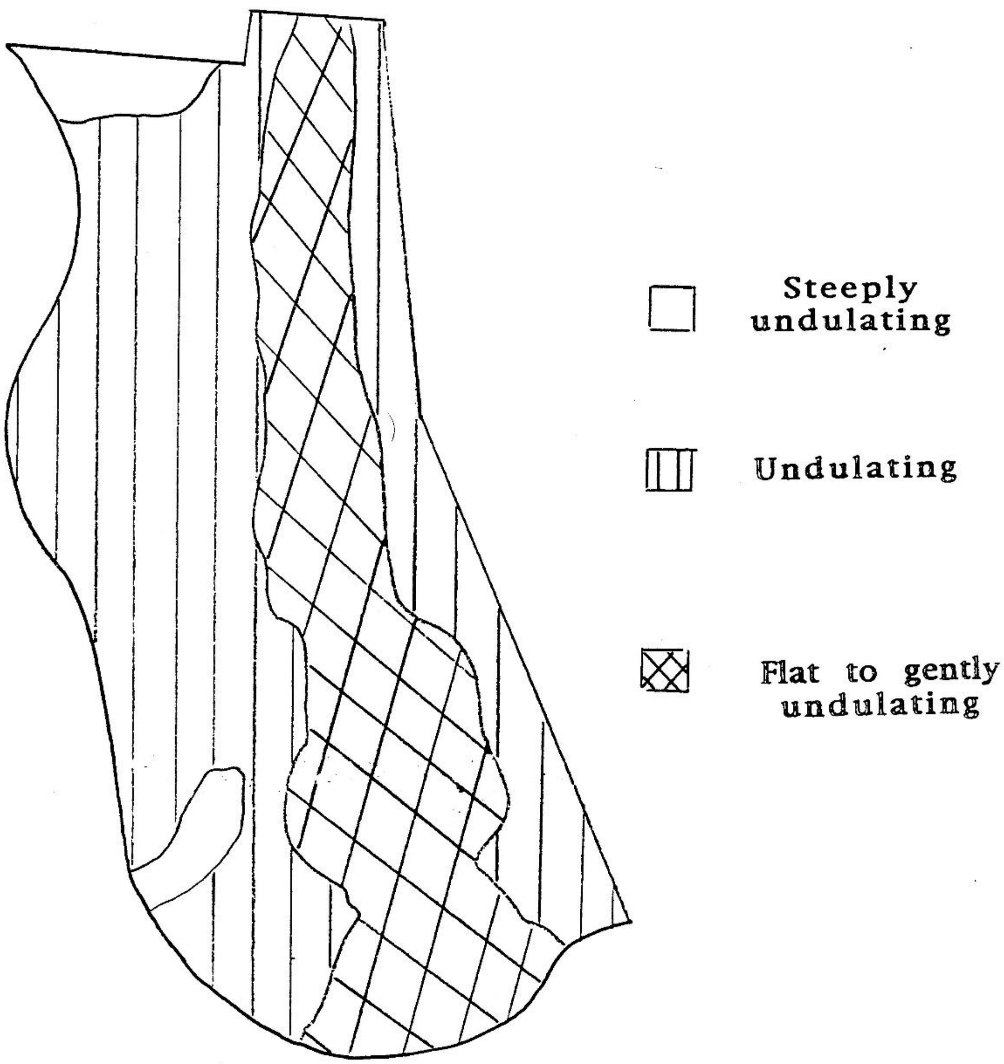
INCOME

Cattle sales	$234,000
Feed sales	$100000
Total	**$334000**

Livestock gross margin budgets (nsw.gov.au)

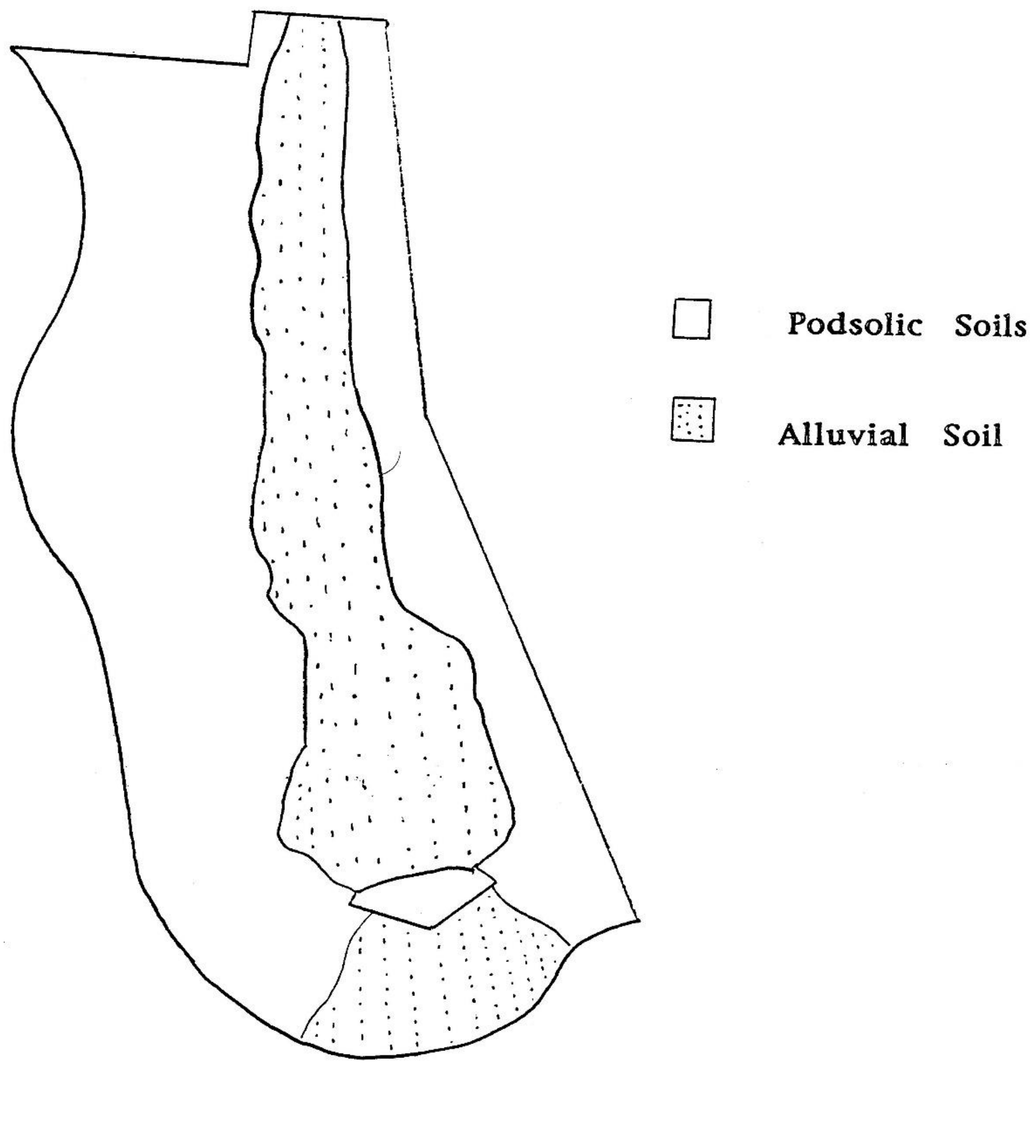
Appendix A

EMAI: Topography



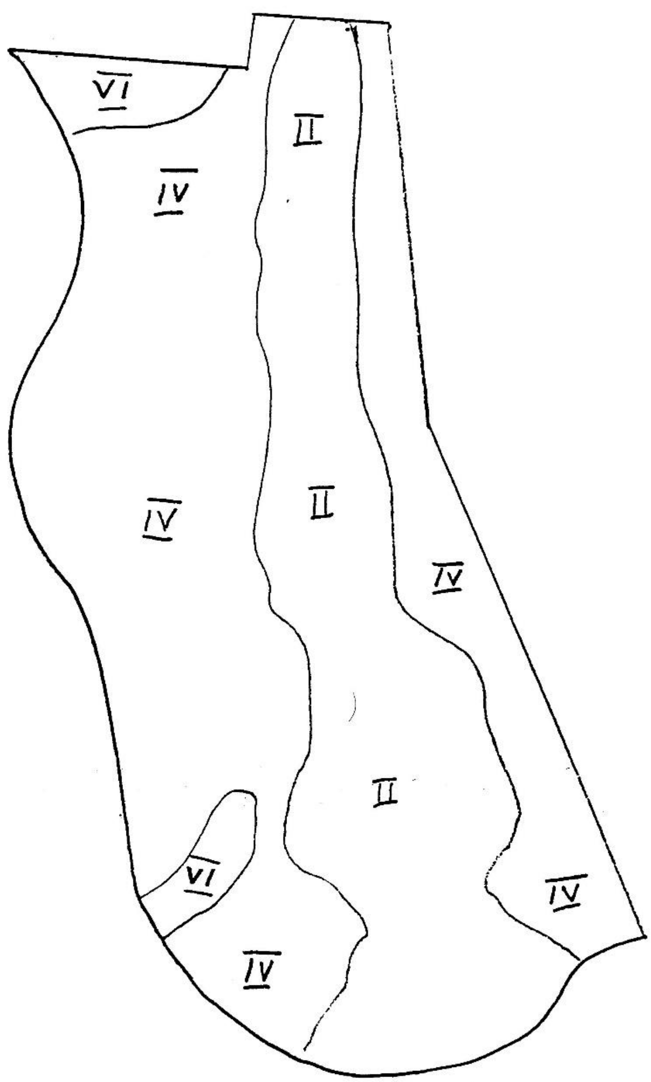
Appendix B

EMAI: Soils



Appendix C

EMAI: Land Capability Classification



Appendix D

EMAI: Land Use
Recommended Whole Farm Plan
(simplified example)