The Cicerone Project

Subdivision of the ABC Farmlet Project Land
into three land units with equivalent land capability

('Chiswick' Armidale, NSW)

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UNE
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OF NEW ENGLAND

Introduction

The 'Cicerone Project' is a New England based producer group dedicated to improving the viability of grazing enterprises through the active participation of producers in relevant research and learning. The Cicerone group was established with funding from WoolMark and subscriptions from members. The management committee is led by producers with links to CSIRO, NSW Agriculture, SGS, TAFE and UNE.

The Cicerone group has interests in a merino wether trial, a footrot trial, pasture persistence and maintenance, drought management strategies, benchmarking, parasite control, financial management, sustainability of livestock grazing systems, farm profitability and viability, and comparison of different grazing systems.

This report deals primarily with planning the subdivision of the central learning farm into three 50 hectare farmlets (A, B & C) in order to conduct a grazing trial comparing the sustainability, profitability and management costs associated with each treatment A, B & C shown in Table 1 below.

Table 1. Proposed treatments for Farmlets A, B and C. Farmlet A is a high input system while Farmlets B and C are medium input treatments with Farmlet C comprising double the number of paddocks (16) of Farmlets A and B to allow for intensive rotational grazing[1].

Farm A	Farm B	Farm C
• High Production using high input strategies	• Medium input strategies	• Same treatment as Farm B but with the following differences
• High Legume Content	• Flexible rotational grazing based on the ProGraze system	• Twice the number of paddocks - 16
• 200 cwt fertilizer (20 kg P per yr.)	• Minimum P level of 10 – 15 ppm	• 6 - 7 DSE per hectare
• Increasing soil P	• 6-7 DSE per hectare	• Longer rest periods for each paddock
• Over 15 DSE	• No cultivation	• Mobs may be combined during a drought
• Condition score as per CSIRO guidelines	• Clover must be broadcast at appropriate times and with appropriate stock management	• Flexible rotational grazing
• Cultivation allowed to put in new pastures	• Vulpia control	
• Flexible rotational grazing using ProGraze principles	• Number of paddocks 8	
• Number of paddocks 8		

In order to ensure the validity of any results from farmlet comparisons, it is imperative that each farmlet is as equal as possible in all factors most important to the productivity of grazing systems (e.g. hydrology, slope) prior to the individual management strategies becoming applied. This is especially true of factors which cannot be changed (such as slope, soil type, etc.). Other factors such as pasture species and soil fertility levels can be changed over time through management. The equality of all three farmlets is a basic assumption when assessing and comparing the individual performance of each farmlet during any trials.

[1] NB. Since this report was completed, each of the 16 paddocks of Farmlet C were further subdivided in 2001 to provide 33 paddocks to allow for greater differences between farmlets in grazing intensity and rest period to be imposed.

Aims and Objectives

Aims

In conjunction with producers, management and administration to:

1. Identify and map the environmental parameters of the study site important to grazing system production.
2. Divide the property into three 50ha farmlets (A, B & C) equal with respect to the distribution of the important environmental parameters.
3. Allocate the three treatments to each farmlet.
4. Divide Farmlets A and B into 8 paddocks.
5. Divide Farmlet C into 16 paddocks.

Considerations

1. Minimise the fragmentation of the farmlets A, B & C.
2. Minimise the total infrastructure costs of the project.
3. Optimise stock transport and handling capacity.

Study Site

The study site (Plate 1) is wholly contained within the CSIRO property 'Chiswick', located 17 km south of Armidale NSW (latitude $30^0$31'S, longitude $151^0$39'E, at an altitude of approximately 1000 m asl). For over 50 years, a range of experiments with grazing animals (mainly sheep) and pasture species and nutrition have been carried out on the subject land.

The total available size of the area being leased by the Cicerone Project is 200 ha of predominantly podsolic soils with some small basaltic areas. The property slopes gently from the south towards a large flat area in the north which is lower and where some drainage problems occasionally occur. Fertiliser (superphosphate) has been applied under various regimes to three separate zones of the property, at least since 1977.

In general the area has been grazed at a low intensity over recent years, resulting in excellent pasture cover (mostly native and sown perennial grasses) over all areas. Some of the areas have good representation of sown species (e.g. phalaris) established in the 1980s and earlier.

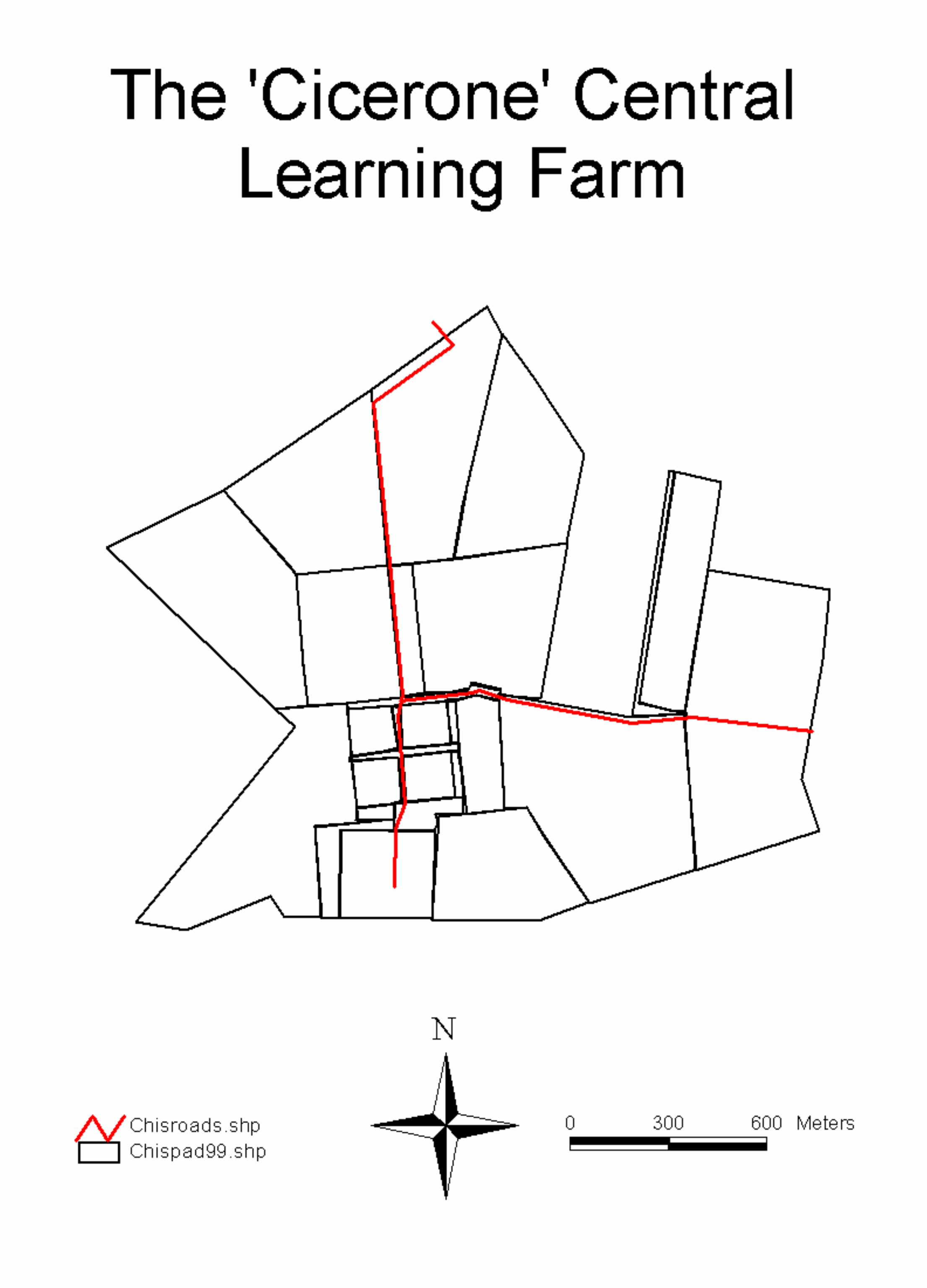


Plate 1. Chiswick Study Site. Aerial plan of the property showing existing roads, fences and borders.

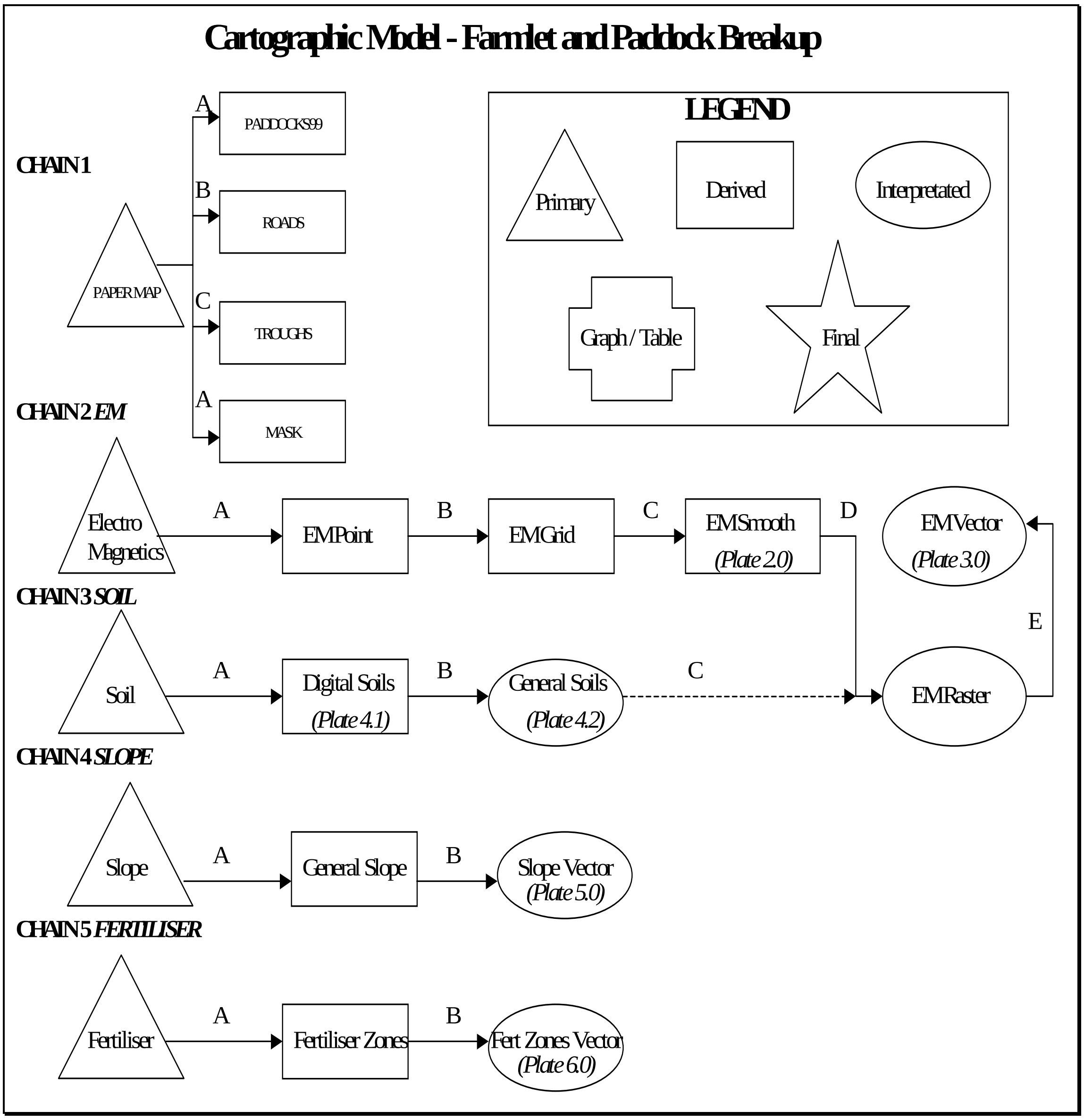
Methods

Parameter selection

Initial consultation with producers, management and administration identified four main parameters which will influence the sustainability and profitability of grazing enterprises at the Chiswick site: soil type, hydrology, slope (as these are expensive or impractical to alter) and fertiliser application history (as recent additions can affect production through residual value over many years). However, fertiliser distribution across the farmlets can be altered by farm management through withholding or applying fertiliser so this parameter took the lowest priority, whilst hydrology, slope and soil type were considered of greater (but equal) importance.

Processing

The body of the methods section for this report takes the form of a cartographic model showing the step by step process (Figure 1) referenced to the explanatory notes below. To check the method used for any step simply find the step on the cartographic diagram and then check the reference located under the specific 'chain' in the explanatory notes section. Alternatively, the explanatory notes section can be read on its own as a more traditional methods section.



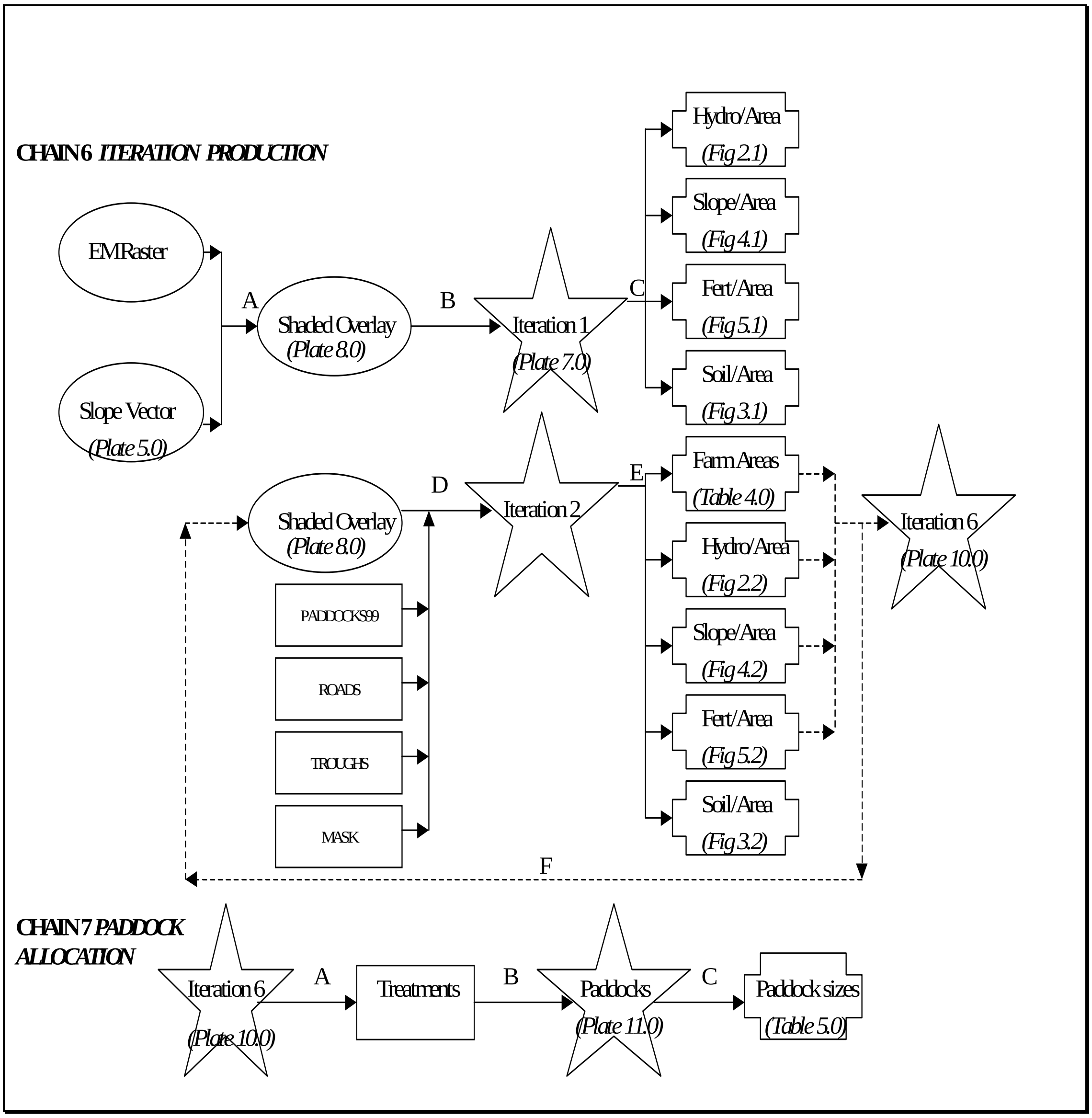


Figure 1. Two part cartographic models illustrating the steps involved over the 6 iterations of planning of land allocation to each of three farmlets.

Explanatory Notes

Software

All digital map production involved the use of Arcview™ during both the digitising and processing stages unless otherwise specified. Data obtained from Arcview™ was transferred to Microsoft Excel™ to produce presentation quality graphs and tables.

Chain 1: Digitising General Chiswick Attributes (fence lines, roads, troughs, boundary)

Primary Data Source: Paper map provided by farm management.

a) The paper map was used as a template to hand digitise fence positions and therefore the property boundary. Fence lengths were then checked against fence measurements taken using ‘Pinpoint’ and found to be consistent.
b) The paper map was used to hand digitise existing roads.

c) The paper map was used to hand digitise approximate trough locations.

Assumptions:

i. Information provided on the paper map was accurate and positionally correct.

Chain 2: Site Electromagnetics (EM) and Hydrology

Primary Data Source: Direct sampling of induced secondary electromagnetics on 4wd bike using GPS for positional accuracy.
5547 data values were obtained ranging between 3 and 147 millimhos/metre.

a) EM data entered into Arcview as point values with an x, y grid position taken from GPS.
b) These point values were interpolated (i.e. points between existing values were estimated assuming a linear gradient) to produce a continuous 2-dimensional surface in spectral space (i.e. x, y space). Isolation gully did not show up on this image as few samples could be taken there due to the difficulty of the terrain. This was accounted for by adding a 'gully' field to the slope map.
c) A 5 * 5 smoothing convolution (filter) was applied across the entire image to remove extreme values and highlight trends/areas of most interest.
d) Dr Simon Murray of the Department of Environmental Engineering, UNE, confirmed that the EM data values were consistent with others taken from the New England region. Dr Murray also agreed that the hydrological classification scheme used by Charles Sturt University, Wagga Wagga (based upon EM values) was also applicable in the New England region. The smoothed image was then reclassified according to the Charles Sturt classification scheme (Table 2) to produce a hydrological map of the site.

Table 2. Hydrologic classification scheme (Charles Sturt University).

EM survey value (millimhos/metre)	Hydrologic Category
less than 20	recharge zone
20 – 70	moderate recharge zone
70 - 100	discharge zone
greater than 100	discharge zone with possible salinity

e) The hydrological map was converted from a raster (grid) into a vector (object based) thematic map for area comparison and display purposes. Producers, management and administration agreed that this map was an accurate and objective approximation of the site hydrology.

Assumptions:

i. It was assumed (and generally accepted) that there is a relationship between the strength of the secondary (measured) magnetic field and the conductivity of the soil profile.
ii. Missing EM data values can be reasonably estimated using basic interpolation between existing values.
iii. Hydrologic classes are indicated by particular zones of EM data values.

Chain 3: Soil Distribution

Primary Data Source: CSIRO colour soil map

i. The CSIRO hard copy soil map was hand digitised, geo-referenced with AMG co-ordinates and converted into Arcview^{TM} format by Cate McGregor, Department of Ecosystem Management, UNE.

ii. Dr Peter Vickery (formerly of CSIRO Livestock Industries) was consulted to provide advice upon general soil groupings as the CSIRO classification scheme was too detailed for a simple comparison of farm areas.

The scheme shown in Table 3 was adopted and the soils reclassified accordingly.

Table 3. Soil reclassification (allocation of original soil units in paddocks into either podsolic or basaltic classes).

Podsolic	Basaltic
Chiswick	Dangarsleigh
Ram	Toby's
Handel	Upper Kirwans
Saumarez	Log
Isolation Gully	Top West
Amby's	
East Armidale	
Cattle	
Sale Yards	

iii. The general soil map was then compared with the map of EM data. The EM data was sufficiently accurate to allow the basaltic and podsolic soil types to be distinguished. It was also considered a more accurate measure of current hydrology due to the recent data acquisition and sheer number of data points acquired, compared to the soils map which was compiled based on widely spaced soil cores. The EM map was therefore assumed to also represent the basic soil distribution of the property.

Assumptions:

i. EM data can be used as an objective and current indicator of general soil type.
ii. The generalised soil distribution is sufficient for property break up.

Chain 4: Slope

Primary Data Source: Aerial Photography

a) Consultation between producers, farm management and administration identified five main slope classes important on the property: hill tops, lower slopes, flats, a steep gully side slope, and Isolation gully. These areas were identified and highlighted on the aerial map.
b) The important slope classes were hand digitised into Arcview to produce a vector slope map.

Assumptions:

i. Human interpretation was sufficient to classify the generalised slope/terrain classes.

Chain 5: Fertiliser History

Primary Data Source: Fertiliser history: provided as paper map by CSIRO farm management

a) Similar sized zones were recognised and highlighted on the paper map. These were identified as follows: no superphosphate since 1977; superphosphate from 1992 – 1997 @ 125 kg/ha; superphosphate applied in most years @ 125kg/ha.
b) The paper map was then hand digitised into Arcview format as a vector map.

Assumptions:

i. The fertiliser map provided was accurate in both fertiliser history and zones of application.

Chain 6: Iteration Production

Primary Data Source: Digital maps produced during Chains 1 - 5

a) The vector slope map was displayed showing individual slope classes as unique colors. The raster EM map was then used as an intensity control within each of these colors to shade areas of low EM and brighten those areas with high EM values.
b) The 'shaded overlay' map was broken into several obvious EM/slope associations under the guidance of property management, producers and administration. These zones were then broken into three equal areas and allocated as Farmlet A, B or C to produce Iteration 1.
c) Graphs were produced of EM, slope, soil type and fertilizer applied for each farmlet A, B & C as Iteration 1 should approximate the theoretical optimum distribution of these parameters.
d) Context layers (roads, fences, water troughs) were added as a guide for further iterations. Iterations were sought that simplified management practices, minimised fencing requirements and produced the most even distribution of important parameters across all Farmlets. Laneways were also introduced to enable efficient stock movement, to allow for access to centralised yards and provide excellent visitor thoroughfare.
e) Graphs were produced as in step 'c' for comparison of parameter distribution between successive iterations and particularly for comparison with the theoretic optimum distribution within Iteration 1.
f) Steps 'd' through to 'f' were then repeated to produce progressive improvements in management and financial constraints while achieving a parameter distribution similar to that of Iteration 1. This process eventually led to the production of Iteration 6.

Assumptions:

i. Human interpretation and experience is sufficient to subdivide the property into 'equal' farmlets based upon the apparent EM/slope relationship.
ii. Iteration 1 is the optimum separation able to be achieved is terms of EM and slope.
iii. Trade offs can be made between the EM/slope distribution and fertiliser history, fencing costs, fragmentation and management costs.

Chain 7 : Treatment allocation and paddock subdivision

Primary Data Source: Iteration 6 - product of iterative process in Chain 6

a) Producers, administrators and managers examined Iteration 6. It was decided that one Farmlet area had large inter-connected areas and excellent lane access and thus naturally suited the application of the 16 paddock configuration – this was then allocated to Treatment C. Farmlets A and B were allocated Treatments A and B through means of a coin toss to remove any hint of naming bias.
b) With respect to laneway access, larger areas of Farmlets A and B were split by eye to produce a total of 8 paddocks in each farmlet. Larger areas of Farmlet C were then split by eye into smaller paddocks until a total of 16 paddocks was achieved. Minor laneways were added where required.
c) Paddock sizes were calculated and tabled.

Assumptions:

i. It is sufficient to split the larger areas by eye based upon laneway access.

Results

Farmlet Areas

The areas of each farmlet, contained in Table 4 below, illustrate that all farmlets A, B & C are approximately 50ha in size. Laneways accounted for 7 ha of the property, while the rest/sick paddock was allocated 3.3 ha.

Table 4. Farmlet areas.

Farmlet	Area (ha)
A	49.8
B	49.9
C	49.8
Sick Paddock	3.3
Laneways	7.0

Electromagnetics

The smoothed EM map is presented as Plate 2. Raw data values ranged between 3 and 147 millimhos/metre. High values can be seen as lighter areas, whilst low values are darkened.

Plate 2. Smoothed EM distribution. This map estimates the EM distribution over the entire study site based upon thousands of individual point measurements (approximately at 10 m intervals).

Hydrology

The basic hydrology of the study area (Plate 3) comprises a small recharge zone, large discharge zone and some small areas possibly susceptible to salinity. Isolation gully runs north within the property and is evident within the slope map (Plate 5).

Plate 3. Site Hydrology. This map is based upon EM measurements categorised using the CSU Hydrologic Classification Scheme.

The distribution of Hydrologic classes across each farmlet for Iterations 6, presented as Figure 3, was very close to optimum (Figure 2) with the exception of a small area of Farmlet A, with approximately 10% (5 ha) more discharge area than Farmlets B or C.

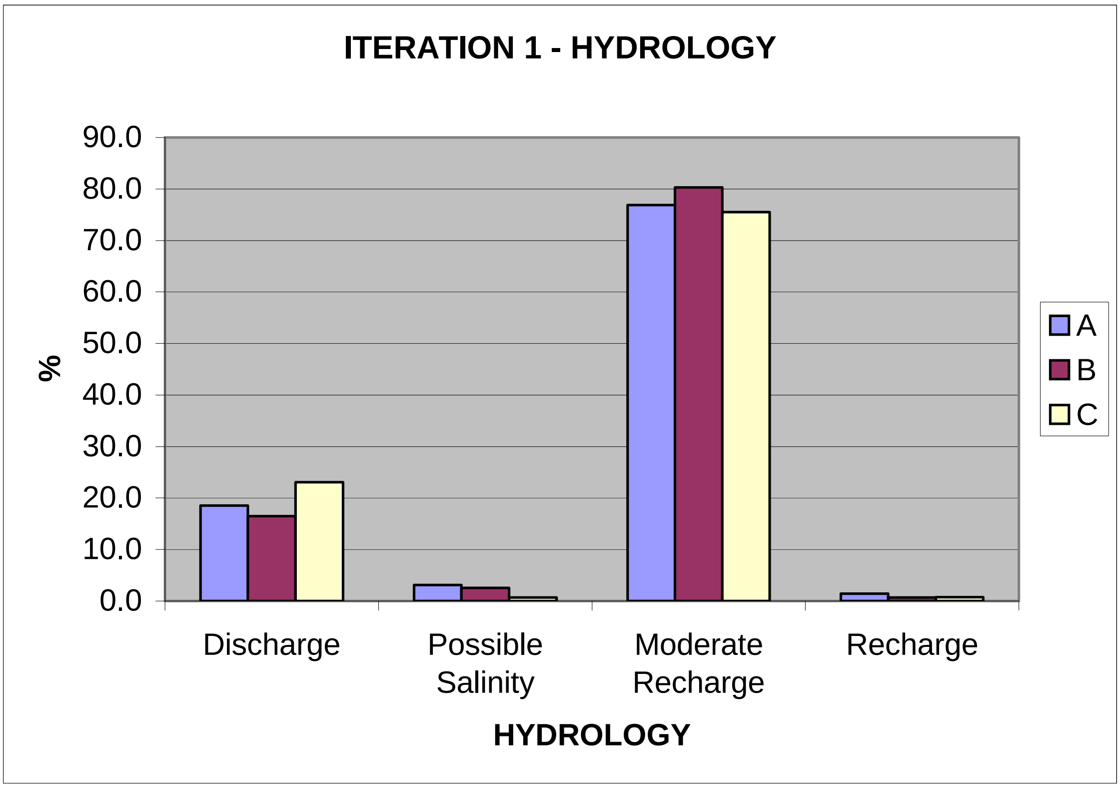


Figure 2. Percentage distribution of hydrologic classes across Farmlets A, B & C - Iteration 1.

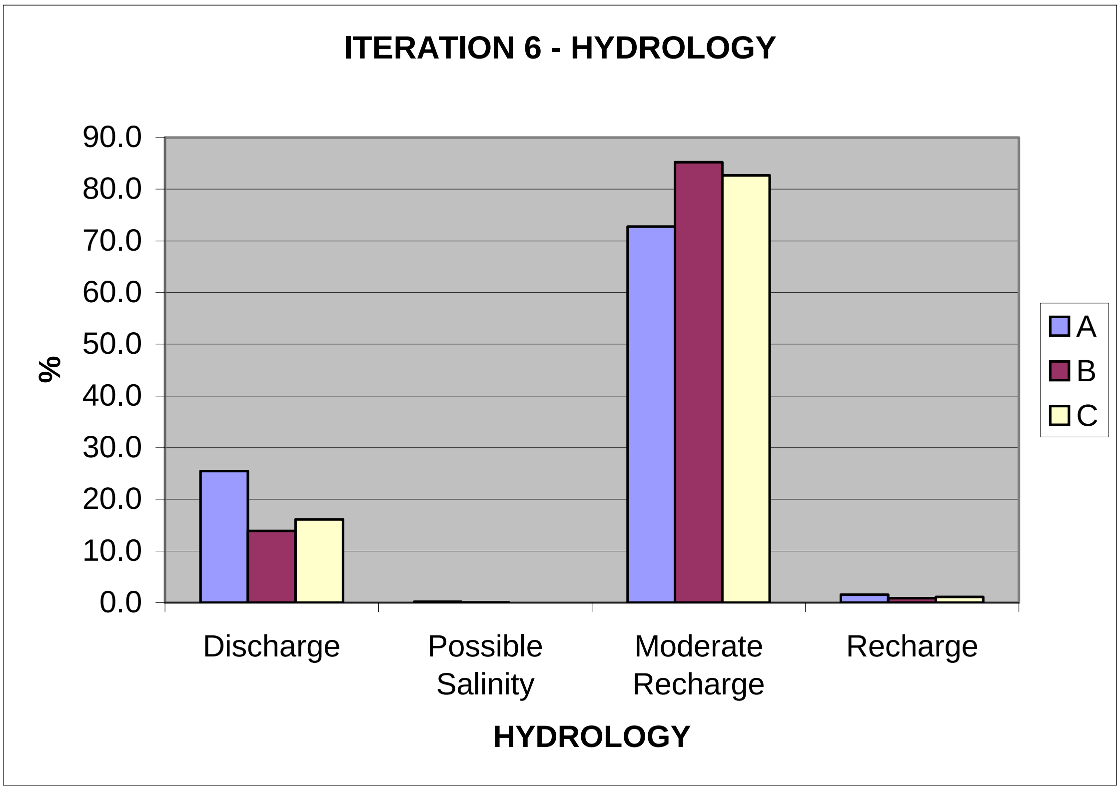


Figure 3. Percentage distribution of hydrologic classes across Farmlets A, B & C - Iteration 6.

Soil

The primary soil data source available was a CSIRO soils map, a digitised version of which is presented as Plate 4. This map was further generalised into two soil classes: podsolic and basaltic (Plate 5).

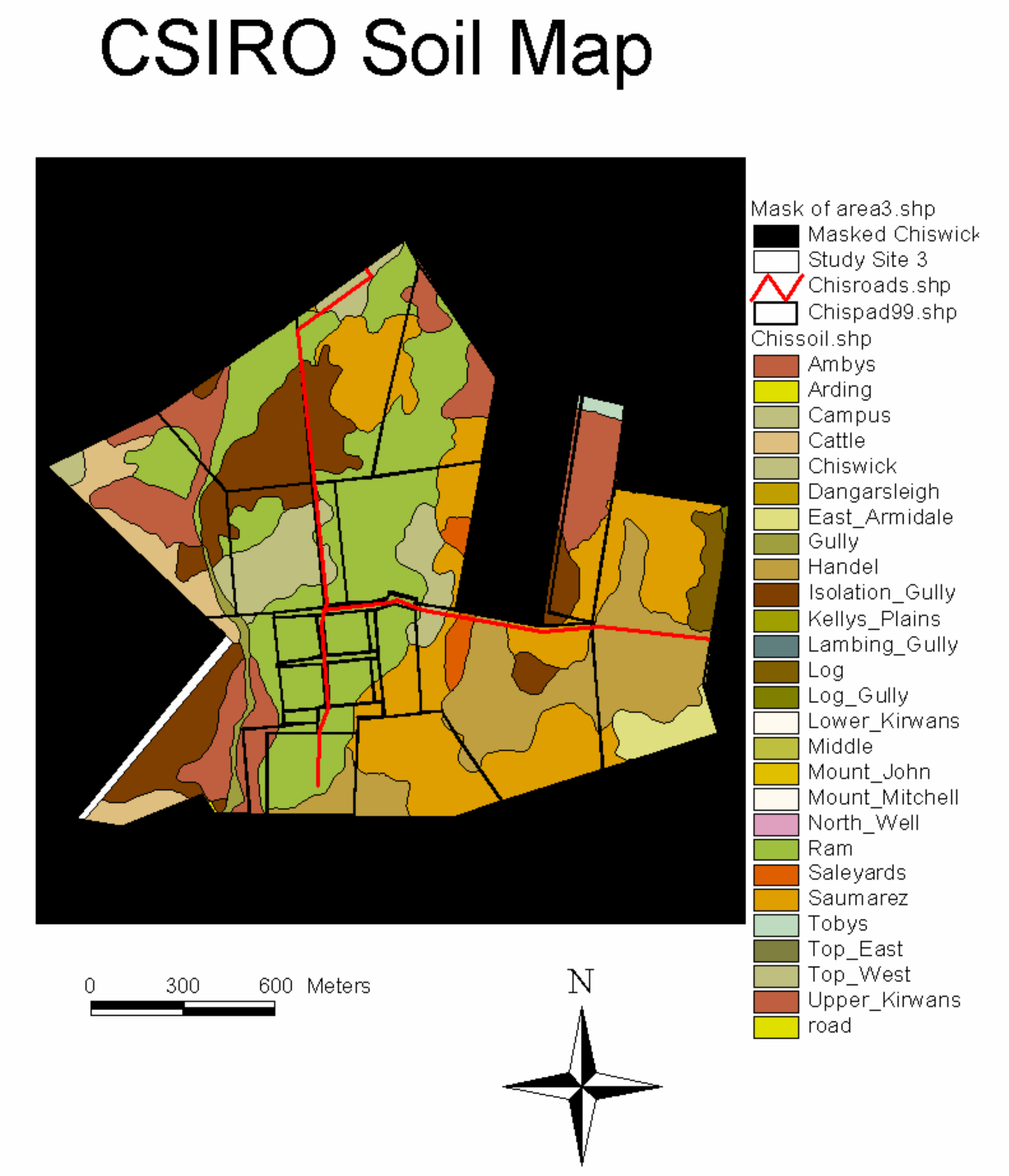


Plate 4 CSIRO soil map: sub-section showing CSIRO commissioned soil distribution on the study site at 'Chiswick'.

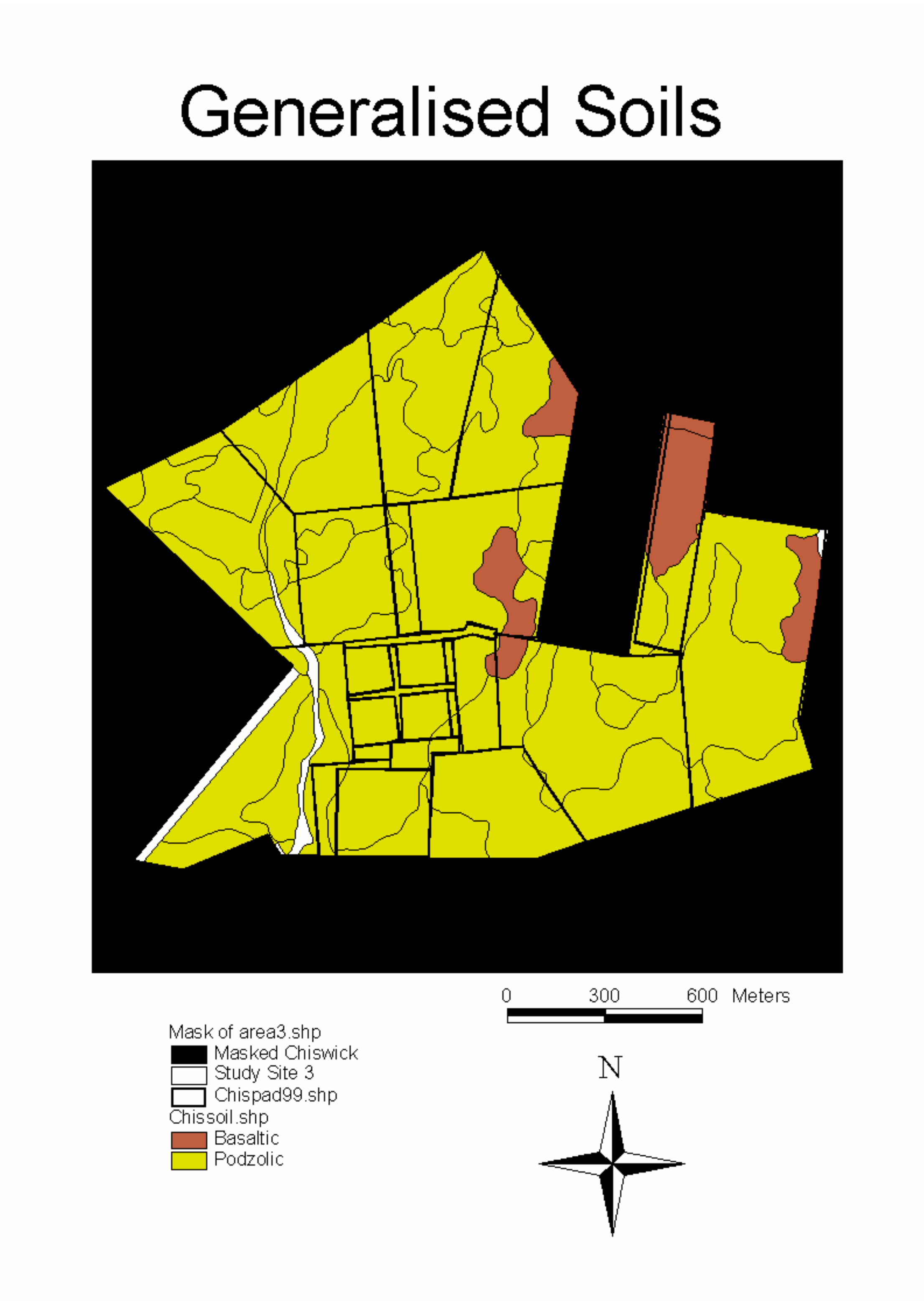


Plate 5. Generalised Soil Map. Generalised version of CSIRO soil map showing broad podsolic and basaltic soil types.

Figures 4 and 5 illustrate the distribution of soil types across the farmlets. Considering that the CSIRO generalised soil data was not used in the actual iterative process, this distribution of soil types shown in Iteration 6 (Figure 5) reinforces the notion that the EM data was in fact a reliable data source as it more than adequately accounted for the CSIRO soil data with out its actual inclusion.

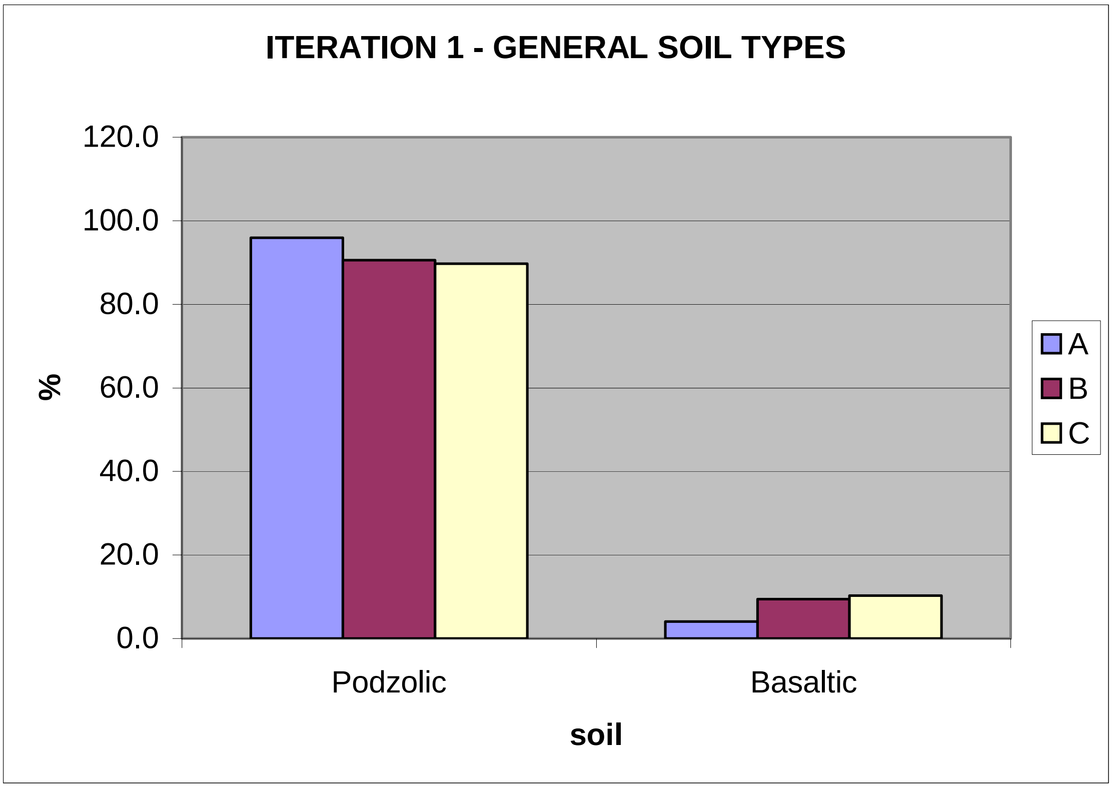


Figure 4. Percentage distribution of soil types across Farmlets A, B & C - Iteration 1.

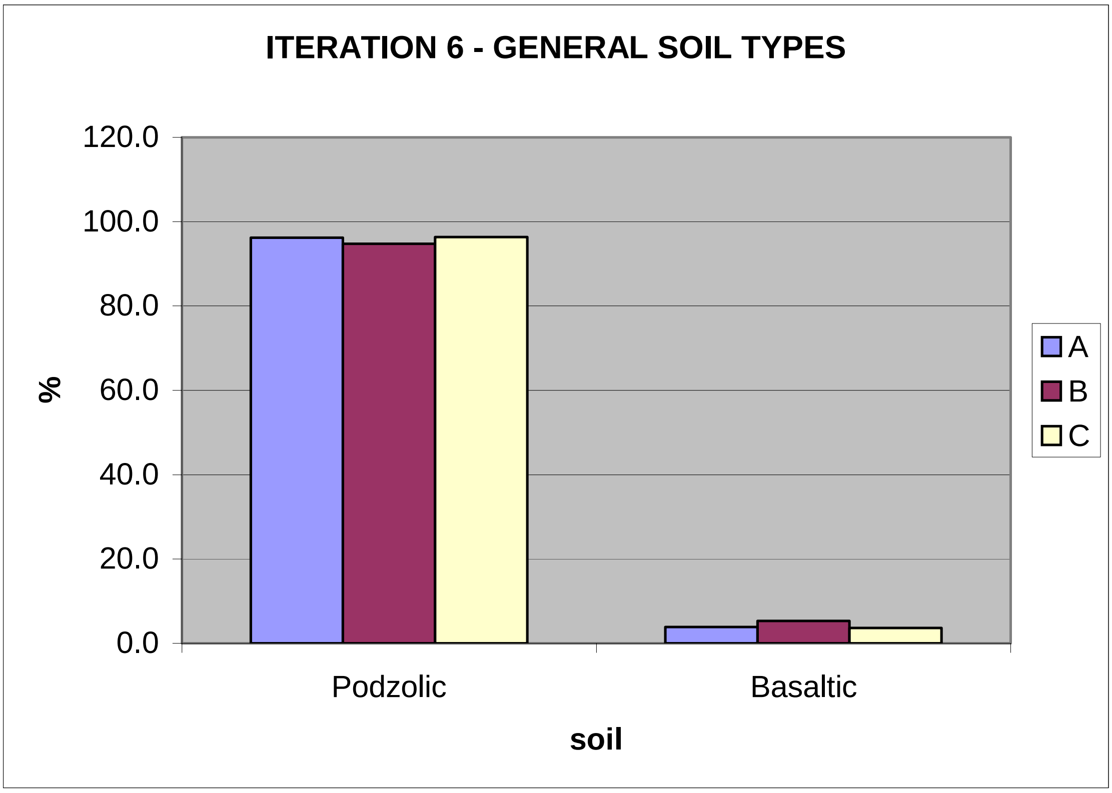


Figure 5. Percentage distribution of soil types across Farmlets A, B & C - Iteration 6.

Slope

Plate 6 illustrates the main terrain classifications for the property. There is a small hill to the south with a steep side slope on the west leading into isolation gully. A moderate lower slope surrounds the northern and eastern faces of the hill undulating towards the flatter areas of the property's north.

Plate 6. Slope unit distribution across the study site.

The distribution of the slope classes across each of the farmlets was excellent and reasonably uniform when comparing Iteration 1 and Iteration 6 (Figures 6 and 7).

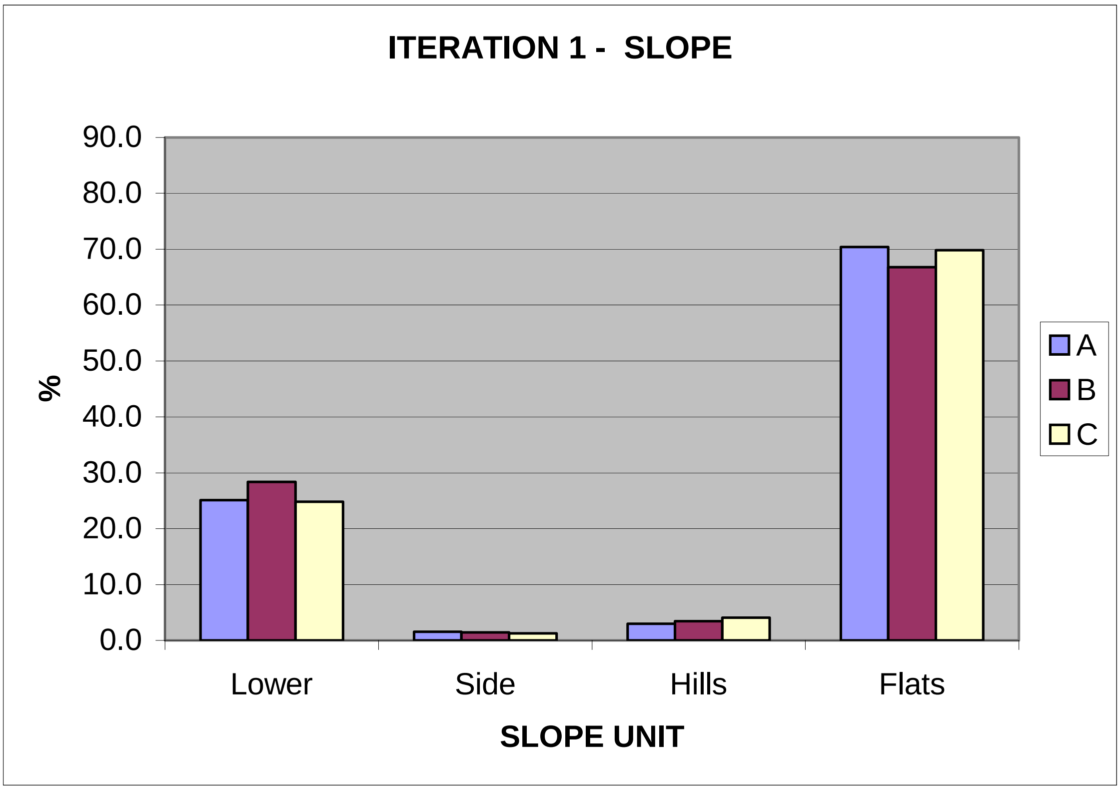


Figure 6. Percentage distribution of slope classes across Farmlets A, B & C - Iteration 1.

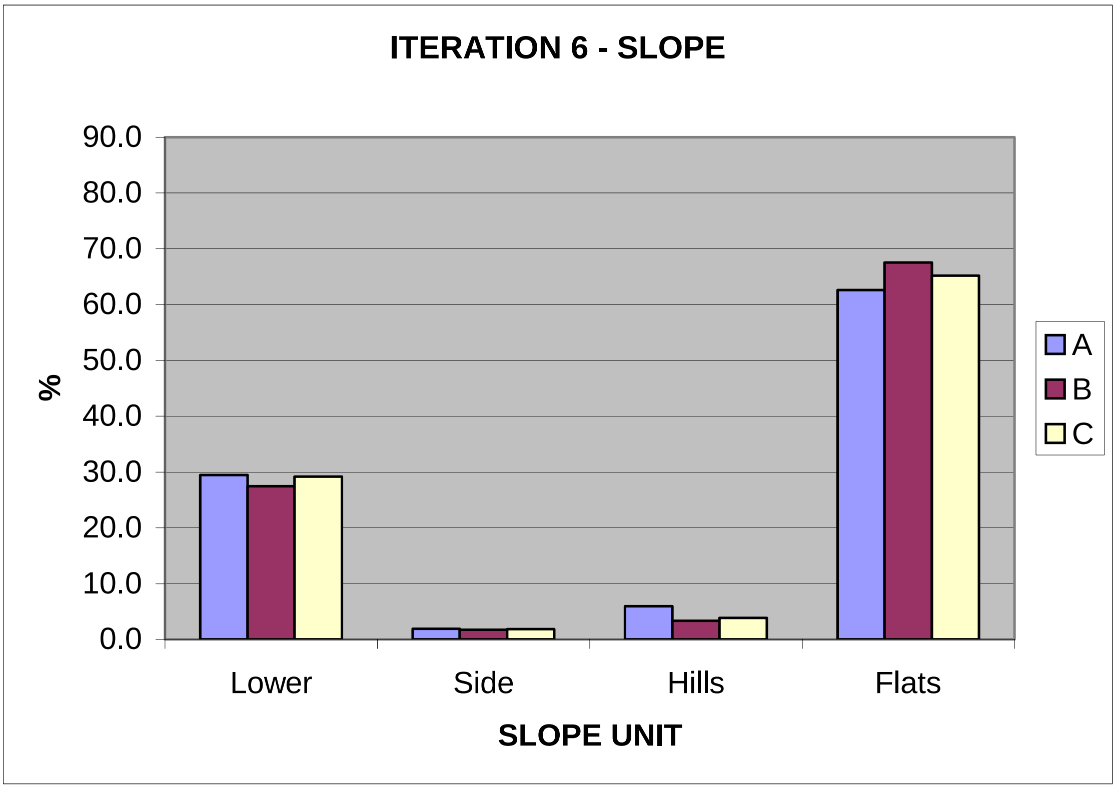


Figure 7. Percentage distribution of slope classes across Farmlets A, B & C - Iteration 6.

Fertiliser History

The fertiliser distribution shown in Plate 7 comprises three different fertiliser zones. Fertiliser history was considered to be the lowest priority during the iterative process as this can be manipulated by farm management.

Plate 7. Fertiliser distribution. History of fertiliser application on the study site.

The distribution of fertiliser across each farmlet for iterations 1 and 2 is shown below as Figures 8 and 9 respectively. The distribution of areas with different fertiliser histories is approximately equal with the following exceptions: Farmlet B has approximately 5% (2.5ha) more area of land with a history of no superphosphate application than either Farmlets A or C, and Farmlet C has approximately 12% (6ha) more area within the 'superphosphate 1992 –

1997 @ 125 kg/ha' than Farmlets A and B.

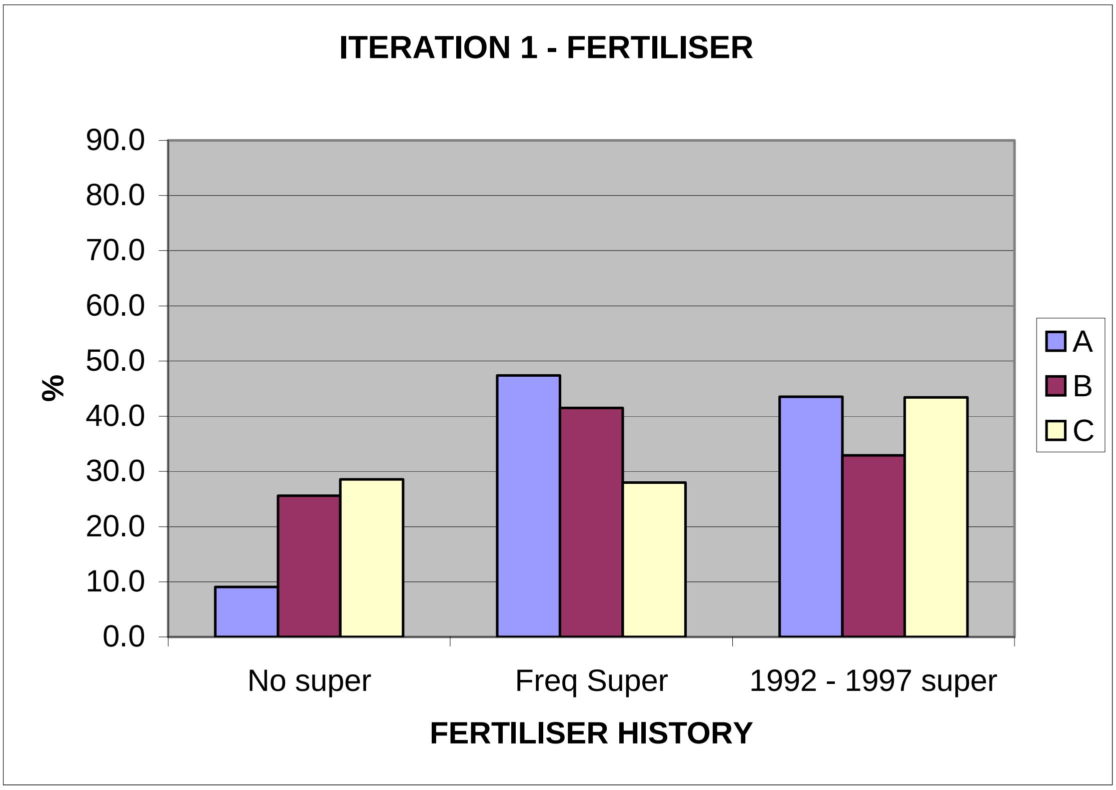


Figure 8. Percentage distribution of fertiliser classes across Farmlets A, B & C - Iteration 1.

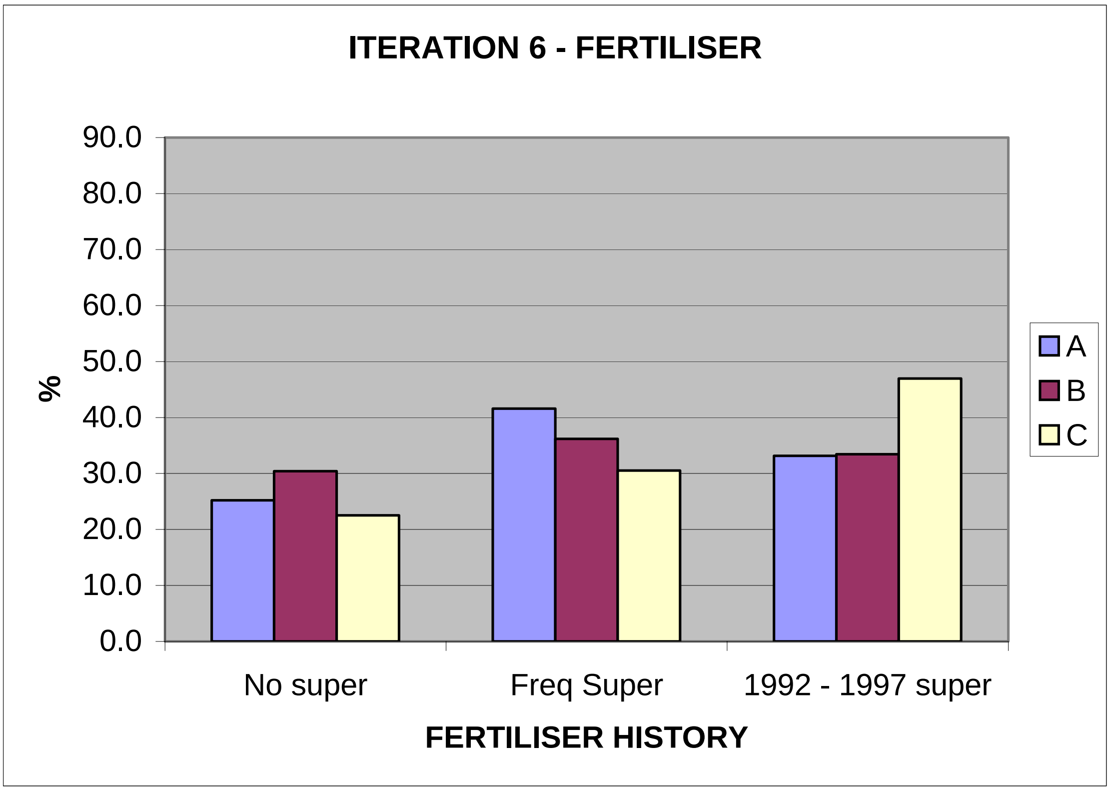


Figure 9. Percentage Distribution of Fertiliser Classes across Farmlets A, B & C - Iteration 6.

Iteration 1

Iteration 1 (Plate 8) represents the theoretical optimal distribution of the three farmlets A, B & C, as it is constrained only by the distribution of environmental factors and not management or financial concerns.

Plate 8. Iteration 1 depicting the initial farmlet allocation based upon the apparent EM/slope relationship (presented below as Plate 9).

EM / Slope Relationship

Plate 9 below displays the EM/slope relationship on the study site.

Plate 9. EM/slope relationship. Areas of different slope are colour coded, whilst the continuous EM spectrum is shown as intensity shading.

Iteration 5

Iteration 5 (Plate 10) is presented as an intermediate step to illustrate the iterative process.

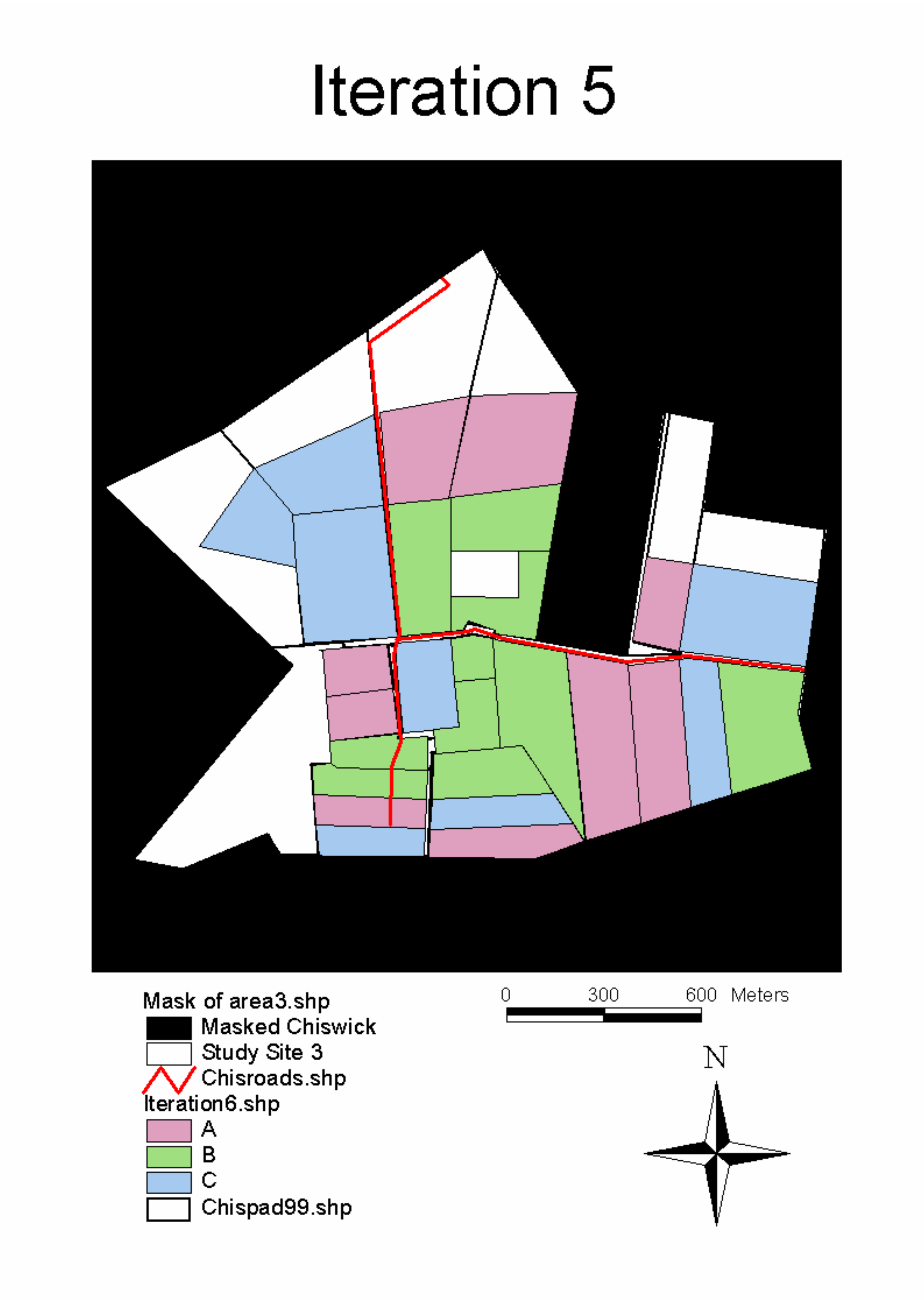


Plate 10. Iteration 5. This iteration displays a fairly even distribution of important parameters, yet would require less fencing than Iteration 1 (Plate 8). However, improvements in fragmentation, and therefore management can still be achieved as evident in comparison with Iteration 6 (Plate 11).

Iteration 6

This iteration (Plate 11) was the final product of the iterative process. No further improvements in fragmentation, fencing requirements or paddock size uniformity could be achieved without significant degradation of the EM and Slope distribution over each farmlet.

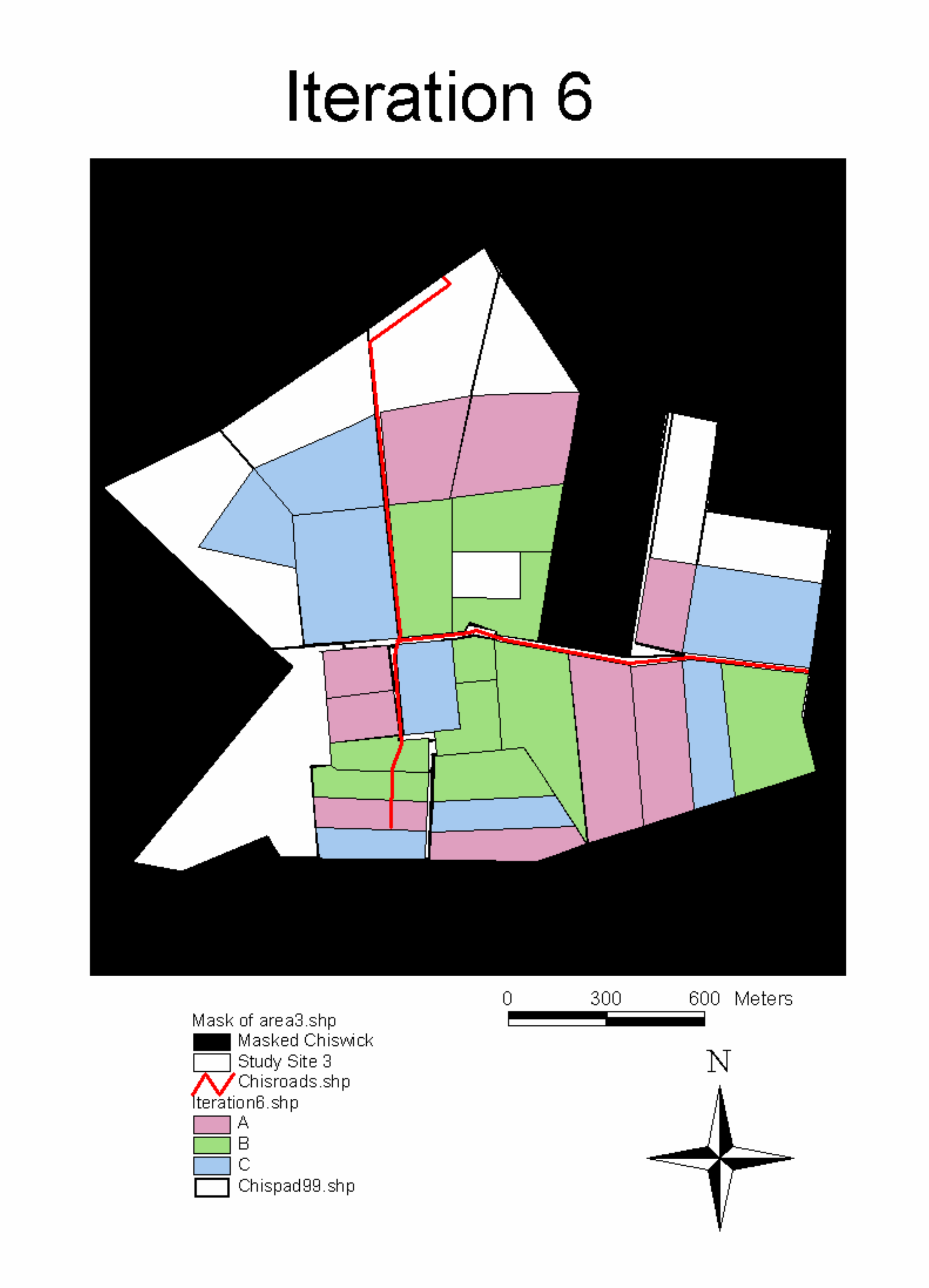


Plate 11. Iteration 6. Final farmlet allocation. This iteration produced reasonable parameter distributions with improved management and financial standing when compared with Iteration 1 (Plate 8).

Treatment Map

This map is equivalent to Iteration 6 in all respects as Treatments A, B and C were allocated to the corresponding Farmlets A, B and C.

Final Paddock Allocation

The final break up of paddocks within each farmlet is presented as Plate 12.

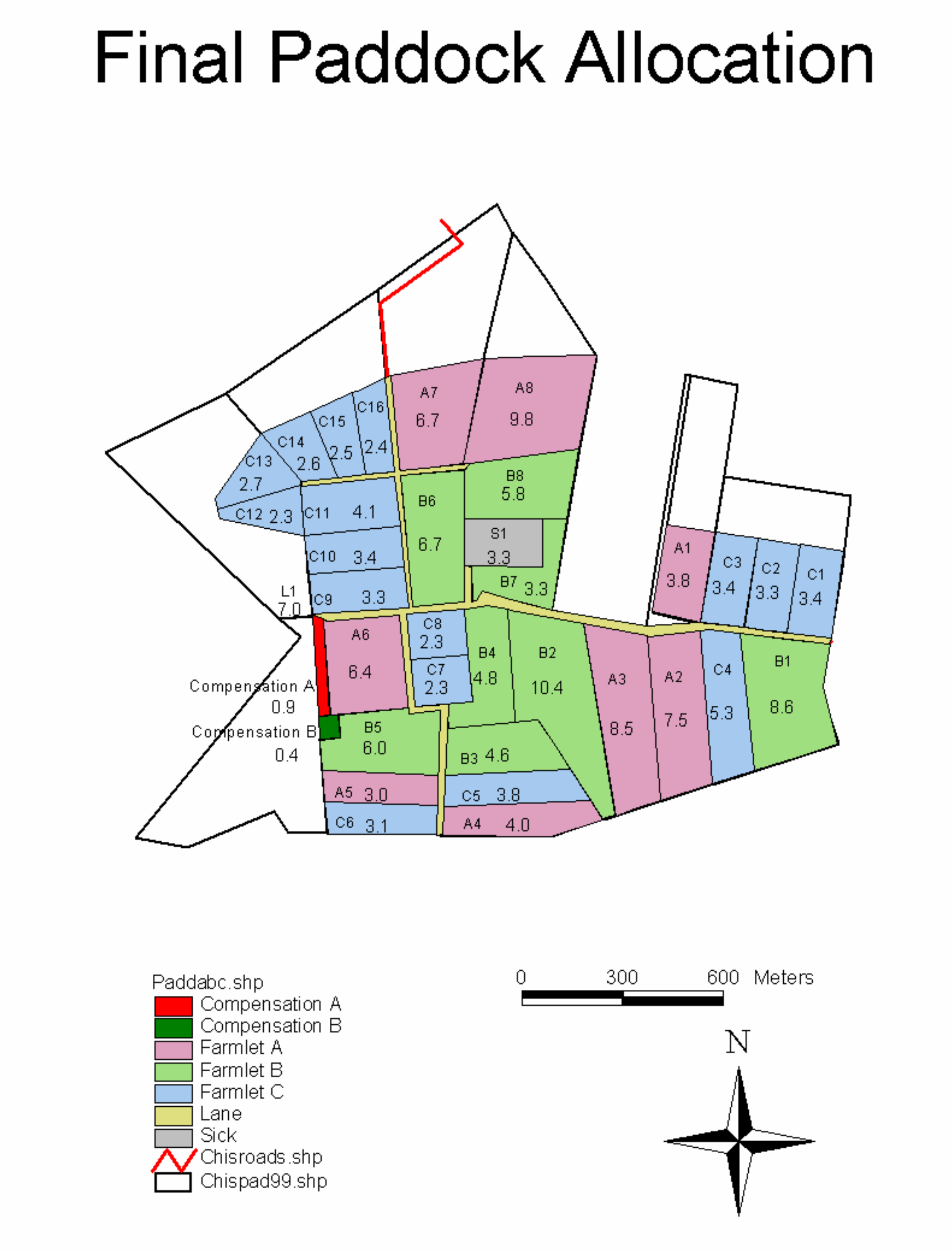


Plate 12. Final paddock allocation. This map illustrates the final paddock structure of Farmlets A, B & C.

The distribution of paddock sizes for each farmlet is presented below as Table 5.

Table 5. Paddock size distribution.

Farmlet	A	B	C
Number of paddocks	8	8	16
Minimum paddock size (ha)	3.3	3.4	2.3
Maximum paddock size (ha)	9.8	10.4	5.3
Average paddock size (ha)	6.2	6.2	3.1
Standard Deviation (ha)	2.4	2.4	0.8

Discussion

Parameter Selection

The EM data provided a solid objective point for separating the three farmlets. Although this method of data capture encounters difficulties with land forms such as gullies (as a 4WD bike cannot traverse) it was able to produce good quality two dimensional maps correlating well with both soil type and hydrology.

The slope data was somewhat subjective as it was based upon human interpretation of an aerial photograph. However, the land classes present on the property are generally large and sweeping (enabling an experienced operator to estimate the actual boundaries) or stark contrasts (such as Isolation gully), and therefor easily mapped.

Available soil data was not considered during the iterative process due to the high correlation with the EM data as outlined previously. It is worth mentioning however that the distribution of the two basic soil types (podsolic and basaltic) over each of the farmlets in Iteration 6 (Figure 5) displays remarkable uniformity considering this data was not incorporated directly and lends weight to the assumed correlation between the EM and soil data.

Fertiliser was applied in three regimes in three separate zones of the property (Plate 7). It was decided that fertiliser distribution was not a high priority as this could be altered by human intervention after farmlet allocation (unlike soil type and slope).

Division of Property

Farmlet Areas

The total areas of each farmlet A, B and C are approximately equal at 50 hectares as can be verified by Table 4. Ground truthing using Pinpoint^{TM} confirmed that all digital measurements were reasonably accurate and this translated into easy field measurements by farm managers when erecting the new fence lines.

Fragmentation and Laneways

An unfortunate side effect of the almost ideal parameter break up is that it has led to some fragmentation of the farmlets (Plate 12). Although minimised through successive iterations, the fragmentation within each farmlet has necessitated the inclusion of laneways as a transport system. The laneway system connects all areas of the property with all other areas of the property at minimum fencing cost (as most laneways will only require additional fencing on one side) and is designed so that there are no excessive distances for stock to travel. The laneway system also gives superior access to the central handling yard, the sick paddock and for farm visitors. Additionally, when viewed from a scientific standpoint, the spatial distribution of the farmlets lends additional weight to the assumption that the farmlets are in fact equal in all respects (i.e. all farmlets are spread fairly evenly over the actual property).

The Rest (or sick) Paddock

A rest paddock was included in the farm design as an exclusion zone for new or ailing stock. This paddock is approximately 3.3 ha in area and is situated on an area excluded from farmlet allocation due to drainage problems. This paddock can be accessed via the laneway system from any other paddock in the farmlet system and is located in close proximity to the centralised handling yards.

Distribution of parameters

The distribution of all parameters across each of the Farmlets in Iteration 6 was close to the theoretical optimum distributions of Iteration 1. The only significant deviations related to a 10% (5 ha) difference in hydrology between Farmlet A and that of Farmlets B and C, and some small fertiliser history differences. The deviations in hydrology could not be overcome as changes to the hydrology of Farm A necessarily resulted poorer distribution of the other important parameters.

However, fertiliser history can be easily corrected through additional application to key areas. In order to even the fertiliser distribution, it is recommended that superphosphate be applied to 5% (2.5 ha) of Farmlet B in an area designated previously as a 'no superphosphate' zone at a rate equal to that of the 'frequent superphosphate' zone. This will decrease the 'no superphosphate' area of Farmlet B by 5% and increase the 'frequent superphosphate' area of Farmlet B to levels approximating that of Farmlet A. In addition, 12% (6 ha) of the '1992 - 1997 superphosphate' zone of Farmlet C should have fertiliser added to reach the equivalent of the 'frequent superphosphate' zone, thus almost completely removing any differences in fertiliser distribution among farmlets.

It is important to remember the effects of time on past fertiliser applications (due to residual fertiliser effects) and this must be considered when deciding equitable application rates.

Treatment allocation

The paddock distribution of Farmlet C was the most suitable for application of Treatment C as lane way access was required for 16 paddocks. Ironically, after this initial allocation, the randomised allocation of Treatments A and B produced a distribution of Treatments A, B and C across Farmlets A, B and C respectively. This distribution, although unexpected, is convenient in that it allows easy interpretation of the graphs and tables produced for Farmlets A, B and C prior to treatment allocation (i.e. farmlet A has not become Farmlet B or C in the graphs and tables of the results).

Division into Final Paddocks

Paddock Size Distribution

The distribution of paddock sizes within the farmlets was also cause for some concern. In an ideal situation all paddocks would be of equal size in Farmlets A & B (8 paddocks of approximately 6.25 ha), and half this size in farmlet C (16 paddocks of approximately 3.125 ha each). However, the small amount of suitable available land, the existing initial internal fencing pattern, the distribution of important parameters and the overall shape of the property made this extremely difficult to achieve. Actual paddock sizes ranged considerably (Table 5) within each of the farmlets and therefore stocking regimes may need to be calculated for each paddock of each farmlet in order to carry out successful implementation of the farmlet treatments.

Fencing

Efforts were made to ensure that fencing costs were minimised within the project enabling many reductions in fencing requirements to be made over successive iterations. Iteration 1 required the removal of almost all existing fence lines and appeared expensive to re-fence due to the jagged and erratic nature of the paddock shapes. Iteration 6 was able to retain most major existing fence lines, requiring mostly the removal of the smaller paddock fences on the southern hilltop. The large number of small paddocks removed naturally contained many gates, star pickets and strainer posts that could be utilised elsewhere in the paddock design, thus further lowering fencing costs through material recycling.

Conclusion

The Final Paddock Allocation Map (Plate 12) based upon the distribution of important parameters in Iteration 6 (Plate 11) represents the most equal subdivision of the study site into three Farmlets A, B and C. The paddock design of the 'Final Paddock Map' (Plate 12) minimises fencing costs, fragmentation and paddock size deviation while optimising stock transport capacity, laneway access and environmental equality. Paddock size distribution remained a problem, however, with small applications of fertiliser the farmlets can be considered approximately equal in terms of location, area, hydrology, soil type, slope, and fertiliser history, consistent with experimental assumptions.

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