

Identifying Potential Agricultural and Horticultural Markets for Composted Garden Organics in New South Wales

Department of **Environment & Climate Change** NSW



Published by:
Department of Environment and Climate Change NSW
59–61 Goulburn Street
PO Box A290
Sydney South 1232
Ph: (02) 9995 5000 (switchboard)
Ph: 131 555 (environment information and publications requests)
Ph: 1300 361 967 (national parks information and publications requests)
Fax: (02) 9995 5999
TTY: (02) 9211 4723
Email: info@environment.nsw.gov.au
Website: www.environment.nsw.gov.au

DECC 2008/99
ISBN 978 1 74122 745 1
February 2008
© Copyright Department of Environment and Climate Change NSW February 2008

TABLE OF CONTENTS

Executive summary.....	6
1 Introduction.....	9
2 Objectives.....	9
3 Defining the Product.....	10
3.1 Definition of composted garden organics.....	10
3.2 Quantity and quality of composted garden organics produced in the Sydney Metropolitan area.....	11
3.2.1 Sources and Quantities of Garden Organics.....	11
3.2.2 Production Processes.....	12
3.2.3 Characteristics of Composted Garden organics.....	12
4 Segmenting the Market for Composted garden organics products.....	18
4.1 Competing Products.....	18
4.1.1 Characteristics of composted garden and agricultural organics.....	18
4.1.2 Inorganic fertilisers and soil amendments.....	19
4.1.3 Biosolids.....	20
4.1.4 Poultry Litter.....	21
4.1.5 Pig and cattle manure.....	22
4.1.6 Crop residues and green manure crops.....	22
4.1.7 Summary.....	23
4.2 Agricultural and horticultural production systems in NSW.....	23
4.2.1 Conventional Broadacre.....	24
4.2.2 Conventional Vegetables.....	24
4.2.3 Cotton.....	24
4.2.4 Organic Agriculture.....	25
4.2.5 Perennial Horticulture.....	25
4.2.6 Turf.....	25
4.2.7 Viticulture.....	25
4.3 Profitability of the agricultural and horticultural market segments.....	35
4.4 Comparative Market size and Gross Margins for different cropping systems.....	39
4.4.1 Use of Fertilisers and soil amendments in NSW farming systems.....	39
5 Soils and potential benefits of RO application to agricultural land.....	43
5.1 Distribution of soil types in NSW.....	43
5.2 Soil Organic Matter.....	43
5.3 Potential benefits of composted garden organics to soils.....	45
5.4 Carbon storage potential of agricultural soils in NSW.....	45
5.4.1 Impact of farming systems on soil carbon status.....	46

5.4.2	Attributes of sites most likely to respond to composted garden organics:.....	53
6	Potential markets for Composted garden organics.....	53
6.1	Potential Markets.....	53
6.1.1	Conventional Broadacre.....	53
6.1.2	Conventional Vegetables	54
6.1.3	Cotton.....	55
6.1.4	Organic Agriculture.....	56
6.1.5	Perennial horticulture	57
6.1.6	Turf.....	58
6.1.7	Viticulture.....	59
6.2	Value chain analysis.....	59
6.3	Barriers to markets	62
6.3.1	Policy and Regulatory	62
6.3.2	Economic.....	62
6.3.3	Social.....	62
6.3.4	Technical	62
6.4	Critical success factors for supplying composted garden organics into agricultural and horticultural markets	63
6.4.1	Conventional Broadacre.....	63
6.4.2	Conventional Vegetables	64
6.4.3	Cotton.....	65
6.4.4	Organic Agriculture.....	66
6.4.5	Perennial Horticulture.....	67
6.4.6	Turf.....	68
6.4.7	Viticulture.....	69
7	Strategy for creating new markets for Composted garden organics.....	69
7.1	Consistently producing a high quality product.....	69
7.2	Quantifying the benefits.....	70
7.2.1	Agronomic production and soil health	70
7.2.2	Environmental issues in Catchments	70
7.2.3	Global warming and Greenhouse gas abatement schemes	70
7.3	Promoting the benefits to stakeholders	71
7.4	Identifying mechanisms to establish new markets	71
8	Conclusions and Further Research	71
9	Bibliography.....	74

Tables

Table 1.	Definitions of terms used in this report	10
Table 2.	Estimate of the quantity of garden organics processed in the Sydney and non-Metropolitan Areas in New South Wales during 2002/03	11
Table 3.	Summary of physical, chemical and biological characteristics of composted garden organics collected from compost producers in Sydney	13
Table 4.	Comparison of the characteristics of composted garden organics, biosolids, poultry litter, cattle feedlot manure piggery solids and cotton gin trash generated in NSW	19
Table 5.	Market segments and indicator crops used to quantify potential market size for composted garden organics in agricultural and horticultural markets in NSW	23
Table 6.	Average wheat and canola yields in the Cowra, Wellington and Gunnedah districts in NSW from 1993-2003	24
Table 7.	Summary of gross margins for different agricultural and horticultural market segments, based on average yields and prices.	35
Table 8.	Variable cost components as a percentage of the total variable cost for different agricultural and horticultural production systems in New South Wales.	38
Table 9.	Organic carbon concentrations (%) (0-10cm) in cropped and undisturbed soils in different farming systems of NSW	50
Table 10.	Comparison of current asking price for composted soil conditioners and mulches against the price the market is willing to pay for these products for agricultural and horticultural uses	61
Table 11.	Critical Success Factors for composted garden organic soil conditioners in Conventional Broadacre markets	63
Table 12.	Critical Success Factors for composted garden organic soil conditioners in Conventional Vegetable markets	64
Table 13.	Critical Success Factors for composted garden organic soil conditioners in cotton markets.....	65
Table 14.	Critical Success Factors for composted garden organic soil conditioners in Organic Agriculture markets	66
Table 15.	Critical Success Factors for composted garden organic mulches in Perennial Horticulture markets	67
Table 16.	Critical Success Factors for composted garden organic soil conditioners in Turf markets.....	68
Table 17.	Critical Success Factors for composted garden organic mulches in Viticulture markets.....	69

Figures

Figure 1. Market segment demand for recycled organics products.....	11
Figure 2. Variation in pH and Electrical Conductivity (dS/m) in composted soil conditioner produced at a single composting facility within the greater Sydney Metropolitan Area over time	15
Figure 3. Variation in Organic Matter (%) and C/N ratio in composted soil conditioner produced at a single composting facility within the greater Sydney Metropolitan Area over time	16
Figure 4. Variation in compost Total Nitrogen (%) and Total Phosphorus (%) concentrations in composted soil conditioner produced at a single composting facility within the greater Sydney Metropolitan Area over time.....	16
Figure 5. Variation in metal concentrations (mg/kg) in composted soil conditioner produced at a single composting facility within the greater Sydney Metropolitan Area over time.....	17
Figure 6. Plastic contamination reduces market perception of compost products	18
Figure 7. Area of wheat grown in New South Wales in relation to distance from the Sydney Metropolitan Area.....	26
Figure 8. Area of canola grown in New South Wales in relation to distance from the Sydney Metropolitan Area.....	27
Figure 9. Area of vegetables grown in New South Wales in relation to distance from the Sydney Metropolitan Area	28
Figure 10. Area of cotton grown in New South Wales in relation to distance from the Sydney Metropolitan Area.....	29
Figure 11. Number of Apple trees grown in New South Wales in relation to distance from the Sydney Metropolitan Area.....	30
Figure 12. Number of orange trees grown in New South Wales in relation to distance from the Sydney Metropolitan Area	31
Figure 13. Number of peaches trees in New South Wales in relation to distance from the Sydney Metropolitan Area	32
Figure 14. Area of turf grown in New South Wales in relation to distance from the Sydney Metropolitan Area	33
Figure 15. Area of grapes grown in New South Wales in relation to distance from the Sydney Metropolitan Area.....	34
Figure 16. Comparative market size and gross margins for different cropping systems within 300 km of Sydney.....	39

Figure 17. Area of land treated with gypsum in New South Wales in relation to distance from the Sydney Metropolitan Area 41

Figure 18. Area of land treated with lime in New South Wales in relation to distance from the Sydney Metropolitan Area 42

Figure 19. Soil types around the Sydney region (NSW Soil Conservation Service)..... 44

Figure 20. Average annual rainfall in NSW 47

Figure 21. Locations of existing soil carbon data from undisturbed sites 48

Figure 22. Locations of existing soil carbon data from cropping sites of NSW..... 49

Figure 23. Changes in soil carbon storage (0-10 cm) as a function of annual rainfall for pasture and cropping soils of NSW 51

EXECUTIVE SUMMARY

This report evaluates potential agricultural and horticultural markets for composted garden organics in New South Wales by considering the location, size and production economics of different potential markets, identifying sites with the potential to respond to composted garden organics products based on soil characteristics and seeking out viable agricultural industries. Information obtained from stakeholders, including compost processors, certifying bodies, agronomists and researchers, was also used to identify opportunities for and potential barriers to market establishment.

Defining the product

Composted garden organics are products derived from composting grass cuttings, prunings and other organic material collected from domestic gardens. This report focuses on soil conditioners and mulches made from composted garden organics in the greater Sydney Metropolitan area, of which an estimated 270,000 tonnes are produced each year.

The main beneficial chemical characteristic of composted garden organics is organic matter, which ranges from 17-54%. The consistency of composted garden organics is influenced by a number of factors, including the size of the composting operation, geographical location, season, rainfall patterns and method of collecting garden organics. Plastics also have a major impact on compost quality, particularly mulches, and strongly influence market perception of the product. Processors believe the best long-term solution for reducing plastic contamination in compost products is source separation at the household level.

Segmenting the market for composted garden organics

Composted garden organics are unlikely to directly compete with inorganic and organic fertilisers, such as poultry litter, animal manure and biosolids, as an economically viable source of nutrients for growing plants. However, opportunities exist to blend composted garden organics with inorganic and/ or organic fertilisers to create a stable product, which is high in nutrients and organic matter for application in production systems where improved nutrient management is required. Composted garden organics also have potential for use as soil amendments either as a stand alone product, or in combination with gypsum and lime.

Agricultural and horticultural production systems in NSW

Data on the size, location, production figures and areas of different agricultural and horticultural production systems in NSW were analysed to characterise existing agricultural production systems and quantify the potential of each market. The total agricultural and horticultural market was segmented into conventional broadacre, conventional vegetables, cotton, organic broadacre, organic vegetables, perennial horticulture, turf and viticulture. Gross margins budgets were also used to evaluate the profitability of each market segment.

The relative size and value of each market segment within 300 km of Sydney, was evaluated by plotting crop area against the average gross margin. This revealed a trade-off exists between market profitability and size, with turf being the most profitable and conventional broadacre the largest potential market. Viticulture and cotton have high gross margins and large areas of production, followed by perennial horticulture and vegetables. Organic broadacre and organic vegetables have higher gross margins than conventional production systems but currently only represent small percentage of total production area.

Soils and potential benefits of applying composted garden organics to agricultural land

Composted garden organics have the potential to improve soil physical, chemical and biological characteristics. However, most of the research into the benefits of composted garden organics has been conducted overseas, which creates uncertainty about their relevance to Australian

conditions. There have been some studies in Australia, although many of these have been non-replicated, have had inconclusive results and have not been published in peer reviewed journals. Moreover, few studies have quantified these benefits in terms of increased crop productivity, reduced variable costs and increased profitability or gross margins (\$/ha). Hence, there is a need to quantify these benefits and promote the overall benefit in terms of improving the sustainability of the production system.

In order to identify soils or regions with the greatest potential to respond to composted garden organics, the soil carbon storage potential of agricultural soils in NSW was evaluated by collating existing information on the soil carbon status from different farming systems. This revealed that large amounts of soil carbon have been lost from agricultural soils in New South Wales as a consequence of historical soil management practices, such as excessive cultivation, and that significant potential exists in these soils to store carbon.

The soil carbon storage capacity is greatest in higher rainfall areas (>600 mm). Higher rainfall cropping zones are more likely to positively respond to organic inputs, such as composts, and so efforts to establish markets for composted garden organics should focus on these areas. Soils with low organic matter, poor soil structure and low chemical fertility should be identified within each market segment, as these sites are most likely to respond to the application of composted garden organics.

Potential markets for composted garden organics

Turf has immediate potential as a market for soil conditioners, given there is demand for a source of organic matter which is low in nutrients, to replace topsoil removed when turf is harvested. The turf market is highly profitable, well organised, relatively homogenous and nearly wholly within the Sydney basin. However, turf is only a small market in comparison to the total quantity of composted garden organics produced and so other markets will also need to be developed.

Vegetables have also been identified as a potential market for soil conditioners made from composted garden organics, near Sydney, given their potential to reduce the impact of nutrients on water quality within the Hawkesbury-Nepean River. However, incentives and initiatives will need to be developed for vegetable producers to change current nutrient management practices.

From a sustainability perspective, broadacre agriculture is the market with the greatest potential because it has large areas of land which are low in soil organic matter and subject to problems with soil structural stability. In addition, fertilisers and soil amendments are major input costs in broadacre systems, suggesting there is scope for composted garden organics to improve fertiliser use efficiency and increase crop gross margins.

Viticulture and perennial horticulture have been identified as the markets with the greatest potential to consume composted garden organic mulches. This is because large areas of high value irrigated grape, citrus, pome and stone fruit crops are grown in close proximity to Sydney. Decreased water availability is increasingly becoming an issue for growers and so opportunities exist to promote composted garden organic mulches as a way of conserving water in these systems.

A value chain analysis was performed to compare current retail prices for mulches and soil conditioners, including purchasing, transport and application costs, with the prices each market segment is likely to pay for them. This revealed a negative price differential for all market segments evaluated. The price differential was the least negative for supplying mulch into viticulture and perennial horticulture at -\$5 and -\$8/t, respectively. For composted soil conditioners, turf and vegetable production systems were the least negative at -\$25/t. Hence, the perceived value of these products by the market needs to increase and the costs of producing and delivering these products to market needs to decrease to reduce the gap between market asking and buying prices.

Central west New South Wales should be targeted as the most suitable area for establishing agricultural markets for composted garden organics outside Sydney because it has high rainfall (>600mm), produces a diverse number of crops and has large areas of soils which could respond to organic inputs. Additional research is required to identify responsive sites in this district and quantify the benefits of using composted garden organics in these systems.

Strategy for creating new markets for composted garden organics

A strategy is required to establish environmentally sustainable and economically viable markets for composted garden organics. The components of this strategy should include:

- Undertaking targeted research aimed at demonstrating how composted garden organics can help overcome specific crop syndromes, nutritional disorders or soil quality issues.
- Promoting these benefits to farmers and food consumers through education and extension campaigns to create market pull.
- Highlighting the value of composted garden organics to Government and stakeholders, as a tool in addressing waste management and soil and water quality issues in urban and agricultural catchments.

This will improve the perceived value of composted garden organics and help reduce the costs which currently act as the main barrier to delivering these products to agricultural and horticultural markets.

1 INTRODUCTION

Australian agricultural soils are generally low in soil chemical and physical fertility and have traditionally relied on inorganic fertiliser inputs to sustain production. Agricultural production systems have evolved where nutrients are typically imported into agricultural catchments and the outputs are exported from them. This has resulted in a one way flow of resources to overseas or metropolitan markets, which act as nutrient sinks.

Metropolitan areas generate significant quantities of organic material, which often end up in landfills. Many landfills are approaching capacity, with limited opportunities to establish new ones within close proximity to metropolitan areas, because of community resistance and/ or physical limitations of sites.

Consequently, NSW Government policies are placing increasing emphasis on beneficially reusing the resources contained in garden organics generated in metropolitan areas. An example of this is collecting and composting grass clippings, leaves and prunings from residential areas to produce mulches and soil conditioners for use in urban and agricultural areas. The nutrients and organic matter in these composted garden organics” have the potential to improve plant growth, soil structure and water holding capacity, as well as suppress weeds and diseases.

The Department of Environment and Conservation NSW (formerly Resource NSW) commissioned the New South Wales Department of Primary Industries to undertake a project on “Quantifying the benefits of recycled organics in agricultural cropping systems”. As part of this project it is necessary to identify potential agricultural and horticultural markets for composted garden organics from metropolitan areas to contribute towards the more sustainable use of natural resources in New South Wales.

2 OBJECTIVES

The objective of this study is to identify potential agricultural and horticultural markets for composted garden organics in NSW by:

- Considering the location and size of potential markets;
- Identifying sites with the potential to respond to composted garden organics based on soil types and existing organic carbon concentrations;
- Seeking out viable agricultural industries (dryland and irrigated), based on good gross profit margins.

3 DEFINING THE PRODUCT

3.1 Definition of composted garden organics

This study focuses on composted garden organics and their potential application in agriculture and horticulture. The definitions in ROU (2003a) have been used to describe the terms used throughout the report. These definitions are summarised in Table 1:

Table 1. Definitions of terms used in this report (ROU (2003a) and ^AStandards Australia (2003)).

Term	Definition
Compost	An organic product that has undergone controlled aerobic and thermophilic biological transformation to achieve pasteurisation and a specified level of maturity. Compost is suitable for use as a soil conditioner or mulch and can improve soil structure, water retention, aeration, erosion control and other soil properties.
Composted mulch	Any pasteurised product, which has undergone composting for not less than 6 weeks (excluding polymers, which do not degrade such as plastics, rubber and coatings) that is suitable for placing on soil surfaces. Composted mulch has at least 70% by mass of its particles with a maximum size of greater than 15mm
Composted soil conditioners	Any composted product, including vermicast, manure and mushroom substrate that is suitable for adding to soils. This term also includes 'soil amendment', 'soil additive', 'soil improver' and similar terms, but excludes polymers, which do not biodegrade, such as plastics, rubber and coatings. Soil conditioner has not more than 20% by mass of particles with a maximum size above 16mm.
Composting	The process whereby organic materials are pasteurised and microbially transformed under aerobic and thermophilic conditions for a period not less than 6 weeks. By definition it is a process that must be carried out under controlled conditions yielding mature products that do not contain any weed seeds or pathogens.
^A Fine mulch	Any pasteurised or composted organic product (excluding polymers that do not degrade, such as plastics, rubber and coatings) that is suitable for placing on soil surfaces. Fine mulch has more than 20% but less than 70% by mass of its particles with a maximum size above 16mm and complies with the appropriate criteria in Table 3.1 (Standards Australia 2003).
Garden organics	The garden organics material definition is defined by its component materials including: Putrescible garden organics (grass clippings); non-woody garden organics; woody garden organics; trees and limbs; stumps and rootballs. Such materials may be derived from domestic, commercial, industrial and demolition sources. Garden organics is one of the primary components of the compostable organics stream.
Recycled organics	The term Recycled Organics has been adopted by NSW Waste Boards and EcoRecycle Victoria as a generic term for a range of products manufactured from compostable organic materials (garden organics, food organics, residual wood and timber, biosolids and agricultural organics).

3.2 Quantity and quality of composted garden organics produced in the Sydney Metropolitan area.

3.2.1 Sources and Quantities of Garden Organics

Most compost producers have contracts with either Waste Service NSW and/or local Councils, to receive domestic garden organics harvested from kerbside collections or public drop off points. A typical contract price paid to compost producers for receiving unprocessed garden organics is in the order of \$50/t. This represents approximately 50-60% of a compost producer’s revenue, with the remainder coming from the sale of the composted mulch or soil conditioner.

An estimated 635,469 tonnes of garden organics were processed in New South Wales during 2002/03 and of this, 84% was processed in the Sydney Metropolitan Area (Table 2).

Table 2. Estimate of the quantity of garden organics processed in the Sydney and non-Metropolitan Areas in New South Wales during 2002/03.

	Garden Organics processed	
	(t)	(%)
Sydney Metropolitan Area	536,481	84
Non-Metropolitan Area	98,988	16
Total	635,469	100

Source: (DEC 2004)

Most (87%) of the recycled organics generated in the Sydney Metropolitan Area are consumed in the urban amenity market segment (Figure 1), including landscaping, and domestic garden applications. However, the urban amenity market is approaching saturation and so opportunities for increasing demand for recycled organics in other market sectors need to be identified, in order to meet anticipated increases in production.

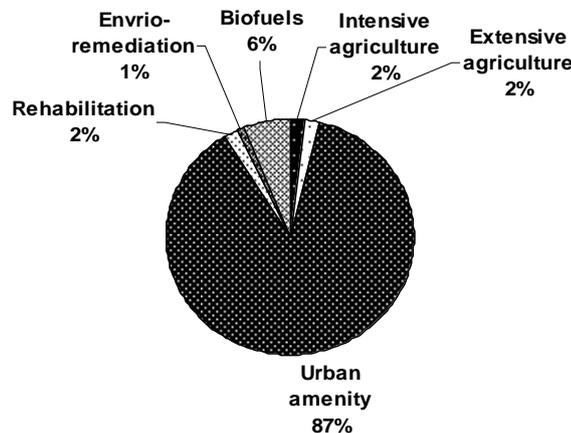


Figure 1. Market segment demand for recycled organics products (DEC 2004).

Agriculture only represents a small proportion of the current total market (4%) (Figure 1). Assuming 1 tonne of garden organics yields 0.5 tonnes of compost, approximately 10,800 t of composted garden organics, are currently applied to agricultural land. This means approximately 216 -1,080 ha of land is currently treated with composted garden organics, based on an application rate of 10-50 t/ha. However, given the large areas of arable agricultural land in New South Wales (104,241 km² (ABS 1996)), significant potential exists to grow this market segment.

3.2.2 Production Processes

Production processes vary depending on the size of the operation, input material and end-product. The general composting process is outlined below.

Once received on-site, the raw material is inspected and sorted to remove coarse contaminants such as plastics, metals and glass before it is ground using a tub or horizontal grinder. After grinding, biosolids, cattle manure or poultry litter may be added to increase the nutrient content of the end product, whilst wood chips may be added as a source of carbon. Sand or soil may also be added as a bulking agent.

The ground material is watered and piled to promote heat generation by decomposition of the material at least 55°C for three consecutive days to pasteurise the material. After pasteurisation the material is placed in windrows for up to 3 months for composting and maturation. During this time the windrows are turned and mixed to achieve even composting. Temperature, moisture and nitrogen mineralisation are commonly measured to assess compost maturity.

After the compost is matured it is screened to different grades to suit the end use of the product. Soil conditioners and coarse mulches are typically screened to <10 mm and >15 mm, respectively.

3.2.3 Characteristics of Composted Garden organics

Quality Assurance is important to ensure composts do not contain weeds, pathogens or contaminants and develop market confidence in the reliability of RO products. Hence, this study focuses on developing markets for RO products which conform with the Australian Standard for composts, soil conditioners and mulches (AS4454) (Standards Australia 2003).

As part of this study, the major compost producers in the greater Sydney Metropolitan Area were visited during June and July 2004. During these visits representative samples of composted garden organics mulches, soil conditioners and blended soil conditioners were collected and analysed for a range of physical, chemical and biological properties. This data was summarised and compared against the physical, chemical and biological characteristics of composted garden organics reported by (Wilkinson *et al.* 2000) and the limits defined in AS4454 (Standards Australia 2003).

In addition, one producer provided historical monitoring data on a soil conditioner, which has been used to examine variability in compost quality over time.

A summary of the characteristics of the composted garden organics collected from the visits to processors is presented in (Table 3). These results are comparable with data reported by Wilkinson *et al* (2000), although his data is more variable because of the larger number of sites visited and variety of samples collected. The main beneficial chemical characteristic of composted garden organics is organic matter (Wilkinson *et al* 2000), which in our survey, ranged from 17-65% organic matter (Table 3). The C/N ratios described by Wilkinson *et al* (2000) ranged 16-134 (Table 3). The C/N ratio influences the rate and effectiveness of composting and can reduce the availability of nitrogen. The C/N ratio in a mature composted garden organics should be in the order of 13-17:1 (Verdonck 1998). The low nitrogen (0.4-1.6%) and phosphorus (0.05-0.6%) concentrations in composted garden organics (Table 3) indicate they do not generally offer much fertiliser value (Wilkinson *et al.* 2000). However, composted garden organics blended with materials such as biosolids, poultry litter or cattle manure, have higher nitrogen and phosphorus concentrations (Table 4), which can be used as a source of nutrients to plants. Potassium concentrations in mulches and soil conditioners produced from composted garden organics range from 0.1-0.8% (Table 3).

Table 3. Summary of physical, chemical and biological characteristics of composted garden organics collected from compost producers in Sydney (Mean \pm s.e. (Min – Max) of samples collected).

Parameter	Mulch (n=8)	Soil conditioner (n=11)	Blended soil conditioner (n=10)	Wilkinson <i>et al.</i> (2000) (n=49)	AS4454 (SA 2003)
pH	6.5 \pm 0.3 (5.0-7.3)	6.9 \pm 0.2 (5.2 - 7.5)	7.2 \pm 0.2 (5.9-7.9)	7.3 (5.6-8.3)	5.0 - 7.5 ^A
EC (dS/m)	1.2 \pm 0.2 (0.4-2.0)	2.2 \pm 0.2 (1.2 - 3.5)	3.0 \pm 0.5 (1.3-7.2)	2.0 (0.8-5.1)	No limit
P (mg/L)	2.7 \pm 0.5 (0.9-5.3)	2.5 \pm 0.7 (0.2 - 7.1)	10.5 \pm 4.3 (0.2-43.4)	-	$\leq 5^B$
NH ₄ ⁺ -N (mg/L)	13.2 \pm 7.7 (5.0-63.7)	10.7 \pm 5.3 (0.4 - 57.4)	87.8 \pm 27.9 (1.3-231)	11 (0-75)	<200
NO ₃ ⁻ -N (mg/L)	0.9 \pm 0.3 (0.4-2.0)	2.4 \pm 1.6 (0.0 - 16.0)	88.9 \pm 51.7 (0.0-527)	-	$\geq 10^C$
NH ₄ ⁺ NO ₃ ⁻ -N (mg/L)	15.9 \pm 7.5 (0.9-65.7)	14.7 \pm 4.8 (5.0 - 57.4)	177.1 \pm 52.6 (5-530)	-	>200 ^C
%OM (%)	59.2 \pm 2.1 (45.8-65.2)	31.1 \pm 2.1 (17.4 - 43.1)	25.9 \pm 1.9 (18.5-37.4)	-	≥ 25
Toxicity	-	-	-	79 (13-100)	$\geq 60^D$
C (%)	44.6 \pm 0.7 (41-47)	24.1 \pm 2.0 (14 - 32)	21.3 \pm 2.0 (14-31)	-	-
N (%)	0.7 \pm 0.1 (0.5-1.0)	1.0 \pm 0.1 (0.6 - 1.3)	1.3 \pm 0.2 (0.4-2.1)	0.88 (0.4-1.6)	$\geq 0.6^C$
P (%)	0.1 \pm 0.0 (0.0-0.1)	0.2 \pm 0.0 (0.1-0.2)	0.4 \pm 0.1 (0.1-0.8)	0.2 (0.05-0.5)	$\leq 0.1^B$
K (%)	0.4 \pm 0.0 (0.1-0.5)	0.5 \pm 0.0 (0.2 - 0.7)	0.4 \pm 0.1 (0.1-0.8)	-	-
S (%)	0.1 \pm 0.0 (0.1-0.2)	0.1 \pm 0.0 (0.1-0.2)	0.2 \pm 0.0 (0.1-0.3)	-	-
Ca (%)	0.7 \pm 0.1 (0.5-1.1)	1.7 \pm 0.3 (0.7 - 3.9)	2.1 \pm 0.4 (1.0-4.3)	63 (10-165)	-
Mg (%)	0.1 \pm 0.0 (0.1-0.2)	0.2 \pm 0.0 (0.2 - 0.4)	0.3 \pm 0.0 (0.2-0.4)	-	-
Na (%)	0.1 \pm 0.0 (0.1-0.2)	0.1 \pm 0.0 (0.1 - 0.2)	0.2 \pm 0.0 (0.1-0.3)	0.1 (0.08-0.23)	<1 ^E

Table 3. (continued).

Parameter	Mulch (n=8)	Soil conditioner (n=11)	Blended soil conditioner (n=10)	Wilkinson <i>et al.</i> (2000) (n=49)	AS4454 (SA 2003)
Fe (%)	0.4 ± 0.1 (0.2-0.8)	1.2 ± 0.1 (0.7 - 1.6)	1.5 ± 0.2 (0.9-2.6)	-	-
B (mg/kg)	12 ± 1 (6-17)	11.4 ± 1.2 (2.8 - 16)	10 ± 1 (3-17)	25 (15-45)	<200 ^F
Cu (mg/kg)	39 ± 12 (11-110)	56.5 ± 13.9 (25 - 190)	93 ± 21 (32-240)	-	100 ^G
Zn (mg/kg)	65 ± 5 (48-87)	151 ± 14 (63 - 220)	200 ± 24 (81-330)	313 (73-969)	200 ^G
As (mg/kg)	-	-	-	8 (3-35)	20 ^G
Cd (mg/kg)	-	-	-	1 (1-3)	3 ^G
Cr (mg/kg)	-	-	-	60 (8-160)	100 ^G
Pb (mg/kg)	-	-	-	58 (21-272)	150 ^G
Hg (mg/kg)	-	-	-	0.2 (0.1-0.4)	1 ^G
Ni (mg/kg)	-	-	-	23 (5-62)	60 ^G
C:N	72 ± 7 (41-104)	24.7 ± 1.9 (13.6 - 32.0)	20 ± 3 (9-38)	44 (16-134)	-

^AIf pH>7.5 determine total CaCO₃ content.

^B for products which claim to be for P sensitive plants.

^C if a contribution to plant nutrition is claimed. No requirement for composted mulches.

^D for all products except those labelled as manure or mushroom substrate, for which the EC criteria are more appropriate. No requirement for composted mulch products.

^E or at least 7.5 moles Ca plus Mg for each mole of Na in the dry matter.

^F Products with total B <100 can have unrestricted use.

^G for retail sale, all products shall meet the Class A classification of the NSW EPA's Environmental Guidelines: Use and disposal of biosolids products, for unrestricted use.

^S Dry matter basis.

It is sometimes difficult to maintain compost pH within the limits defined in AS4454 (Table 3). Composts with high pH may reduce the availability of phosphorus and micronutrients if applied to alkaline soils ($\text{pH} > 7$), but depending on its neutralising value, could be beneficial for raising the pH in the high proportion of agricultural soils in NSW, which are acidic. Compost EC is often influenced by the quality of the water used to control moisture content within composting windrows and can be high where recycled water is used because of salt concentrating in leachate collected from stockpiles.

Similarly, composted garden organics often exceed the AS4454 limits for Cu and Zn (Table 3). If composted garden organics are blended with biosolids, then the NSW Biosolids Guidelines (NSW EPA 1997) determine how they can be used.

Factors influencing compost consistency

Compost consistency is influenced by the size of the operation, geographical location, season, rainfall patterns and method of garden organic collection. Larger processors tend to source their input material from a greater number of councils and are less sensitive to variations in inputs. Coastal processing facilities tend to receive garden organics with higher moisture content, more leafy material and a lower C/N ratio, whilst those situated in western Sydney have a higher proportion of timber. Likewise, fewer grass clippings are received during winter and periods of drought. These factors influence the carbon to nitrogen ratio of the inputs which, in turn, affect the rate of composting. These factors influence the chemical characteristics of the final compost products, as demonstrated by Figures 2-5, which give the monitoring data collected over a 5 year period by a compost manufacturer located in the Sydney basin.

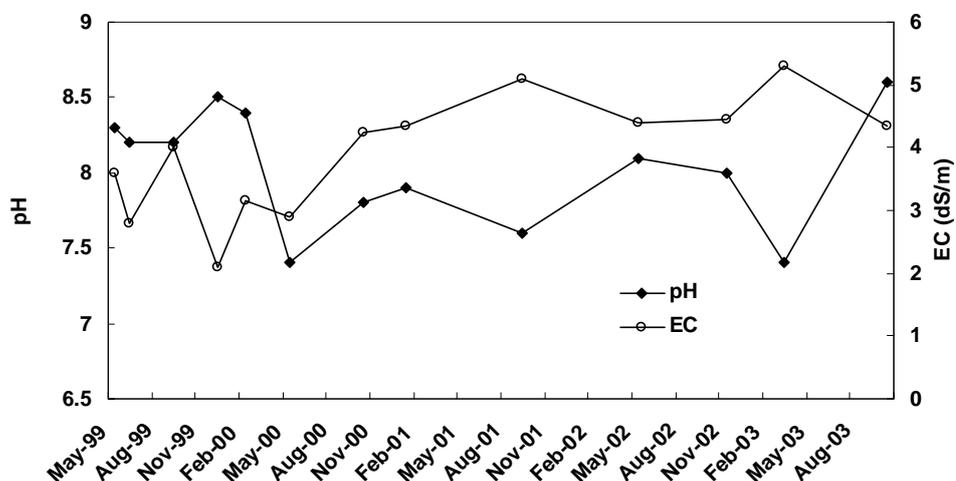


Figure 2. Variation in pH and Electrical Conductivity (dS/m) in composted soil conditioner produced at a single composting facility within the greater Sydney Metropolitan Area over time.

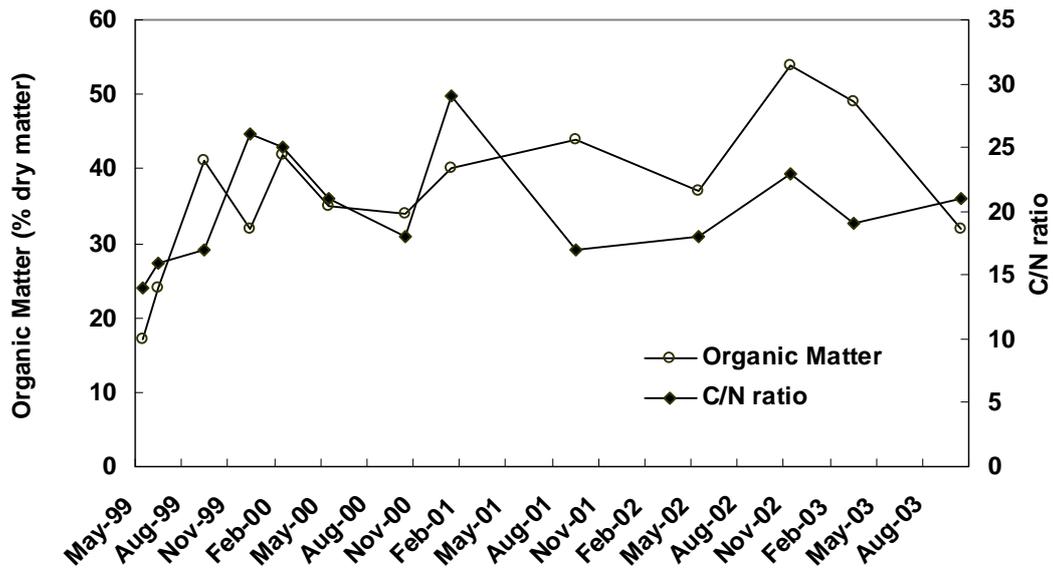


Figure 3. Variation in Organic Matter (%) and C/N ratio in composted soil conditioner produced at a single composting facility within the greater Sydney Metropolitan Area over time.

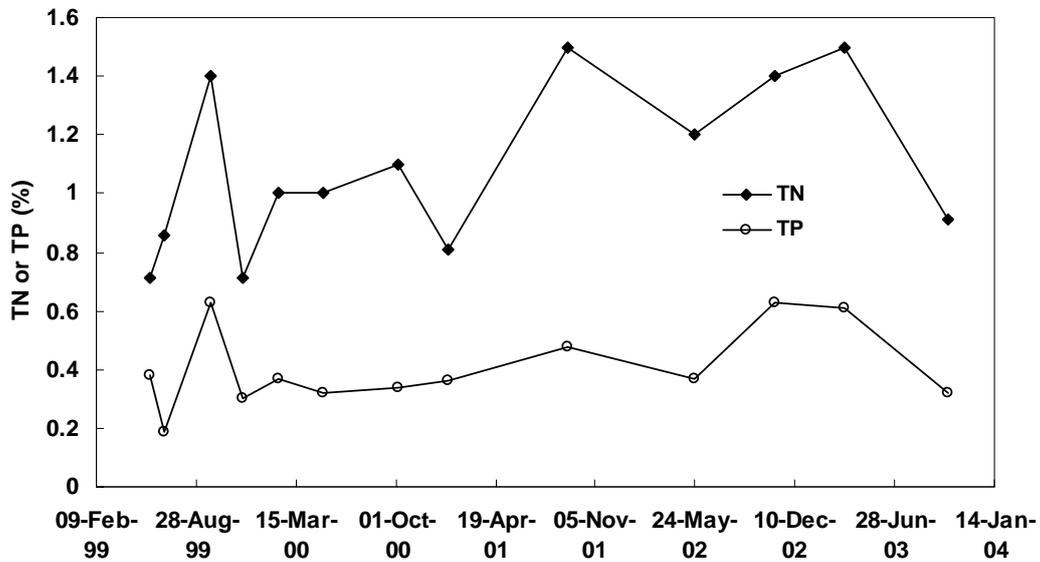


Figure 4. Variation in compost Total Nitrogen (%) and Total Phosphorus (%) concentrations in composted soil conditioner produced at a single composting facility within the greater Sydney Metropolitan Area over time.

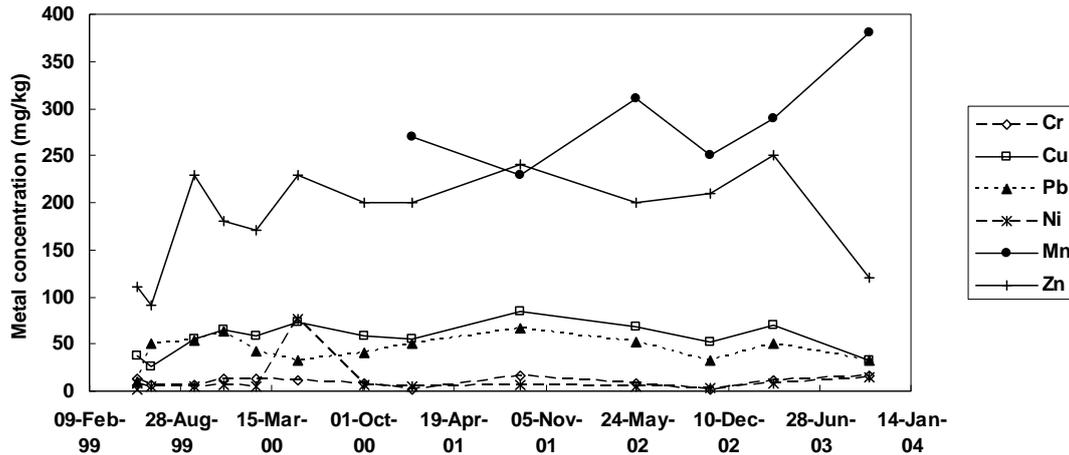


Figure 5. Variation in metal concentrations (mg/kg) in composted soil conditioner produced at a single composting facility within the greater Sydney Metropolitan Area over time.

Plastic contaminants in compost

Plastics also have a major impact on compost quality, particularly mulches, and strongly influence market perception of the product. Composted garden organics containing even small amounts of visible contaminants, such as fragments of plastic bags, reduce the perceived value of the product and create a barrier to demand and acceptance (Figure 6). Plastic contamination tends to increase with proximity to the Sydney Metropolitan Area. The type of collection is also a factor, with garden organics sourced from public drop off facilities containing fewer plastic contaminants than those from kerbside collections.

A number of options are available to processors for reducing plastic contamination in composted garden organics. These include establishing picking stations, avoiding re-contamination through yard design and selling product with a guarantee to remove visible plastics after application, if required. However, processors believe the best long-term solution for reducing plastic contamination in compost products is source separation at the household level.



Figure 6. Plastic contamination reduces market perception of compost products.

4 SEGMENTING THE MARKET FOR COMPOSTED GARDEN ORGANICS PRODUCTS

In order to identify potential markets for composted garden organics and effectively position them in the market, it is necessary to compare the characteristics of composted garden organics against other agricultural recycled organics, as well as identify the strengths, weaknesses, opportunities and threats of competing products. This will also help identify potential synergies between composted garden organics and other products.

4.1 Competing Products

4.1.1 Characteristics of composted garden and agricultural organics

The quantity of composted garden organics generated within metropolitan areas is similar to those for poultry litter and piggery solids generated across New South Wales (Table 4). However, agricultural recycled organics are mostly generated in regional areas, meaning they are much closer to potential agricultural markets. Whilst biosolids are generated within metropolitan areas such as Sydney and Newcastle, the costs of transporting and applying them to broadacre markets are generally factored into the water utilities' residual management programs, making them a cost effective form of nutrients, especially nitrogen and phosphorus, for farmers.

Generally, composted garden organics are lower in nitrogen, phosphorus and potassium than other organic inputs such as biosolids, poultry litter or cattle and pig manure (Table 4). However, they have comparable or higher carbon concentrations and generally have lower EC, suggesting they could have an advantage over

competing products where salinity is an issue and nutrients are not limiting to plant growth.

The advantages and disadvantages of inorganic and organic fertilisers and soil amendments are explored in more detail in the following section.

Table 4. Comparison of the characteristics of composted garden organics, biosolids, poultry litter, cattle feedlot manure piggery solids and cotton gin trash generated in NSW.

Parameter	^A Soil	^A Mulch	^B Biosolids		^C Poultry	^D Cattle	^E Piggery	^F Composted
	conditioner		DWB	LAB	Litter	Feedlot Manure	Solids (Deep litter)	Cotton Gin trash
Quantity ('000 fresh t/yr)	----- 270 -----		----- 40 -----		500	-	219	-
Price (\$/t delivered < 60 km) [‡]	20 - 40	8 - 10	[§] contribution		16	-	15	-
pH	6.9	6.5	6.7	12.5	8.1	7	7.3	-
EC _{1:5} (dS/m)	2.2	1.2	0.4	7.7	6.8	12.4	7.6	-
Dry matter (%)	74	-	17.7	35.8	75	-	51	-
Carbon (%)	24	45	-	-	36	-	65	10
N (%)	1	0.7	3.7	2	2.6	2.2	1.6	1.2
P (%)	0.2	0.1	3.4	0.8	1.8	0.8	0.7	-
K (%)	0.5	0.4	0.3	0.1	1	2.3	1	1.3
Ca (%)	1.7	0.7	1.2	14.6	2.5	-	0.9	3.3
Na (%)	0.1	0.1	0.1	0.06	0.3	0.6	0.2	0.036
Cu (mg/kg)	57	39	100 - 500 [†]		0	-	200	-
Zn (mg/kg)	151	65	200 - 2500 [†]		-	-	170	-

Sources:

^ATable 3.

^B Typical Dewatered and Lime amended biosolids: Restricted Use (NSW EPA 1997)

^C Griffiths (2004)

^D McGahan and Tucker (2003)

^E I. Kruger (pers. comm.)

^F N. Hulugalle (pers. comm.).

[‡] Indicative prices from market research undertaken in this study.

[§] Independent market information indicates farmers pay a small contribution towards biosolids beneficial reuse.

[†] Maximum allowable contaminant concentrations for Grade A – C Biosolids (NSW EPA 1997).

4.1.2 Inorganic fertilisers and soil amendments

These include fertilisers containing nitrogen, phosphorus, potassium, sulphur and essential micronutrients used for plant nutrition, as well as lime and gypsum, which are used as soil amendments.

Strengths

- Cost effective way of applying agronomic rates of essential plant nutrients.
- Concentrated products which are relatively easy to transport, handle and apply.
- Chemical manufacturing process results in a consistent product with known concentrations of desired nutrients.
- Relatively easy to uniformly apply desired application rates.
- Fertiliser industry is well developed and covers all aspects of the value chain, from supplying and distributing fertilisers to providing soil testing services and agronomic advice (eg. Incitec "Nutrient Advantage Program"). (IBIS World 2004a).
- Fertiliser manufacturers are able to produce purpose specific fertilisers based on farmers' individual nutrient requirements (IBIS World 2004a).

Weaknesses

- Over- or prolonged application in some areas has increased soil nutrient concentrations, particularly nitrogen and phosphorus, to levels which have impacted on water quality.
- Nutrients released often exceed plant requirements and can become fixed in the soil or rendered unavailable to growing plants.
- Do not contain organic matter and associated organic forms of nutrients.
- May contain traces of heavy metals, such as cadmium, which can accumulate in agricultural soils over time.
- Source material is mined from finite global resources.
- Manufacturing processes consume large amounts of energy and can cause environmental impacts.

Opportunities

- Identify the potential to use composted garden organics in combination with inorganic fertilisers to increase fertiliser use efficiency and decrease the impacts of nutrients on the environment.
- Create alliances with fertiliser companies and industry groups (eg. Australian Fertiliser Spreaders Association) to utilise existing distribution and advisory networks and promote the use of organic inputs as a component of farming systems.

Threats

- Global supplies of some elements, such as phosphorus are limited.
- Increased regulation on the use of inorganic fertiliser and tighter regulation on manufacturing inputs to reduce contaminants, such as heavy metals.
- Highly competitive and well established industry making it difficult for smaller and newer players to gain entry to existing markets for fertiliser and soil conditioning products.

4.1.3 Biosolids

Strengths

- High in nutrients and organic matter.
- Lime amended biosolids have good liming value and can ameliorate soil acidity.
- Beneficial reuse of resources, which has improved marine water quality around metropolitan areas, as well as soil quality in agricultural areas.
- Subsidised form of soil ameliorants/ nutrients for farmers. Costs of production, transport and application subsidised by Water authorities.
- Reuse supported by the NSW Biosolids Guidelines (NSW EPA 1997), which creates greater market certainty and confidence in the product, as well as ensures the environment is protected.
- Biosolids beneficial use was developed on the basis of strong research findings.
- All products are processed/ treated to reduce pathogens and tested for contaminants.

Weaknesses

- Requires significant capital and on-going investment by water authorities.
- Stigma and negative public perception associated with the product
- Potential impacts to the environment and public health if not managed properly.
- Biosolids must be managed in accordance with the NSW Biosolids Guidelines (NSW EPA 1997), which can restrict opportunities for reuse and requires careful management.

Opportunities

- Learn from the experience gained by stakeholders from creating agricultural markets for biosolids.
- Build upon current practice of blending composted garden organics with biosolids (eg. Australian Native Landscapes) to create a soil conditioner with higher nutrient status.
- Framework for regulating organic waste management has been established and could be adapted for other recycled organics.

Threats

- Public sensitivity about reusing biosolids. For example, any perceived health scare linked to biosolids reuse could erode public confidence in the activity and reduce the viability of the market.

4.1.4 Poultry Litter

Strengths

- Approximately 500,000 m³ poultry litter produced each year. Of this 80% is generated within a 300 km radius of Sydney, indicating large quantities are readily available.
- High in nitrogen (2.6%) and phosphorus (1.8%) (Griffiths 2004).
- Cheap form of fertiliser (\$16/m³).

Weaknesses

- Over-application has elevated soil nutrient concentrations, especially P, which has contributed to reduced water quality in the Hawkesbury-Nepean River and elsewhere.
- Potential for more restricted application in livestock grazing systems because of risk of Bovine Spongiform Encephalitis (BSE or Mad Cows Disease)
- Risk of spreading pathogens and exotic animal diseases
 - For example, some major supermarket chains prohibit the use of animal manures in vegetable farms because of the risk of consumer exposure to *Salmonella* and *E. coli*.
- Very little poultry litter is composted.
- Poultry litter needs to be properly composted before it can be used in organic farming systems.
- Application can generate odours.
- No requirement for processing or treatment prior to beneficial reuse.

Opportunities

- Evaluate the potential to produce a product with good nutrient and organic matter status but lower potential to leach nutrients by blending composted garden organics with poultry litter.
- Participate in initiatives to improve nutrient management and reduce the environmental impacts of using poultry litter.
- Promote composted garden organics as an alternative product for increasing soil organic matter and improving soil physical characteristics.
- Assess the potential for co-composting to stabilise the product and reduce the potential for odours.

Threats

- Outbreak of avian diseases, such as Newcastle Disease could reduce chicken production and restrict the movement of poultry litter.

4.1.5 Pig and cattle manure

Strengths

- Cheap form of nutrients and organic matter.
- Large quantities generated and composted within close proximity to agricultural markets in regional NSW.
- The off-farm use of liquid and solid wastes from intensive livestock industries such as cattle feedlots, dairies and piggeries is increasing as a consequence of the need to manage wastes more effectively.

Weaknesses

- Even with relatively close proximity to end users, transport costs have a strong influence on market viability.
 - For example, piggery litter costs approximately \$15/t delivered within a distance of 20km (I. Kruger, pers. comm.).
- High in BOD, EC and Na with the potential to create problems with odour, soil salinity and soil sodicity, respectively.
- Can contain high concentrations of copper and zinc, which may accumulate in soil over time.

Opportunities

- Explore the potential to blend or co-compost garden organics with manure to create a stable product high in nutrients.
- If it is not feasible to use composted garden organics generated in Sydney, evaluate the potential to use garden organics generated in regional centres.

Threats

- Community/ neighbour opposition to intensive livestock operations due to odour and/ or amenity issues.

4.1.6 Crop residues and green manure crops

Strengths

- Improves soil structure and organic matter levels.
- Commonly accepted and used practice in cropping systems.
- Green manure legume crops have the potential to reduce or eliminate the need for nitrogen fertiliser application.
- Improves infiltration rates and soil moisture retention.

Weaknesses

- Short term opportunity and input costs from growing green manure crops.
- Crop residues can make farming operations, such as planting and cultivation difficult and may require modified machinery.
- Stubble retention can carry over diseases between crops.
- Cotton gin trash may contain chemical residues, such as DDE, which may have implications for beneficial reuse.
- Most residues are kept within the farming system they are produced, with the exception of straw used for making bales or composting manure.

Opportunities

- Perform an economic analysis of the cost/benefits of growing a green manure crop as opposed to applying composted garden organics as to increase soil organic matter and improve soil structural stability.
- Substitute wheat straw with composted garden organics, as a source of carbon for composting animal manure.
- Evaluate the potential to co-compost garden organics with crop residues such as cotton gin trash.
- Retain stubble retention to participate in Greenhouse Gas abatement projects publicised under LULUCF (Land Use, Land Use Change and Forestry) and Article 3.4 of the Kyoto protocol.

Threats

- High commodity prices may increase the opportunity cost of growing green manure crops.
- Low commodity prices may reduce the area of broadacre crops grown.
- Increased understanding of the value of crop residues may increase the proportion kept on farm and reduce the availability off-farm for other uses.

4.1.7 Summary

In summary, composted garden organics are unlikely to directly compete with inorganic and organic fertilisers as an economically viable source of nutrients for growing plants. However, opportunities exist to blend composted garden organics with inorganic or organic fertilisers to create a stable product, which is high in nutrients and organic matter for application in agricultural production systems where improved nutrient management is required. Composted garden organics also have potential for use as soil amendments either as a stand alone product, or in combination with gypsum and lime.

4.2 Agricultural and horticultural production systems in NSW

Data on the size, location and production figures of different agricultural and horticultural production systems in New South Wales (ABS 2001) were analysed to characterise existing production systems and quantify the size of each potential market. The total agricultural and horticultural market was segmented into seven categories. In large market segments, such as conventional broadacre and perennial horticulture, the major crops were used as indicators for market size. Market segments and indicator crops are summarised in Table 5.

Table 5. Market segments and indicator crops used to quantify potential market size for composted garden organics in agricultural and horticultural markets in NSW.

Market Segment	Indicator Crops
Conventional Broadacre	Dryland wheat, dryland canola
Conventional Vegetables	Broccoli, cabbage, cauliflower, lettuce, tomato, zucchini
Cotton	Irrigated cotton
Organic Agriculture	Broadacre: sunflowers, oats, mungbeans, linseed, safflower, sweetcorn.
	Vegetables: pumpkins, tomatoes, watermelon, rockmelon, butternuts
Perennial Horticulture	Apples, oranges and peaches
Turf	Turf
Viticulture	Grapes for wine production

ArcView GIS (ESRI 1996) was used to summarise the results into geographical areas based on the statistical districts used by ABS (2001) and determine the physical size of each potential market segment within a 300 km radius of Sydney. This distance was chosen to represent the maximum distance garden organics are likely to be transported from the source of production. The top 10 geographical areas within or intersecting this zone were plotted against the parameter of concern to readily identify the largest potential markets within each segment.

4.2.1 Conventional Broadacre

The majority of wheat produced in New South Wales is grown more than 300 km from Sydney (Figure 7). However, approximately 282,000 ha of wheat was grown within 300 km of Sydney in 2001, and of this, most was grown in the Gunnedah, Cabonne, Coonabarabran and Wellington Districts (Figure 7). Approximately 58,000 ha of canola were grown within a 300 km radius of Sydney, with the largest proportion grown in the Cabonne, Cowra and Wellington Districts (Figure 8). This indicates the potential market size for conventional broadacre cropping systems within 300 km of Sydney would be at least 340,000 ha. This does not include other crops such as legumes and other cereals commonly grown in rotation with wheat and canola, which would increase the size of the potential market.

These areas are highly productive and represent some of the highest yielding broadacre cropping systems in NSW. For example average wheat yields in the Cowra and Wellington districts over the past 10 years have been 2.9 and 2.7 t/ha, respectively, with maximum yields of 3.5 and 4.2 t/ha, respectively (Table 6).

Table 6. Average wheat and canola yields in the Cowra, Wellington and Gunnedah districts in NSW from 1993-2003.

District	Wheat Yield (t/ha)	Canola (t/ha)
	Average (Range)	Average (Range)
Cowra	2.9 (1.6-3.5)	1.5 (0.8-2)
Wellington	2.7 (1.4-4.2)	1.7 (0.6-2.2)
Gunnedah	2.4 (0.9-3.5)	1.5 (0.6-2.3)

Source: (NSW Agriculture 2004).

This data is retrospective, with current information suggesting that target yields in the Cowra district are approaching 4.5 t/ha, due to improvements in varieties, adoption of new technology and better management practices (A. Mead, pers. comm.). Consequently, any effort to establish a market for composted garden organics in broadacre agriculture should focus on the Cowra, Cabonne and Wellington Districts, because these represent a large, contiguous area of high-yielding cropping systems within reasonable proximity to Sydney.

4.2.2 Conventional Vegetables

In contrast to Conventional Broadacre cropping systems, vegetable production is more evenly distributed across NSW (Figure 9). Approximately 6,400 ha of vegetables are grown within 300 km of Sydney, with the major areas being in the Cowra, Cooma-Monaro, Hawkesbury and Bathurst Districts (Figure 9).

4.2.3 Cotton

Only a small proportion of the total area of irrigated cotton produced in NSW is grown within a 300 km radius of Sydney (Figure 10). Of this, nearly all of it is produced in the Gunnedah District, which grew approximately 17,000 ha of cotton in 2001 (Figure

10). It should be noted that whilst the 300 km radius intersects the Gunnedah District, the majority of the district lies within a 300-400 km radius of Sydney.

4.2.4 Organic Agriculture

Organic agriculture represents 2% of total agricultural production in Australia (Hassall & Associates 2000). Whilst this is only a small proportion of total production, Organic Agriculture is a rapidly growing market sector, with a growth rate exceeding 20% per annum (Kondinin Group 2000). Assuming 2% of the total area of crops within 300 km of Sydney are grown using an organic production system, the potential market size of organic broadacre crops is approximately 6,800 ha, whilst that for organic vegetables is 130 ha. More specific data on the area of organic production are not available.

4.2.5 Perennial Horticulture

There are approximately 870,000 apple trees within 300 km of Sydney, with the major growing areas being the Orange, Cabonne and Hawkesbury Districts (Figure 11). Most of the oranges grown near Sydney come from the Gosford, Wyong and Hawkesbury Districts, although there are fewer orange trees (270,000) compared with apple trees (Figure 12). The numbers of peach trees (250,000) within a 300 km radius of Sydney are similar to the number of orange trees, although these are mainly located in the Hornsby, Hawkesbury and Tallaganda Districts (Figure 13).

Assuming an average planting density of 600 trees/ha, the area of apples, oranges and peaches grown within a 300 km radius of Sydney is approximately, 1450, 450 and 420 ha, respectively, indicating the potential market size for perennial horticultural crops is at least 2,300 ha.

4.2.6 Turf

In contrast to all of the other market segments evaluated, the majority of turf produced in New South Wales is grown within close proximity to Sydney (Figure 14). Further of the 1,750 ha of turf grown within 300 km of Sydney, 63% or 1,100 ha is grown within the Hawkesbury District.

4.2.7 Viticulture

Approximately 10,300 ha of grapes are grown within 300 km of Sydney, with most produced in the Mudgee, Cessnock and Muswellbrook Districts (Figure 15). The Cowra, Cabonne and Singleton Districts, also grow significant areas of grapes (Figure 15).

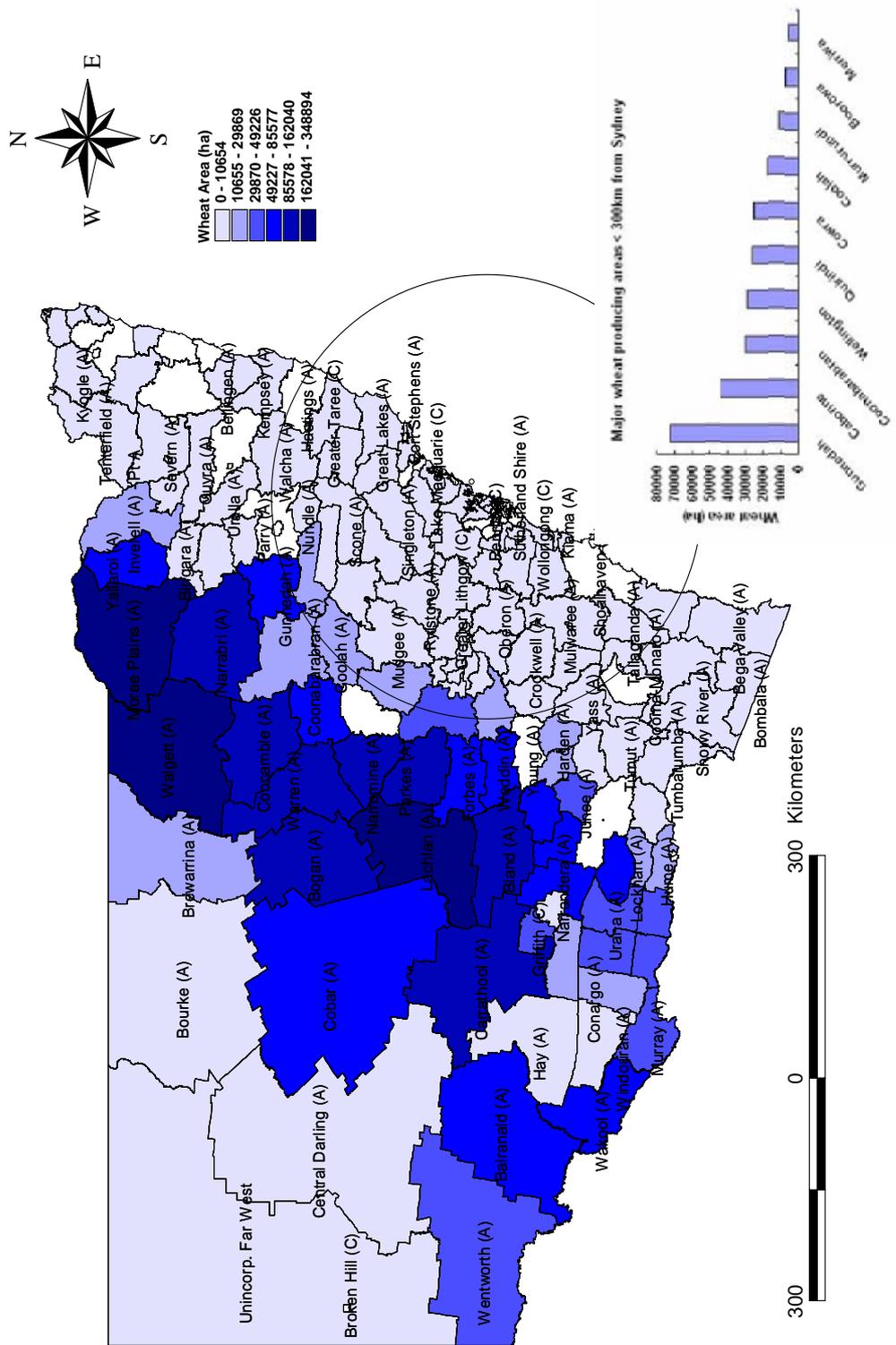


Figure 7. Area of wheat grown in New South Wales in relation to distance from the Sydney Metropolitan Area (ABS 2001). The radius of the circle is 300km from the Sydney GPO.

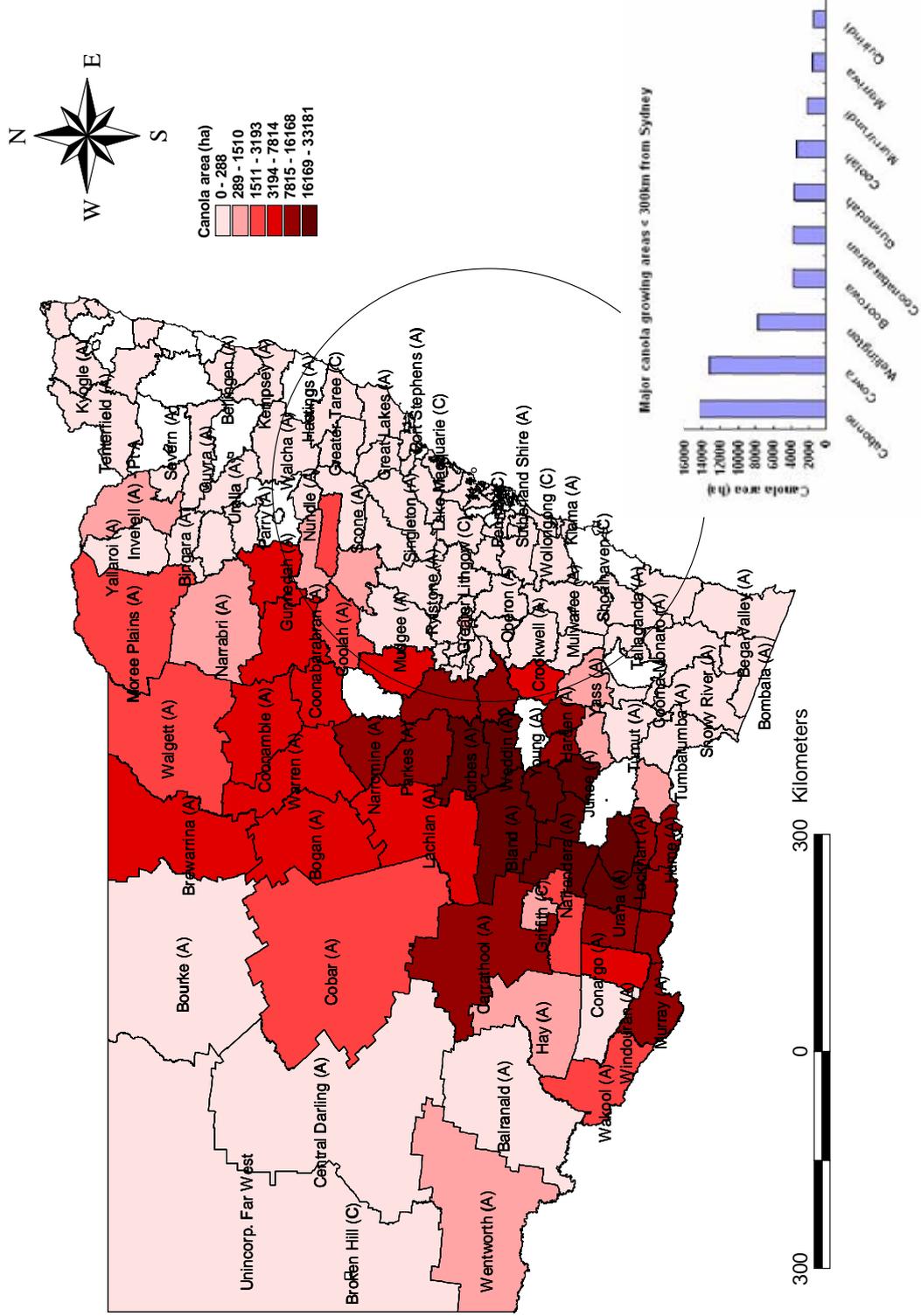


Figure 8. Area of canola grown in New South Wales in relation to distance from the Sydney Metropolitan Area (ABS 2001). The radius of the circle is 300km from the Sydney GPO.

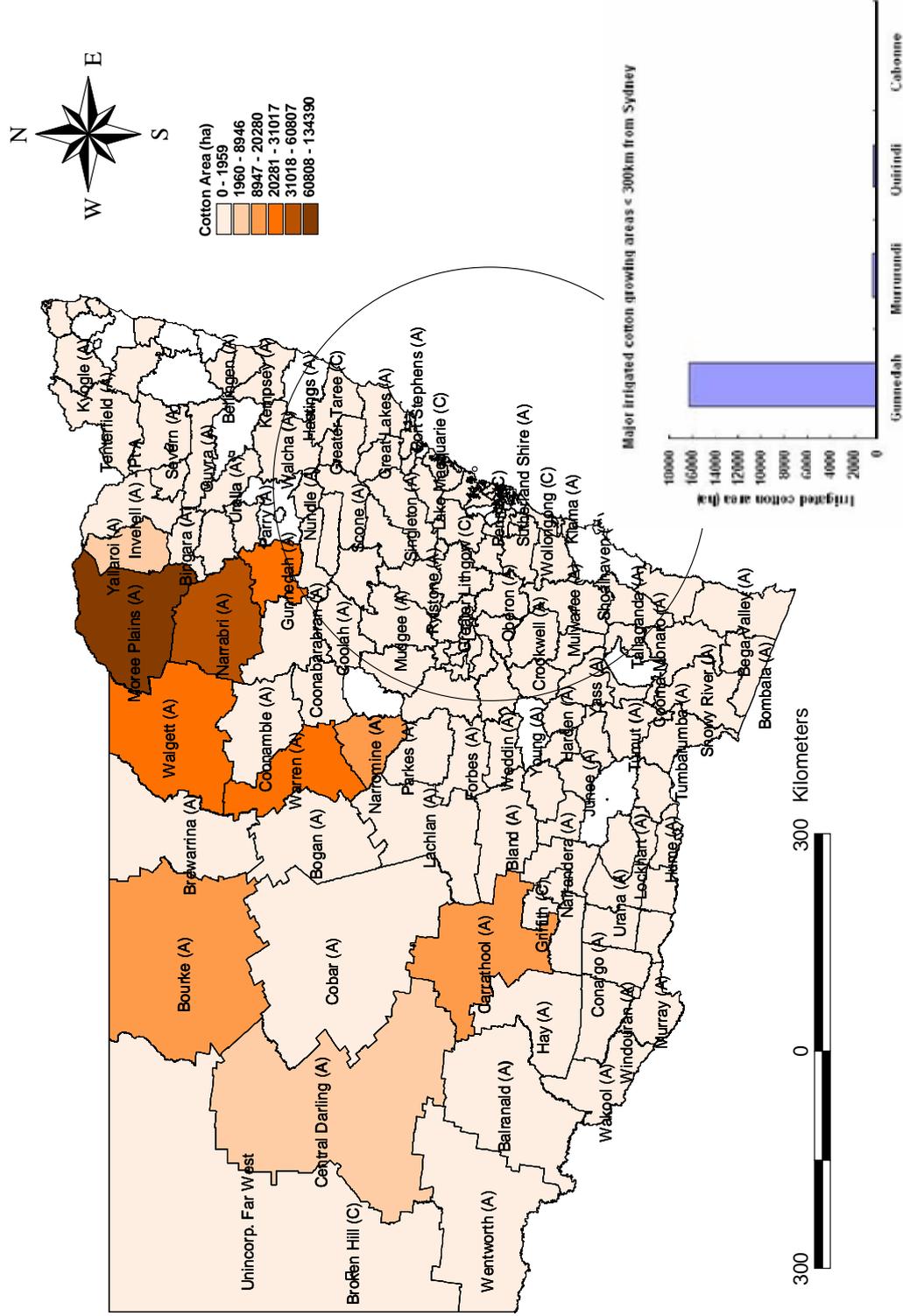


Figure 10. Area of cotton grown in New South Wales in relation to distance from the Sydney Metropolitan Area (ABS 2001). The radius of the circle is 300km from the Sydney GPO.

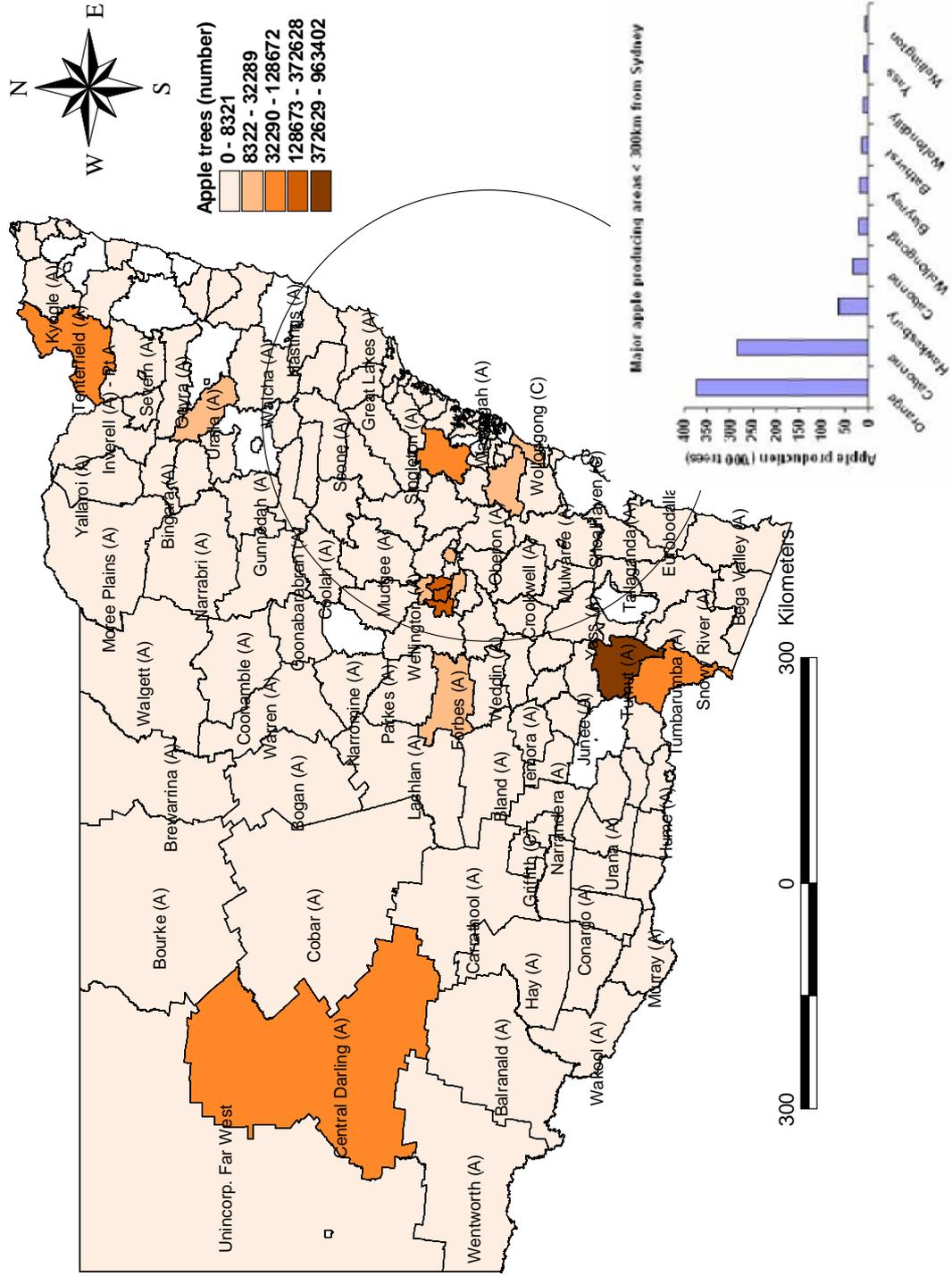


Figure 11. Number of Apple trees grown in New South Wales in relation to distance from the Sydney Metropolitan Area (ABS 2001). The radius of the circle is 300km from the Sydney GPO.

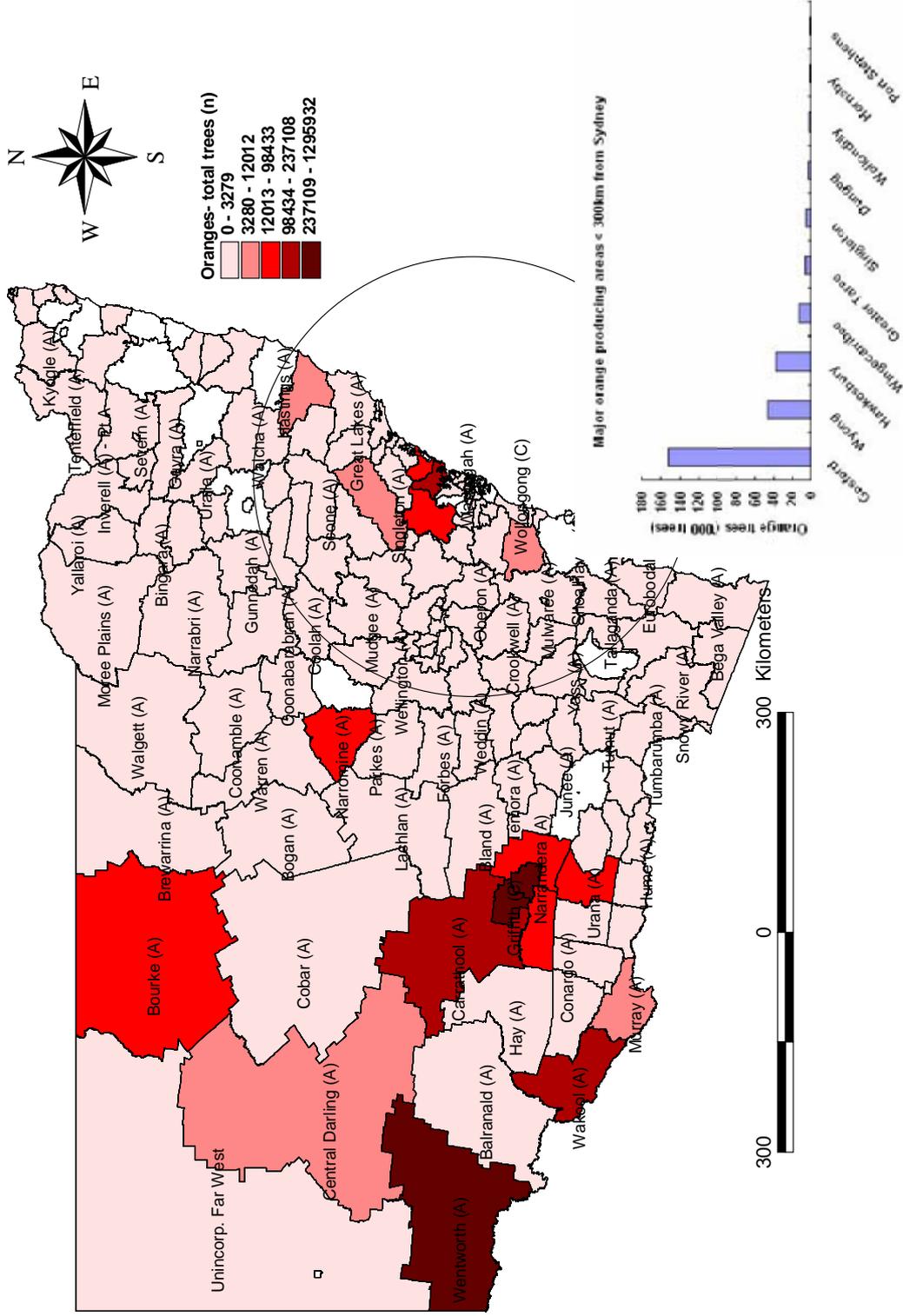


Figure 12. Number of orange trees grown in New South Wales in relation to distance from the Sydney Metropolitan Area (ABS 2001). The radius of the circle is 300km from the Sydney GPO.

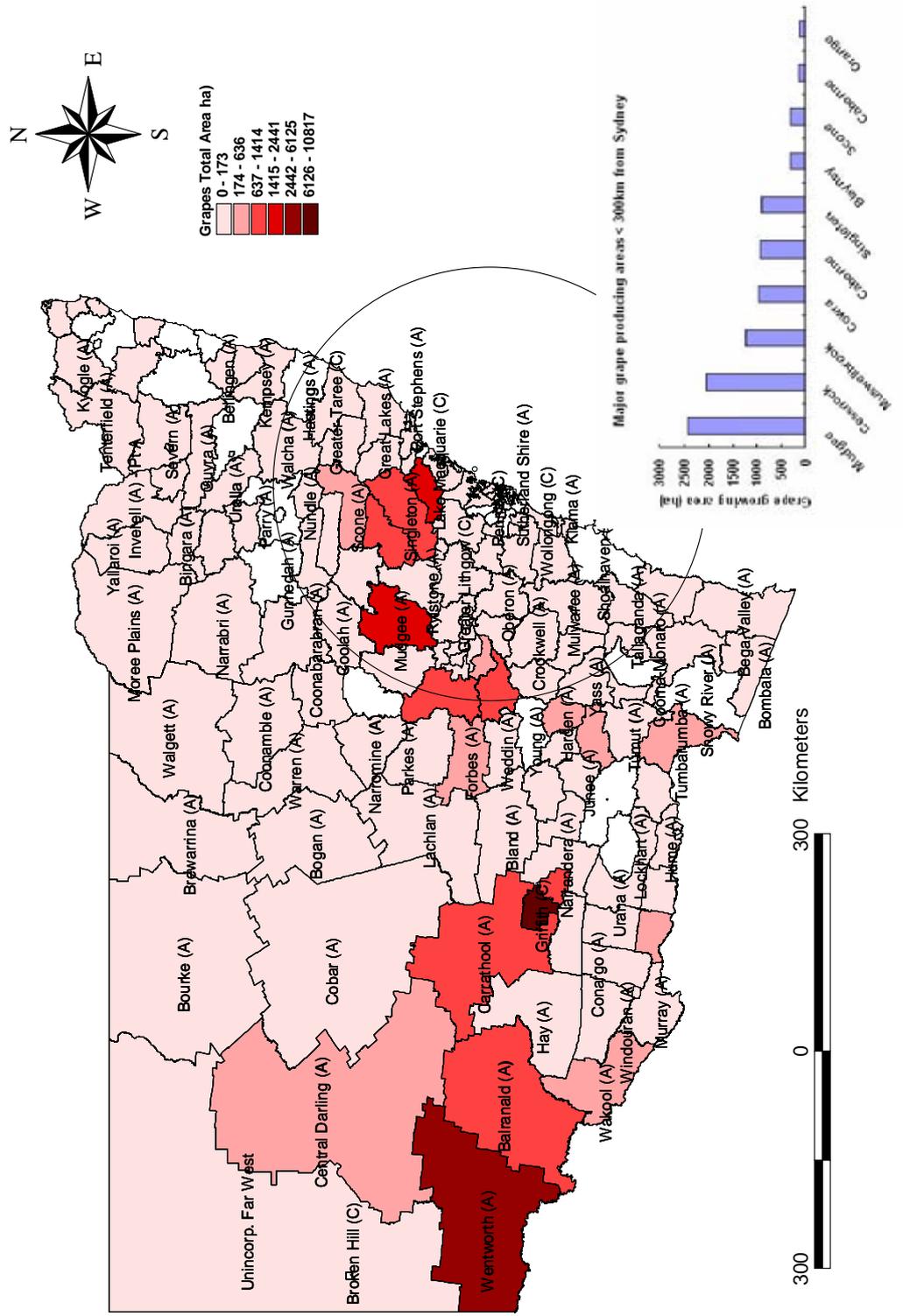


Figure 15. Area of grapes grown in New South Wales in relation to distance from the Sydney Metropolitan Area (ABS 2001). The radius of the circle is 300km from the Sydney GPO.

4.3 Profitability of the agricultural and horticultural market segments

Gross Margin Budgets for each of the market segments described in Section 4.2 are summarised in Table 7 based on information available from the NSW Department of Primary Industries. Turf is the market segment with the highest gross margin (\$45,000/ha) followed by Viticulture (\$22,000/ha) (Table 7). Conventional and Organic Broadacre market segments had the lowest gross margins of approximately 180 and 261 \$/ha (Table 7).

Table 7. Summary of gross margins for different agricultural and horticultural market segments, based on average yields and prices.

Market segment	Indicator Crop	Income (\$/ha)	Variable Costs (\$/ha)	Gross Margin	
				Average (\$/ha)	[§] Range (\$/ha)
^A Conventional	Wheat	522	300	222	(116) - 484
Broadacre	Canola	525	396	129	(86) - 579
^A Conventional	Broccoli	11,200	8,949	2,251	(1,779) - 9,431
Vegetables	Cabbage	13,000	11,621	1,379	(7,808) - 22,817
	Cauliflower	10,800	9,455	1,345	(782) - 13,111
	Lettuce	17,600	14,867	2,733	(3,646) - 17,250
	Tomato	45,000	39,680	887	(12,173) - 40,414
	Zucchini	15,000	12,201	2,799	(1,721) - 18,244
^A Cotton	Irrigated Cotton	4,340	2,125	2,124	806 - 3,815
^B Organic Broadacre	Sunflowers	720	605	115	-
	Oats	551	286	265	-
	Mungbeans	500	515	-15	-
	Linseed	900	289	611	-
	Safflower	590	365	225	-
	Sweetcorn	1,616	1,251	365	-
^B Organic	Pumpkins	17,600	6,044	1,926	-
Vegetables	Tomatoes	3,762	2,846	916	-
	Watermelon	12,000	4,428	7,572	-
	Rockmelon	25,883	9,064	16,819	-
	Butternuts	16,800	7,653	9,148	-
Perennial	^C Oranges	6,000	5,589	411	(1,406) - 2,228
Horticulture	^D Peaches	36,000	24,275	11,724	(544) - 38,073
^E Viticulture	Grapes	25,283	3,305	21,978	19,712 - 24,244
^F Turf	Turf	-	-	45,000	20,000 - 120,000

[§]Figures in parentheses indicate a negative (<\$0/ha) gross margin.

Sources: ^A NSW Agriculture (2004).

^B R. Neeson, pers. comm.

^C Falivene (2003).

^D Hardy *et al.* (1999).

^E Boon *et al.* (1999).

^F A. Senn, pers. comm.; H. Allan, pers. comm.

The wide range of gross margins within each production system illustrated in Table 7, is due to differences in crop yields and prices, which vary from enterprise to enterprise and year to year. Hence, even the market segments with low average

gross margins are likely to contain enterprises which are highly profitable and vice versa. This variability makes it difficult to directly compare enterprises. Similarly, the size of the operation will influence its profitability. For example, the size of a broadacre wheat enterprise is likely to be in the order of hundreds or thousands of hectares, whereas in vegetable production systems, 53% of operations in Australia occupy less than 50 ha and only 7% are larger than 500 ha (IBIS World 2004b). The challenge is to identify areas where the application of composted garden organics would contribute to increasing the overall productivity and profitability of the enterprise. This will be explored further in the following sections.

The costs of production also strongly influence the profitability of an enterprise. For example, managing inputs more effectively can reduce the variable costs associated with crop establishment, irrigation water, fertilisers and chemicals and improve the overall profitability of an enterprise.

In order to identify which variables have the greatest impact on the total cost of production, the cost of each variable input was expressed as a proportion of the total variable cost for each indicator crop within each market segment. The average percentage of variable cost components for each indicator crop was then used to compare the relative contribution of each input to total variable costs between market segments. These results are summarised in Table 8.

Establishment

Costs associated with plant establishment, such as seed, transplants and sowing make up 10-13 % of the total variable costs for both Conventional and Organic Broadacre and Vegetable crop production systems (Table 8).

Fertiliser

Fertiliser is a major input for Conventional and Organic Broadacre cropping systems, comprising 33 and 38 % of total variable costs, respectively (Table 8). It is also a significant input for Perennial Horticulture and Viticulture, making up 11% of total variable costs (Table 8). In contrast, Table 8 demonstrates that nutrients only make up a small proportion of input costs for Vegetable, Cotton and Turf production systems.

Irrigation

Irrigation is a major input cost for grape production, comprising 19% of total variable costs of production (Table 8). Water is only a minor input cost for the other production systems evaluated. However, this is likely to change in the future as prices increase due to increased competition between agriculture, the environment and cities for limited supplies of water.

Weed, Disease and Insect Control

Weed control is a major input cost for Conventional Broadacre and a moderate cost for Cotton, comprising 23 and 10% of total variable costs, respectively (Table 8). The costs of weed control is a minor input cost for Organic production systems, although the higher proportion of tractor costs in Organic Broadacre may be due to increased cultivation for controlling weeds. Disease control is only a minor cost in Viticulture and Perennial Horticulture and is insignificant for the other production systems evaluated (Table 8). Insect control is a major input cost for cotton production and a small cost for Perennial Horticulture, comprising 17 and 4% of total variable costs, respectively.

Other costs

The remainder of production costs are largely associated with harvesting, freight, casual labour, levies and insurance.

Any inputs or management practices, which can reduce input costs or improve the performance of inputs should improve the overall profitability of the enterprise. The potential for composted garden organics to achieve this will be explored in the following sections of this report.

Table 8. Variable cost components as a percentage of the total variable cost for different agricultural and horticultural production systems in New South Wales.

Variable Cost	Conventional		Organic		Irrigated Turf (%)	Perennial Horticulture (%)	Viticulture		Fibre Cotton (%)
	Broadacre (%)	Vegetables (%)	Broadacre (%)	Vegetables (%)			Grapes (%)		
Transplants/ seed/ sowing	11	10	13	12	0	0	0	0	4
Tractor	1	3	15	4	1	5	12	10	10
Plastic, mulch & trellis	0	3	0	0	0	0	0	0	0
Irrigation	0	1	7	2	1	1	19	5	5
Fertiliser	33	3	38	7	2	11	11	5	5
Insect control	2	1	1	0	1	4	0	17	17
Disease control	0	1	0	0	1	5	7	0	0
Weed control	23	2	1	3	0	1	3	10	10
Casual labour	0	7	0	5	14	0	7	0	0
Harvesting	11	42	20	48	79	40	26	21	21
Freight	8	12	0	18	0	1	12	3	3
Levy	2	1	1	0	0	1	2	1	1
Agents commission	0	14	0	0	0	0	0	0	0
Pollination	0	0	0	0	0	0	0	0	0
Pruning	0	0	0	0	0	21	1	0	0
Ginning	0	0	0	0	0	0	0	20	20
Crop insurance	6	0	0	0	0	11	0	3	3
Windrowing	3	0	3	0	0	0	0	0	0
Other	0	0	0	0	0	0	0	2	2
Total	100	100	100	100	100	100	100	100	100

4.4 Comparative Market size and Gross Margins for different cropping systems

In order to evaluate the relative size and value of each market segment within 300 km of Sydney, the areas of crops grown were plotted against their average gross margin using a logarithmic scale (Figure 16). This illustrates there is a trade-off between market profitability and size, with Turf being the most profitable and Conventional Broadacre the largest potential market. Viticulture and Cotton have high gross margins and areas of production, followed by Perennial Horticulture and Vegetables. Organic Broadacre and Organic Vegetables have higher gross margins than Conventional production systems but currently have much smaller areas of production. However, the area of Organic production systems is likely to increase in the future (Section 5.2.4).

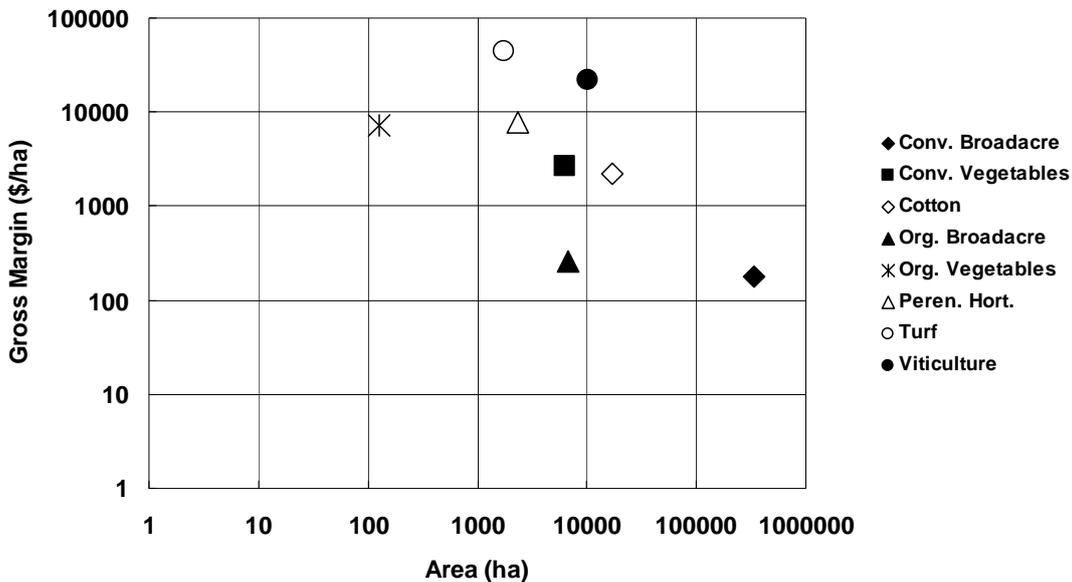


Figure 16. Comparative market size and gross margins for different cropping systems within 300 km of Sydney.

4.4.1 Use of Fertilisers and soil amendments in NSW farming systems

Most Australian agricultural soils are inherently low in essential plant nutrients, particularly phosphorus and nitrogen. However, application of fertilisers and soil ameliorants has increased soil fertility, especially with respect to phosphorus, sulphur and calcium (ANRA 2001). Crop and pasture legumes are major suppliers of nitrogen to soil, although large quantities of nitrogenous fertilisers are also applied to crops (ANRA 2001). It is estimated that Australian farmers use 5.6 million tonnes of mineral fertilisers with a value of approximately \$2 billion (IBIS World 2004a).

The Australian Natural Resource Audit conducted in 2001 (ANRA 2001) assessed farm gate nutrient balances for grazing and cropping systems across Australia:

Nitrogen:

Nitrogen balances for cropping systems in New South Wales were neutral to moderately positive, although negative balances occurred in the north-west slopes and plains, which also had low to moderate soil organic matter status (ANRA 2001). Positive nitrogen balances occurred in areas where dairy and horticulture were the major forms of land uses (ANRA 2001).

Phosphorus:

The phosphorus status of most agricultural soils in New South Wales has increased due to phosphorus fertiliser application, with the highest rates of P application occurring in the more reliable rainfall regions. Less than 1% of land in New South Wales is classified as having very low P status (Colwell P < 10 mg/kg), whilst approximately 21% has marginal P status (Colwell P 10- 20 mg/kg) (ANRA 2001). Approximately 4% of land in New South Wales was classified as having high P status (Colwell P > 80 mg/kg). This largely corresponds with intensive, irrigated agriculture, especially dairying and horticulture, which are located on soils inherently high in P.

The phosphorus balance was positive in most areas, with the exception of the northern slopes, which were negative. SCARM (1998) reported positive phosphorus balances on a national basis, with the rate of phosphorus accumulation in soil increasing over the past 20 years. It should be noted that this is based on total phosphorus loading to agricultural soils, which does not necessarily reflect the concentration of P which is available to plants growing in these soils.

Potassium

ANRA (2001) reported negative potassium balances across New South Wales, with the exception of coastal regions, which exhibited neutral balances. This is consistent with the national K balance, which has remained negative (-100 to -150 kt) from 1986 to 1996 (SCARM 1998). Whilst approximately 98% of land in New South Wales has a moderate to high (> 120 mg/kg) potassium status (ANRA 2001), the negative potassium balance suggests the incidence of K deficiency may increase in the future unless additional K is applied.

Soil amendments:

Data on the use of soil amendments, such as gypsum and lime, (ABS 2001) was analysed using ArcView (ESRI 1996) in the same manner as the agricultural production statistics (Section 5.2). This revealed approximately 48,000 ha of land within 300 km of Sydney was treated with gypsum, with the largest areas occurring in the Young (13,600 ha) and Cowra (5,400 ha) districts (Figure 17). This suggests these areas have high incidences of treatment of soil structural problems, namely surface sealing, crusting and hard-setting, often associated with sodicity, given gypsum is usually applied to ameliorate sodic soils.

Similarly, approximately 90,000 ha of land within 300 km of Sydney was treated with lime, with the largest areas occurring in the Cabonne (13,100ha), Young (9,300 ha) and Cowra (7,300 ha) districts (Figure 18). This indicates that soil acidity is an issue in these areas given lime is commonly used to increase soil pH.

As outlined in Section 3.2.3, composted garden organics have low fertiliser value, indicating they are unlikely to replace inorganic fertilisers as a source of nitrogen or phosphorus. However, composted garden organics are a valuable source of carbon, which is important for a range of soil properties, including structural stability. This suggests there could be demand for composted garden organics in the Young and Cowra districts, given these areas consume large quantities of gypsum.

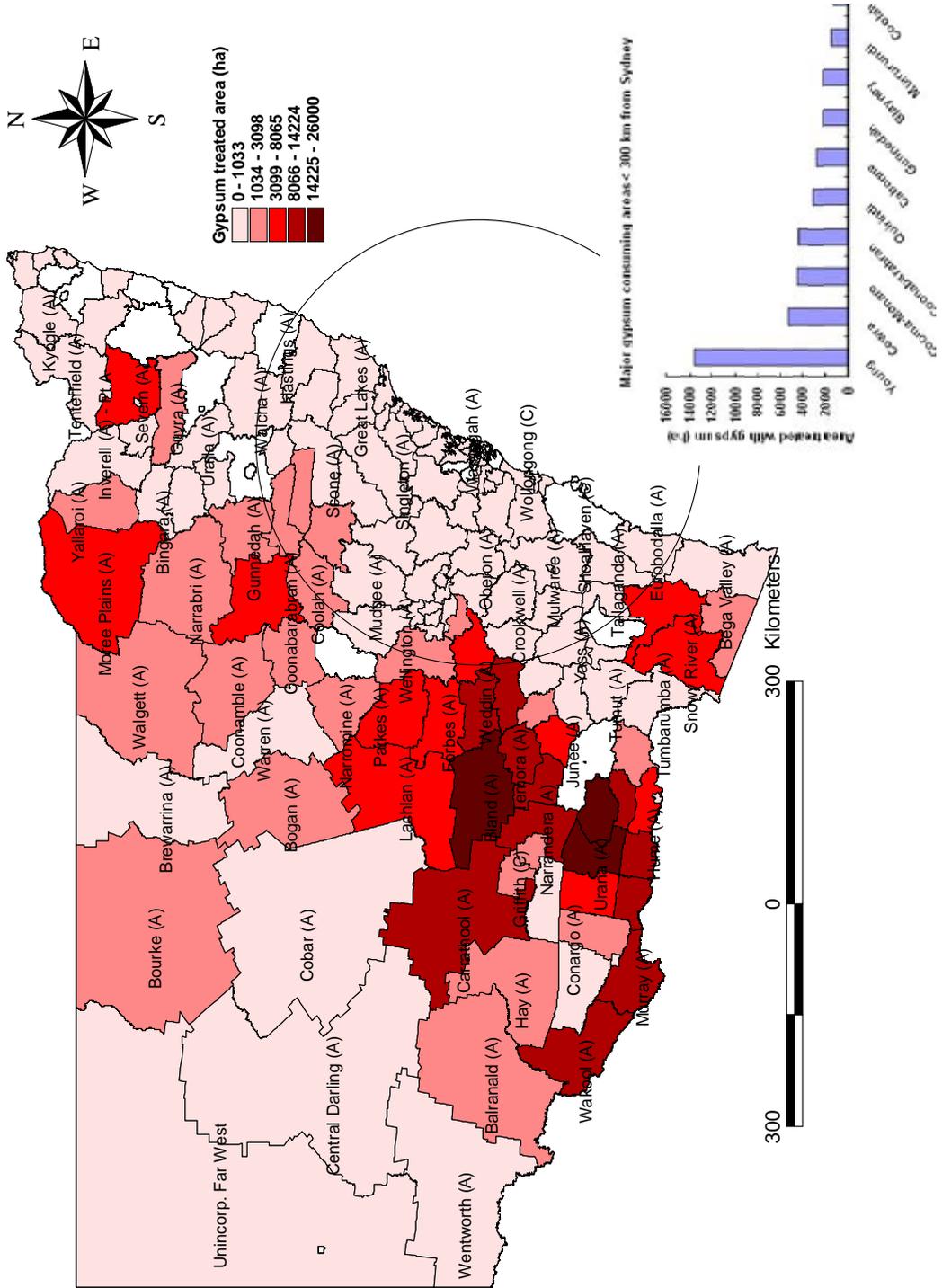


Figure 17. Area of land treated with gypsum in New South Wales in relation to distance from the Sydney Metropolitan Area (ABS 2001). The radius of the circle is 300km from the Sydney GPO.

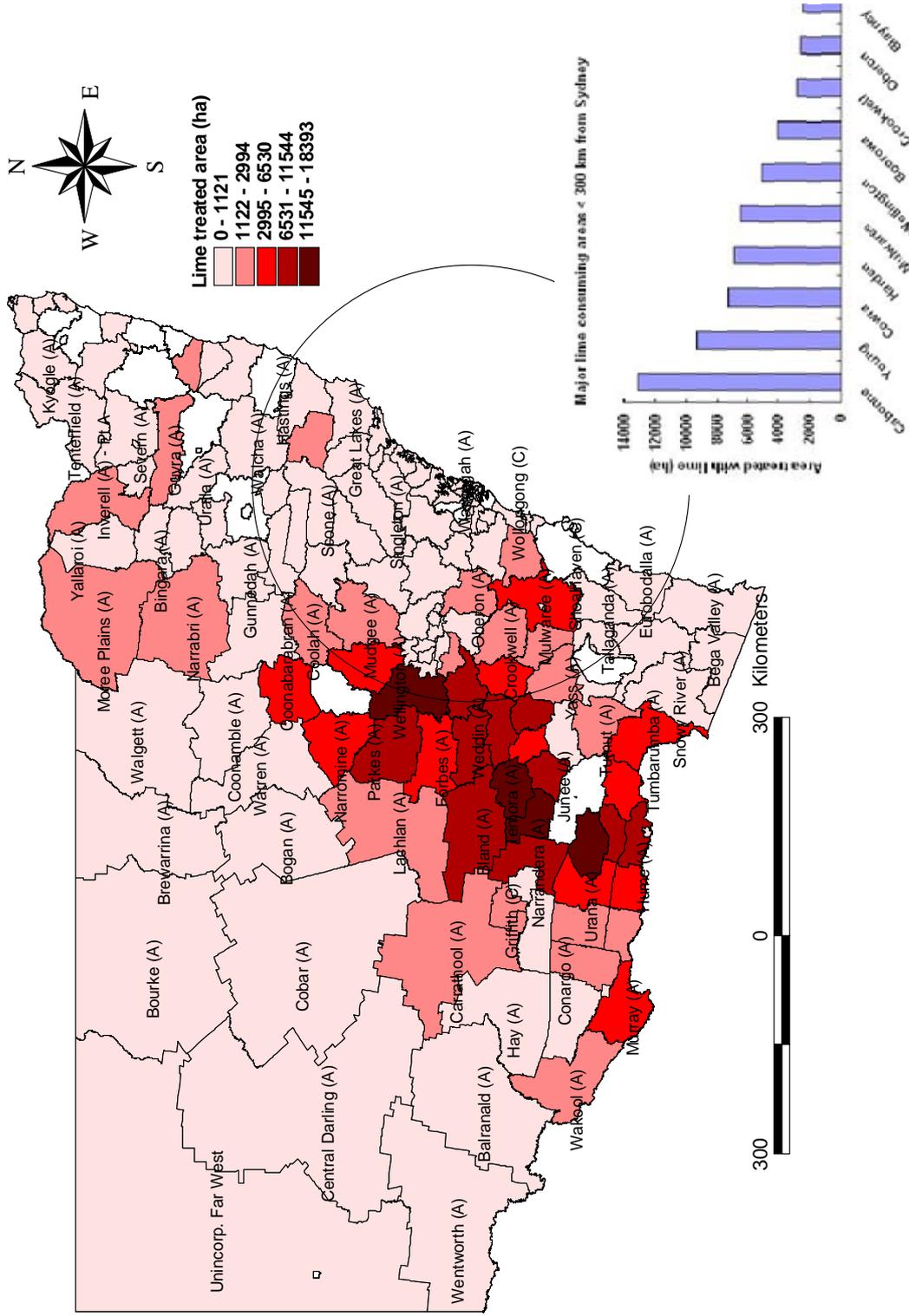


Figure 18. Area of land treated with lime in New South Wales in relation to distance from the Sydney Metropolitan Area (ABS 2001). The radius of the circle is 300km from the Sydney GPO.

5 SOILS AND POTENTIAL BENEFITS OF RO APPLICATION TO AGRICULTURAL LAND

5.1 Distribution of soil types in NSW

There are a variety of soil types within close proximity to Sydney, ranging from well structured and highly fertile alluvial loams to soils with low chemical and physical fertility (Figure 19). The large proportion of Yellow and Red Texture Contrast Soils, Shallow Loams and Massive Red and Yellow Earths in Figure 19 suggests there are significant areas of land near Sydney, which are low in nutrients and are prone to soil structural problems, such as hard-setting topsoils, subsoils with low hydraulic conductivity and erosion. Understanding soil distribution around Sydney is helpful for identifying sites with the potential to respond to the application of composted garden organics. This will be explored further in the following sections.

5.2 Soil Organic Matter

The majority of soil organic matter is derived from the decomposition of plants and soil animals, with humus being the end product of organic matter decay (Blair and Sale 1996). Soil organic matter is a heterogeneous mixture of organic substances in soil and comprises approximately 50% carbon, lesser amounts of oxygen and hydrogen, as well as small amounts of nitrogen, sulphur and other elements (Gibson *et al.* 2002). It is usually measured by analysing soil for organic carbon and then applying a conversion factor, which is typically 1.72. Gibson *et al.* (2002) summarised the important roles of soil organic matter to include:

- Acting as a source of carbon and energy for soil micro-organisms
- Increasing cation exchange capacity, which affects the retention, release and availability of nutrients
- Acting as a major source of and temporary sink for plant nutrients, such as nitrogen, phosphorus and sulphur
- Improving soil buffering capacity against acidification and toxicities
- Forming and maintaining desirable soil structure
- Improving water percolation into and retention by the soil
- Absorbing solar radiation which influences soil temperature
- Stimulating plant growth.

With the important functions listed above, soil organic carbon serves as a good indicator of soil health and its chemical, physical and biological fertility. In this review soil organic carbon concentration is used as an indicator of responsiveness to composted garden organics application.

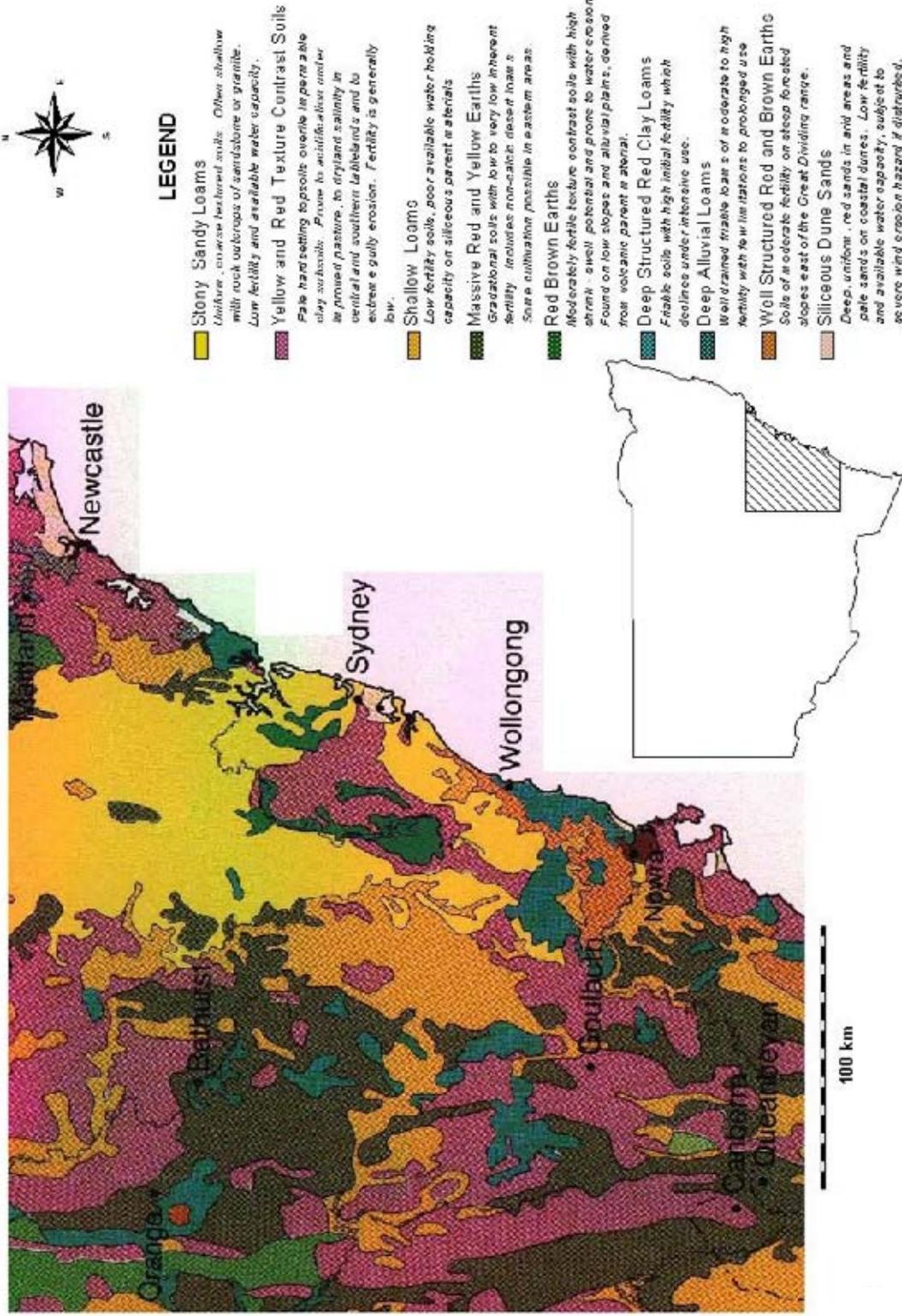


Figure 19. Soil types around the Sydney region (NSW Soil Conservation Service).

In the global carbon cycle, approximately 1500 billion tonnes of carbon is stored in the soil (Post *et al.* 1990). This is more than twice that in the atmosphere and is three times that in the biotic pool of all living matter. It has been recognised that soil carbon can be used as a sink for atmospheric carbon and therefore offers potential for greenhouse gas abatement. Under natural ecosystems, equilibrium soil carbon levels are attained and the levels achieved are dependent on rainfall, temperature and soil factors (mainly soil texture). However, in agriculture, the soil carbon level, in addition to the above factors, is also dependent on management practices that influence input and decomposition of organic materials. The management practices include tillage, stubble management, crop/pasture rotation and others. In Australia, as well as in many other parts of the world, large amounts of soil carbon have been lost under cropping. The carbon loss has also been linked to the land degradation problems found worldwide. Restoring the soil organic carbon level is therefore seen as an effective measure for not only reversing land degradation but also mitigating the global warming problem – a win-win situation.

5.3 Potential benefits of composted garden organics to soils

Composted garden organics can improve soil physical characteristics by improving aggregate stability, increasing porosity, particularly macroporosity, water infiltration and soil moisture retention, as well as decreasing soil bulk density (Gibson *et al.* 2002). Similarly, composted garden organics have the potential to enhance soil chemical fertility by improving nutrient availability, increasing cation exchange capacity (CEC) and ameliorating inherent problems such as salinity, sodicity and acidity (Gibson *et al.* 2002). Composts also have the potential to suppress and control plant diseases via competition for nutrients amongst pathogens and beneficial micro-organisms, the production of antibiotics, predation and parasitism or systemic disease resistance in host plants induced by compost treatments (ROU 2003a).

Most of the information presented in these reviews is from overseas, which creates uncertainty about their relevance to Australian conditions. Moreover, few studies have quantified these benefits in terms of increased crop productivity, reduced variable costs, increased profitability or gross margins (\$/ha) and improved environmental quality. This is particularly difficult given that some of the benefits, such as improved soil structure are less tangible and may not be expressed in the year of application.

OWRU (2000) concluded that in order to gain a better appreciation of the economics of compost use, research should be conducted over a number of years and assess the full range of benefits, not just yield responsiveness. ROU (2003a) also highlighted the need to assign a monetary value to the environmental benefits associated with applying composted garden organics. Hence, there is a need to quantify these benefits as an integrated package and promote the overall benefit in terms of improving the sustainability of the production system.

5.4 Carbon storage potential of agricultural soils in NSW

The soil carbon storage potential of agricultural soils in NSW was evaluated to identify soils or regions with the greatest potential to respond to composted garden organics. This was achieved by collating existing information on the soil carbon status from different farming systems published in soil survey reports and/or paired site studies. Wherever possible, the data was compared with corresponding “undisturbed” reference areas, which included native vegetation, old fence lines and long-term perennial pasture.

The spatial distribution of the information on soil carbon across the state was investigated by plotting the sampling locations for the different databases on a map of New South Wales using Arcview (ESRI 1996). This was helpful for identifying gaps of information on soil carbon status in relation to different farming systems in NSW.

The amount of carbon lost under the particular farming system was calculated as the difference in soil carbon concentrations in the topsoil (0-10 cm) between the farmed and corresponding undisturbed soils. This quantity was assumed to be the amount of carbon that can be stored in the soil profile, or the soil carbon storage potential.

To ensure the comparisons were valid, the following precautions were taken:

- The same method for analysing soil carbon was used. Where this was not the case, the conversion factors devised by Skjemstad *et al.* (2000) were applied to the data to achieve the same basis of comparison.
- Samples collected to depths other than 0-10cm were corrected to 0-10cm by interpolation.

Linear regression models were also developed using soil carbon monitoring data provided by Incitec, to evaluate the effect of rainfall and soil properties, particularly texture, on soil carbon status in New South Wales.

5.4.1 Impact of farming systems on soil carbon status

The locations of existing soil carbon data from undisturbed and cropped sites are plotted in Figure 21 and Figure 22, respectively.

Soil carbon concentrations in cropped soils are considerably lower than those found in the undisturbed soils, with the percentage reduction ranging from 12 to 59 % (Table 9). The magnitude of soil carbon loss is strongly influenced by rainfall. For instance, the average reduction in soil carbon in cropping soils in areas of NSW with an annual rainfall less than 500mm was 13.9 %, compared with the higher rainfall zones (>500mm), which lost an average of 48.4 % (Table 9). The larger reduction in soil carbon found in the higher rainfall areas is due to a combination of the higher carbon concentration in the undisturbed state because of higher inherent productivity and the higher loss in soil carbon under cropping due to higher decomposition rates.

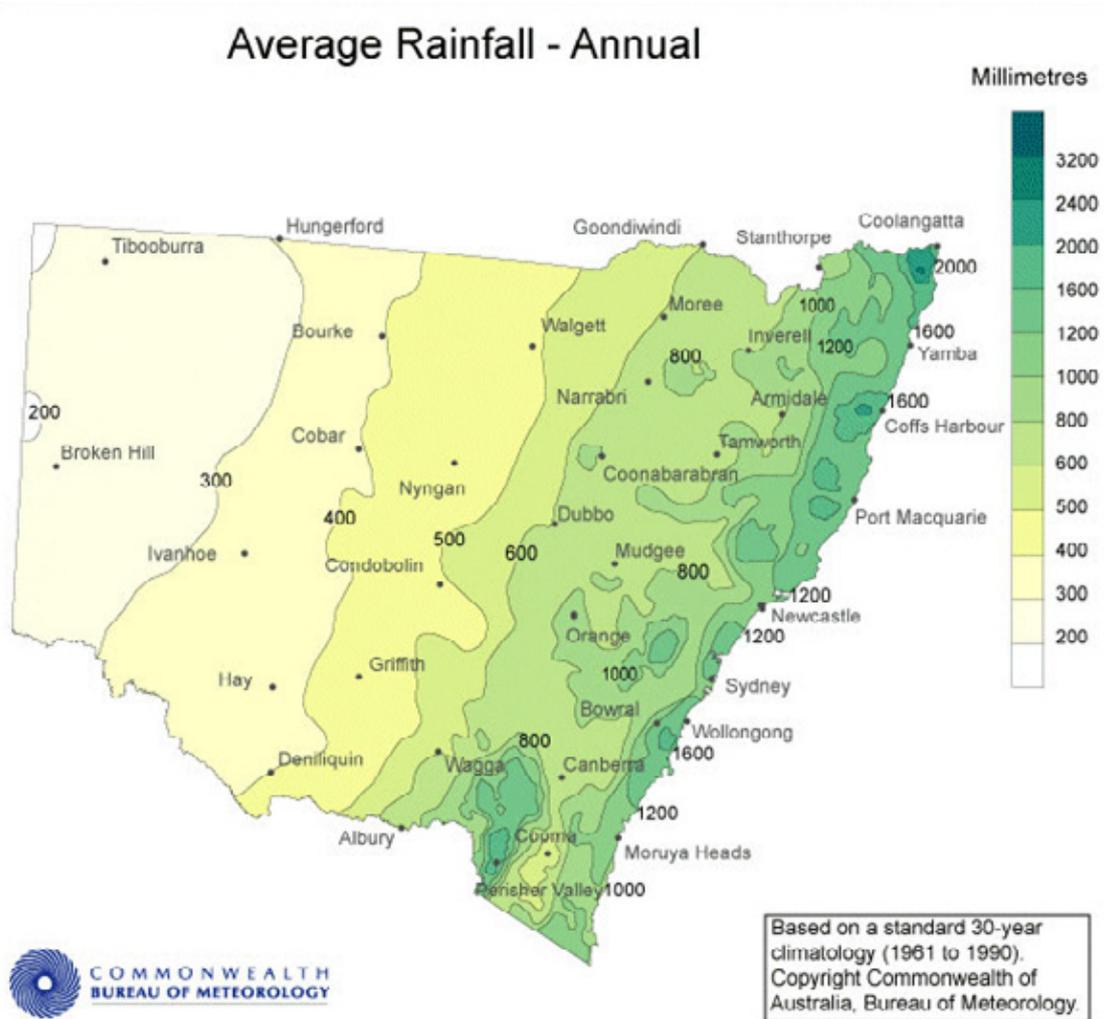


Figure 20. Average annual rainfall in NSW (Australian Bureau of Meteorology 2004).

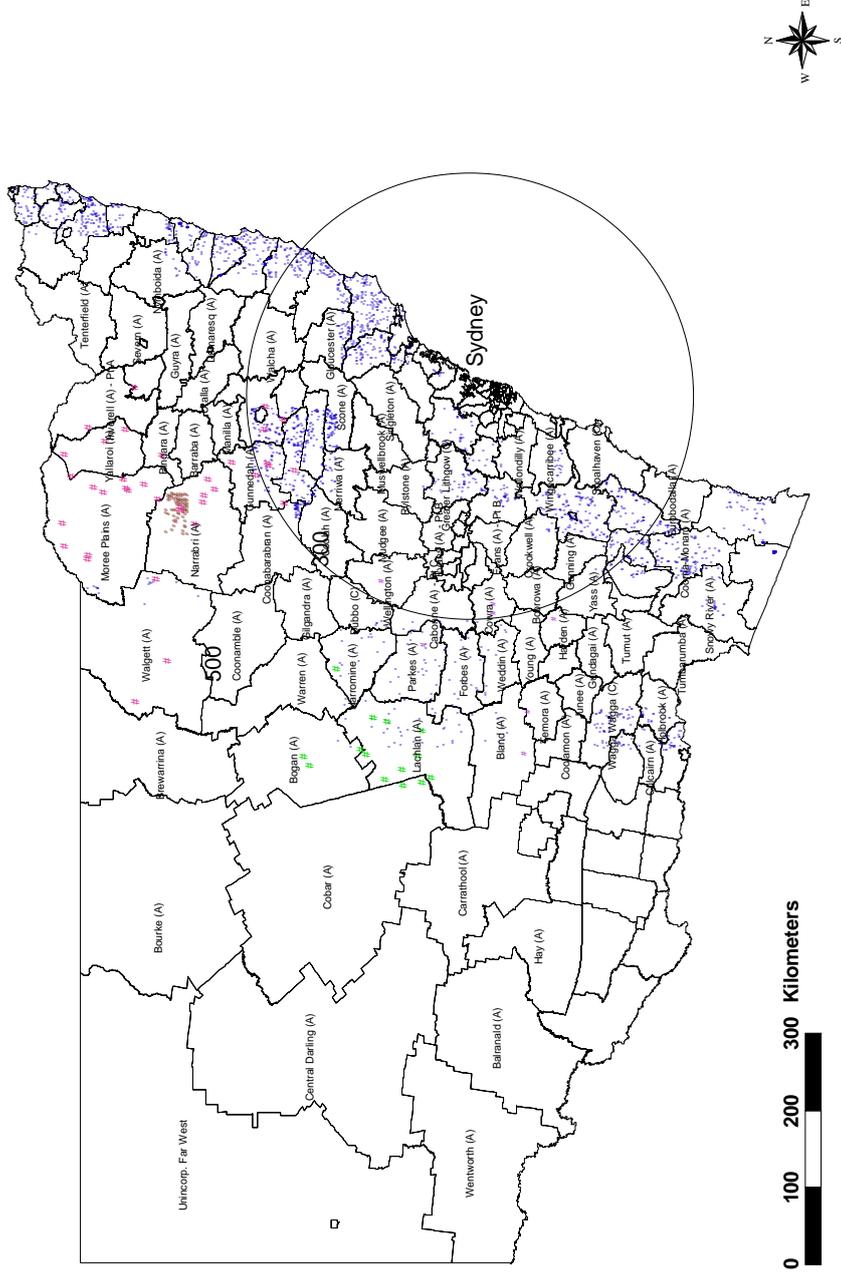


Figure 21. Locations of existing soil carbon data from undisturbed sites. (Blue dot: SALIS (2004); large purple dot : Kirchoff and Daniells (2004); green dot: Khu and Chan (1994); brown dot : McGarry *et al.* (1989); small purple dot: Geeves *et al.* (1995)).

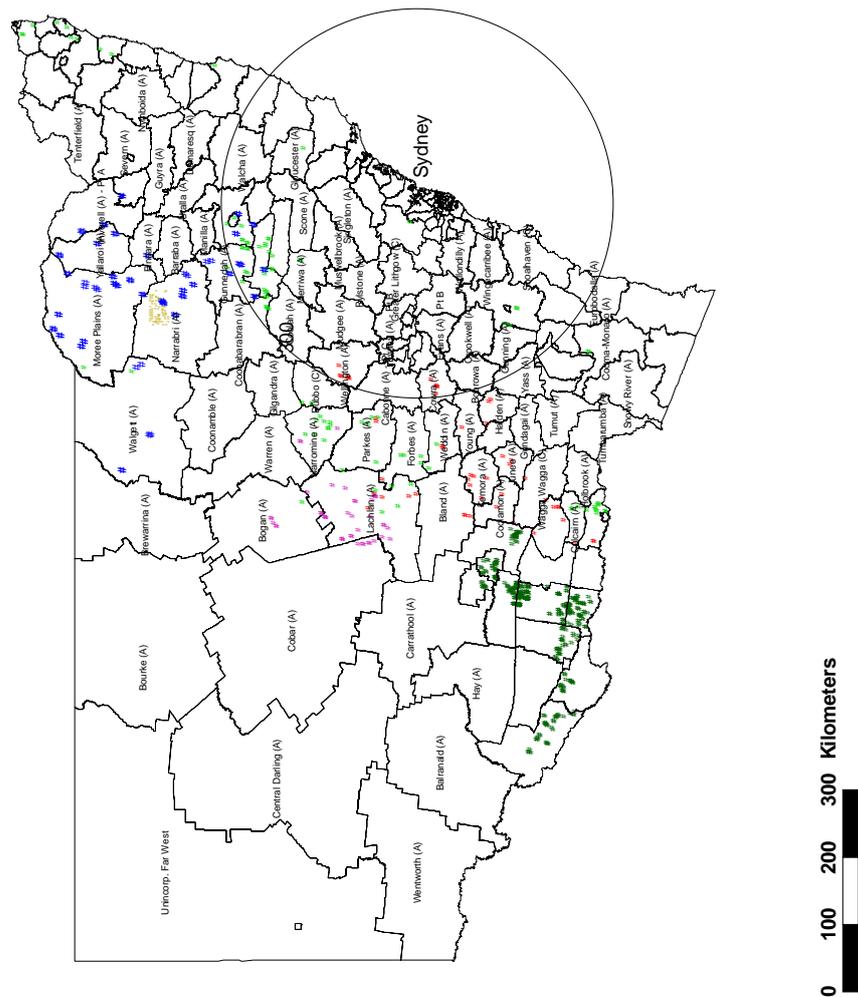


Figure 22. Locations of existing soil carbon data from cropping sites of NSW. (light green dot : SALIS (2004); blue dot : Kirchoff and Daniells (2004); purple dot : Khu and Chan (1994); brown dot : McGarry et al. (1989); dark green dot : ASA database; red dot: Geeves et al. (1995)).

Table 9. Organic carbon concentrations (%) (0-10cm) in cropped and undisturbed soils in different farming systems of NSW.

Rainfall Zone (mm)	Region	Annual Rainfall (mm)	Farming System	Soil Carbon (%)		Difference (%)	Source
				Undisturbed	Cropped		
< 500	Western	<500	Dryland Crops	1.29	1.14	11.6	(Little <i>et al.</i> 1991)
	Western	<500	Dryland Crops	1.49	1.25	16.1	(Khu and Chan 1994)
> 500	Statewide, but closer to the coast		Coastal, Nat. Park, Dryland Crops	3.64	1.49	59	(SALIS 2004)
	Northwest	600	Dryland and irrigated crops	2.3	1.23	46.5	(Kirchoff and Daniells 2004)
	Southwest and central west	600-800	Dryland crops	3	1.36	54.7	(Geeves <i>et al.</i> 1995)
	North and northwest	600-800	Irrigated cotton	1.86	1.24	33.3	(McGarry <i>et al.</i> 1989)
> 800	Sydney	800-1200	Vegetables	2.48 ^A	1.61 ^A	35.1	(Jinadasa <i>et al.</i> 1997)

^A Samples collected to 0-15 cm.

Soil carbon concentrations increase linearly with increasing rainfall for both cropping and pasture soils, although the rate of increase is much higher in pasture soils (Figure 23). The pasture phase of crop rotations in Australian farming systems represents the carbon aggradation period, which suggests the difference in soil carbon concentrations between the crop and pasture line can be taken as a measure of soil's responsiveness to carbon inputs. This indicates the capacity of soils to store carbon is much greater in high rainfall areas than it is in low rainfall zones. The potential of low rainfall areas in the western region of NSW to store carbon is limited by lower productivity and higher potential rates of decomposition of organic matter because of higher temperatures, and approaches zero with less than 450 mm/yr. These results support previous findings that soil carbon storage due to adoption of conservation farming (no-tillage and stubble retention) tends to be negligible for areas with rainfall <500 mm (Chan *et al.* 2003). Therefore, the capability of the soil to store carbon tends to decrease with increasing distance from the coast as rainfall decreases and temperature increases (Figure 20).

Assuming an average bulk density of 1.3 Mg/m³ (0-10 cm) and based on average soil carbon concentrations, soil carbon storage capacity for >500 mm and <500 mm areas was estimated to be 17.8 t/ha and 2.5 t/ha, respectively.

SOC of 0-10 cm layer under pasture and cropping soils as a function of rainfall

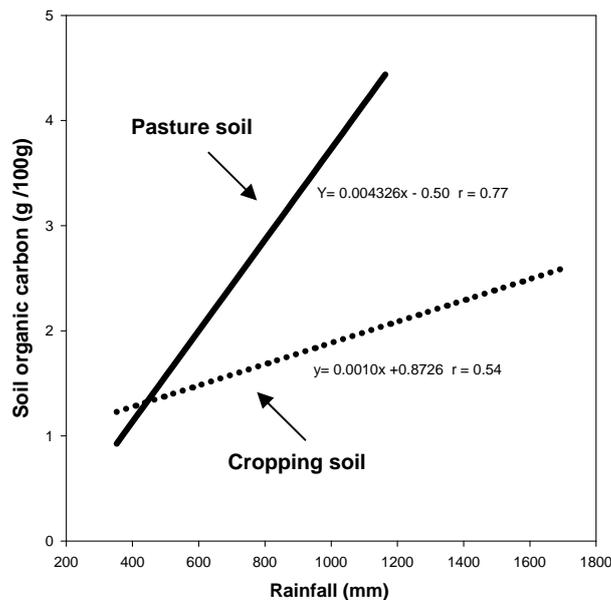


Figure 23. Changes in soil carbon storage (0-10 cm) as a function of annual rainfall for pasture and cropping soils of NSW. (Data provided by Incitec).

Impacts of cropping on soil carbon status and physical and chemical fertility

In soils used for vegetable production in the greater Sydney Metropolitan Area Jinadasa *et al.* (1997) reported a 35% decrease in soil carbon levels as a consequence of cropping. In a study evaluating different vegetable production systems on a Yellow Earth soil at Somersby, NSW, Wells *et al.* (2000) found the systems with high inputs of compost had higher soil organic carbon, water holding capacity, aggregate stability and cation exchange capacity (CEC) relative to conventional production systems. These workers observed that compost application

lead to improvements in soil health and concluded that relatively small changes in management could improve the sustainability of vegetable production systems.

Conteh *et al.* (1997) observed that the organic carbon status of the cracking clay soils (Vertosols) used for cotton production in Australia has declined as a consequence of cultivation. They also highlighted the need for cotton producers to develop management strategies to increase soil carbon levels and avoid problems with soil structural problems such as slaking. Conteh *et al.* (1998) reported that incorporating cotton stubble as opposed to burning it, increased total carbon in these soils. This suggests there is potential for other sources of carbon, such as composted garden organics to increase soil organic matter in cotton soils.

Significant loss in soil organic under cropping has been commonplace in the Australian wheatbelt (e.g. Dalal and Chan 2001). In the northern cropping zone of New South Wales, Whitbread *et al.* (1998) reported a decline in hydraulic conductivity, aggregation and soil carbon in Red Earth (Alfisols or Kandosols), Grey Clay and Black Earth soils (Vertosols). They observed cropping had the most detrimental impact on the Red Earths given these soils lost more C (up to 75%) than those with higher clay contents. Red Earths are inherently infertile and weakly structured (Whitbread *et al.* 1998), suggesting they would respond to organic inputs. Large loss in soil carbon with associated decline in soil health under conventional cropping practices has also been reported in the southern cropping zone of New South Wales in a Red Earth (Chan *et al.* 1992).

Turf production systems remove up to 5 mm of top soil each year when the turf is harvested. This practice removes valuable organic matter and fine clay particles accumulated in the soil surface, which has the potential to reduce soil physical and chemical fertility over time. In addition, turf growers apply poultry litter to meet the crop's nitrogen requirement and supply organic matter. However, this also has the effect of supplying more phosphorus than the crop needs given poultry litter is imbalanced with respect to phosphorus (Griffiths 2004). Consequently, there is a need for the turf industry to find an input which is high in organic matter, but low in nutrients, as an alternative to poultry manure to make turf production more sustainable (P. Martin, pers. comm.).

Little other information is available on the impact of cropping on the soil chemical and physical characteristics of the other cropping systems evaluated in this report.

Existing gaps of knowledge

Existing soil carbon data is patchy in distribution (Figure 21 and Figure 22). This is largely due to the fact that nearly all these data were derived from regional surveys and general soil investigations on broadacre crops rather than systemic studies on soil carbon status. For example, very few data on horticultural cropping soils are available, whilst clear gaps of information on soil carbon exist in the following areas:

1. Sydney Basin
2. higher rainfall wheat growing area around Cowra
3. vineyards throughout the State
4. orchards throughout the State
5. organic farms throughout the State

5.4.2 Attributes of sites most likely to respond to composted garden organics:

Based on the information presented in this section, the following conclusions can be drawn regarding site attributes, which have the greatest potential to respond to composted garden organics:

History of Cropping:

Due to historical soil management practices, such as cultivation, large amounts of soil carbon have been lost and therefore significant storage capacity of soil carbon exists in the cropping soils of NSW.

High rainfall areas:

The soil carbon storage capacity is greatest in higher rainfall areas (>600 mm) and is estimated to be 18 t/ha. For rainfall <500 mm, this reduces to about 2.5 t/ha. Higher rainfall cropping zones are more likely to positively respond to organic inputs, such as composts, and so efforts to establish markets for composted garden organics should focus on these areas. In NSW, this region includes a range of farming enterprises, such as dryland and irrigated broadacre cropping, as well as intensive horticultural crops such as vegetables, viticulture, orchards and organic farms, which are also close to Sydney.

Low chemical and physical soil fertility:

Soils with low organic matter, poor soil structure and low chemical fertility should be identified within each cropping system, as these sites are most likely to respond to the application of composted garden organics.

6 POTENTIAL MARKETS FOR COMPOSTED GARDEN ORGANICS

This section evaluates the strengths, weaknesses, opportunities and threats of each potential market segment, based on the physical, economic and agronomic information presented in the previous sections.

6.1 Potential Markets

6.1.1 Conventional Broadacre

Strengths

- Conventional broadacre agricultural systems represent the largest potential market for composted garden organics in terms of total area of production, with the Cowra and Cabonne Districts being amongst the largest, highest yielding, most profitable and closest to Sydney.
- There is potential for soil conditioners made from composted garden organics to improve the soil chemical and physical fertility of poorly productive soils in this area, as well as improve fertiliser use efficiency and plant establishment because:
 - Cropping has decreased soil organic matter levels in many of the soils in the Central West
 - The Cowra and Cabonne districts receive > 600 mm/yr rainfall.
 - Many soils in the area are acid or sodic and large areas of land are treated with lime and gypsum to increase soil pH and ameliorate problems with soil structural stability.
 - Fertiliser and sowing costs are major components of production costs.

Weaknesses

- Transport costs are likely to be a major barrier to establishing markets in these areas because the largest areas of conventional broadacre systems are located at least 250 km from Sydney, where most of the composted garden organics are produced.
- It would be more difficult for growers to recover the costs of purchasing, transporting and applying RO, based on current pricing structures, given conventional broadacre systems have the lowest gross margins (\$/ha) of the market segments evaluated.

Opportunities

- Target sites with low productivity and chemical and physical fertility (eg. Sodic hardsetting Red Earths and Red Brown Earths) and quantify the benefits composted garden organics could have on the productivity, profitability and sustainability of these broadacre cropping systems.
- Develop synergies and learn from the Biosolids Industry's beneficial reuse programs.
- Promoting the benefits of composted garden organics to the newly established Central West Catchment Management Authority as a tool for rehabilitating degraded land and improving water quality within the catchment.
- Use backloading to reduce the costs of transporting composted garden organics to these areas, given several producers of composted garden organics already source input material for other products, such as landscaping supplies in the Central West. Similarly, growers could backload in trucks used to deliver grain or oilseeds to ports or feed mills near Sydney.
- Blend composted garden organic products with fertilisers or other locally generated recycled organics, such as pig or cattle manure.
- Develop schemes for sourcing composted garden organics produced in regional centres, such as Orange and Bathurst, if it is not economically feasible to supply composted garden organics to broadacre cropping areas from Sydney.

Threats

- Climate, particularly rainfall, has a strong influence on the area, quantity and yield of broadacre crops produced each year. However, the Central West is located in a higher rainfall zone, meaning that this area is more reliable than other areas of the state.
- World commodity prices also impact on production.

6.1.2 Conventional Vegetables

Strengths

- Significant areas of vegetables are grown within close proximity to Sydney, particularly in the Hawkesbury District. Cowra and Cooma are the largest vegetable producing areas within a 300 km radius of Sydney.
- Vegetable production is generally highly profitable with average gross margins in excess of \$2,500/ha.
- Management practices, such as tillage and high rates of fertiliser application are likely to have reduced soil organic matter and elevated the concentration of nitrogen and phosphorus. This indicates vegetable soils could potentially benefit from the application of composted soil conditioners manufactured from garden organics.

Weaknesses

- Vegetable production around Sydney is characterised by a large number of small producers from different ethnic backgrounds, indicating the market is highly fragmented.

- Fertilisers only make up a small proportion of variable production costs and there is little economic incentive for growers to modify current practices.
- It would be difficult for composted garden organics to compete directly with poultry litter as a fertiliser production input, given the latter is cheap and readily available.
- Increased use of composted garden organics in vegetable production systems may create problems with disposing of poultry litter within the Sydney basin.

Opportunities

- Use composted garden organics to increase soil carbon concentrations and improve soil biological health in vegetable production systems.
- Capitalise on the political issue of reducing the impact of agriculture in the Sydney basin on water quality within the Hawkesbury-Nepean River, by using composted garden organics, in combination with poultry litter and inorganic fertilisers, to improve fertiliser use efficiency in vegetable production systems.
- Facilitate the adoption of RO by vegetable producers in Sydney by:
 - Participating in initiatives such as the South Creek nutrient trading scheme and NSW DPI's farmer education and extension programs
 - Promoting the benefits of composted garden organics to the Hawkesbury-Nepean Catchment Management Authority as a tool for improving water quality.
 - Engaging leading and innovative vegetable producers within each community.
- Target vegetable producers and identify potentially responsive sites in the Central West as per Conventional Broadacre systems.
- Blend composted garden organic products with fertilisers or other locally generated recycled organics, such as poultry litter.

Threats

- Continued urban development in Sydney may reduce the area of land available for vegetable production.
- On-going water shortages in Sydney may impact on the availability of irrigation water and subsequent area of vegetable production.

6.1.3 Cotton

Strengths

- A large area of cotton is grown in the Gunnedah District.
- Cotton is a high value crop with an average gross margin of approximately \$2,100/ha.
- The cotton industry has identified declining soil chemical and structural fertility as an issue which needs to be addressed to ensure production is sustainable.
- The cotton industry is well educated, quick to adopt new technology and generally willing to participate in collaborative projects.
- The cotton industry is already aware of the potential to use composted garden organics as a soil ameliorant, given its interest in applying composted gin trash to cotton soils.
- There is potential for soil conditioners made from composted garden organics to increase soil organic matter and improve soil structure, which have declined in many cotton growing soils.

Weaknesses

- The majority of cotton is grown more than 300 km from Sydney, indicating transport costs may limit market viability.

- The cotton soils which are most likely to respond to composted garden organics, such as sodic grey clays, are more widely distributed around Moree and Narrabri, which are 400-500km from Sydney. In contrast the soils around Gunnedah tend to be better structured Black Earths, which would be less responsive.
- Fertilisers only make up a small proportion of production costs.

Opportunities

- Become involved with industry initiatives to improve soil chemical, physical and biological health.
- Crop nutrition is gaining prominence as an issue, particularly with the introduction of Bollgard II cotton in the 2004/05 season. This could create opportunities to look at the potential for composted garden organics to improve fertiliser availability and its recovery by plants.
- The cotton industry is well organised and conscious of the need to improve public perception of its environmental performance, and so using composted garden organics may be one way to enhance its “green” image.
- Blend composted garden organic products with fertilisers or other locally generated recycled organics, such as gin trash.
- Develop schemes for sourcing composted garden organics produced in regional centres, such as Tamworth and Dubbo, if it is not economically feasible to supply composted garden organics to cotton growing areas from Sydney.

Threats

- The area and quantity of cotton produced is strongly influenced by water availability in supply reservoirs, which has been low in recent years.

6.1.4 Organic Agriculture

Strengths

- Once established, organic agriculture generally achieves higher gross margins than conventional broadacre and vegetable production systems.
- Organic producers are already receptive to using composts as a component of their production systems and often have difficulty sourcing appropriate inputs.
- Organic growers may place a higher value on composted garden organics as a tool in controlling weeds and diseases, and supplying nutrients to crops, given they are not able to use conventional chemicals and fertilisers.
- Fertilisers and plant establishment are major costs in organic broadacre agriculture and so there is potential for composted garden organics to reduce these variable costs.
- The use of composted garden organics is consistent with the organic philosophy of using available resources in a more sustainable manner.
- Organic agriculture is a rapidly growing market sector.

Weaknesses

- Organic agriculture only constitutes a small area of production (<2%) and so is currently only a small market.
- The organic market is fragmented geographically, which reduces the practicality of supplying composted garden organics to one particular area.
- The high opportunity cost of switching from a conventional to organic production system may limit the growth of this market segment.

Opportunities

- Capitalise on the rapidly growing Organic agriculture market sector.

- Compost producers should achieve organic accreditation from certifying bodies, such as NASAA and BFA, to gain access to organic markets.
- Use the NSW DPI's Organic Farming Centre, Bathurst to establish and nurture industry linkages.

Threats

- Using non-certified inputs (eg. AS4454) and reduced premiums for organic products as a consequence of poor quality assurance contamination from inputs or adjoining properties have the potential to reduce the premiums paid for organic products.
- Demand for organic produce could diminish depending on consumer trends and preferences.

6.1.5 Perennial horticulture

Strengths

- The average gross margin for perennial horticulture is \$7800/ha indicating it is a profitable market segment.
- Water is a major determinant of yield and so there is potential for composted mulches to improve water use efficiency in perennial horticultural crops.
- Fertiliser is a moderate production cost (11%) and so composted garden organics may also improve fertiliser use efficiency in perennial horticultural crops.

Weaknesses

- The total area of citrus and stonefruit within 300 km of Sydney is only small (~1,000 ha), although the majority of this is within the Gosford, Wyong, Hawkesbury and Hornsby districts.
- Perennial horticultural crops take a long time to establish and respond to treatments, which makes it more difficult to conduct research into quantifying the benefits of composted garden organics and detect crop response in these production systems.
- Little research has been done to characterise soil carbon status in these production systems, which makes it difficult to identify responsive soils.
- Unknown market potential for soil conditioners.

Opportunities

- Capitalise on current water shortages and evaluate the potential of composted mulches to improve water use efficiency and yield in perennial crops.
 - Eg. Explore the potential to deliver irrigation water under mulches through drip irrigation.
- Use composted garden organics to encourage tree establishment and early growth.

Threats

- Exotic diseases such as citrus canker and fireblight have the potential to decimate crops and destroy valuable export markets.
- The pome, citrus and stone fruit industries are subject to fluctuations in commodity prices and are unable to respond quickly to market price signals due to long periods between plant establishment and yield.
- On-going water shortages may limit the availability of water for irrigation and reduce production.

6.1.6 Turf

Strengths

- Most (80%) of the turf produced in New South Wales is grown in the Hawkesbury-Nepean basin, which is close to the source of composted garden organics.
- The turf industry has the highest gross margins of the market segments evaluated.
- The turf industry is interested in alternatives to poultry litter as a soil conditioner to replace the soil and organic matter removed in each harvest.
- The annual removal of topsoil ensures there would be on-going demand for composted garden organics.
- The turf industry is more homogenous than the vegetable industry in the Sydney basin, meaning it would be easier to define and target the market.
- The location of turf farms on alluvial floodplains along the Hawkesbury River, means this land will not be lost to urban development, whilst the high gross margin indicates it is unlikely to be displaced by other agricultural land uses
- Using composted garden organics is consistent with the broader environmental objectives of reducing the impact of agricultural production on water quality in the Hawkesbury-Nepean River.

Weaknesses

- The total area of turf grown in the Hawkesbury valley is only 1,100 ha, indicating that it can only consume a small proportion of the composted garden organics generated each year.
- Achieving full market adoption would displace the poultry litter normally applied to turf which would then require an alternative method of beneficial reuse or disposal.
- Demand would be limited to fine product types, such as premium soil conditioners to ensure compost does not impact upon seed bed stability.

Opportunities

- Identify the impact of current fertilisation practices on soil quality and highlight the need to reduce P loading on turf soils.
- Promote composted garden organics to industry as an alternative to poultry litter.
- Facilitate the adoption of RO by turf growers in Sydney by:
 - Participating in initiatives such as the South Creek nutrient trading scheme
 - Promoting the benefits of composted garden organics to the Hawkesbury-Nepean Catchment Management Authority as a tool for reducing the impact of turf production on water quality.

Threats

- The following issues could affect the viability of a market for composted garden organics in turf and will need to be addressed to achieve market confidence in the material.
 - Soil conditioners with large amounts of woody material and low bulk density can create seed bed instability, which is highly undesirable.
 - The fine material in soil conditioners settles on the soil surface and can become hydrophobic, particularly under dry conditions.
 - High organic material can carry an increased risk of Fusarium wilt in turf.

6.1.7 Viticulture

Strengths

- There are large areas of vineyards established within close proximity to Sydney, either in the Hunter Valley in the north or Cowra and Cabonne districts in the Central West.
- Viticulture has high gross margins and is a growing industry.
- Water scarcity is an issue and so there is potential for composted mulches to improve water use efficiency in viticultural crops.
- There is existing awareness of recycled organics and its benefits through previous DEC, DPI and industry programs.

Weaknesses

- Conservative industry which is slow to adopt new practices.
- Vines take a long time to establish and respond to treatments, making it difficult to conduct research into quantifying the benefits of composted garden organics and detect crop response in these production systems.
- Little research has been done to characterise soil carbon status in these production systems, which makes it difficult to identify responsive soils.
- Sydney is a Phylloxera infested area and so producers will need a compliance agreement with NSW DPI to move composted materials to other parts of New South Wales.
- Uncertain potential for soil conditioners.

Opportunities

- Capitalise on uncertainty about the security of water allocation within the industry to encourage measures which improve water use efficiency.
- Target leading and influential growers to facilitate the adoption of composted garden organics in the viticultural market.
- Build upon existing government programs to increase awareness and adoption of recycled garden organics with the viticultural industry.
- Current DPI Phylloxera surveys may clear much of the Sydney Basin of its Phylloxera infested status.

Threats

- Phylloxera has the potential to infect and decimate vines in Phylloxera free areas.
- Wine grape prices may fall as a consequence of increased plantings and oversupply of grapes on the domestic and export markets.

6.2 Value chain analysis

In order to identify potential markets for soil conditioners and mulches made from composted garden organics, a value chain analysis was performed to compare current retail prices for these products with the prices each market segment is likely to pay for them. The first part of the value chain analysis summarised the current retail price for mulches and soil conditioners, and estimated the likely cost of transporting and applying them to different agricultural and horticultural production systems.

The second step involved estimating the price end users in each market segment are likely to pay for composted soil conditioners or mulches. These prices were based on prices paid for recycled organics, such as biosolids¹ (\$1.50/t), poultry litter (\$15/t) or

¹ Farmers pay a contribution of \$1.50 to \$5.00 per wet tonne for biosolids. For the purpose of this report the lower market contribution of \$1.50/ wet tonne has been used.

mulches (\$10-15/t), which are currently being used in each market segment (Table 4). Whilst soil conditioners and mulches made from composted garden organics have different attributes to other types of recycled organics (Section 4.1), this approach is useful for approximating the entry level market price for recycled organics in each market segment.

The current asking price was then compared with the end user buying price to determine which market segment would be the most commercially attractive for supplying soil conditioners and mulches into.

The value chain analysis suggests that a negative price differential exists between the total asking price, which included the cost of purchasing, transporting and applying composted garden organics, and the end user buying price for all market segments evaluated (Table 10). The price differential was the least negative for supplying mulch into viticulture and perennial horticulture at -\$5 and -\$8/t, respectively (Table 10). For composted soil conditioners, Turf and Vegetable production systems were the least negative at -\$25/t (Table 10).

The large negative price differential in broadacre production systems is a function of the low prices farmers are likely to pay for competing products and the large distance (>200 km) (Figure 7 and Figure 8) between the source of production and the market. Whilst cotton producers might be willing to pay slightly more for composted soil conditioners than broadacre farmers, high transport costs result in a large negative price differential given this market is located more than 300 km from Sydney (Figure 10).

It is recognised that the various cost of the components of the value chain are likely to vary by council, processor, type of compost and distance to market. However, this approach provides a way of comparing the relative profitability of supplying soil conditioners and mulches made from composted garden organics into different agricultural and horticultural markets. Further, it highlights which components of the value chain need to be targeted in order to make each market segment more profitable.

Table 10. Comparison of current asking price for composted soil conditioners and mulches against the price the market is willing to pay for these products for agricultural and horticultural uses.

Component of Value Chain	-----Soil conditioners-----						-----Mulches-----		
	Conventional Broadacre (\$/t)	Conventional Vegetables (\$/t)	Organic Broadacre (\$/t)	Organic Vegetables (\$/t)	Irrigated Turf (\$/t)	Fibre Cotton (\$/t)	Perennial Horticulture (\$/t)	Viticulture Grapes (\$/t)	
Current Retail Price (CRP)	30	30	30	30	30	10	10	30	
Transportation ²	20	5	20	5	5	8	10	30	
Application ³	5	5	5	5	5	5	5	5	
Total Asking Price	55	40	55	40	40	23	25	65	
End user Buying Price	1.5	15	1.65	15	15	15	20	2	
Price differential	-54	-25	-53	-25	-25	-63	-8	-5	

¹Transportation costs calculated by assuming that it costs \$0.10/t/km to transport a load of soil conditioner or mulch (J.Vyse pers.comm). Distances to broadacre, vegetable, turf, horticulture, viticulture and cotton markets is assumed to be 200, 50, 50, 75, 100 and 300 km, respectively from the source of supply.

²Application costs for row crops are likely to be less than those for broadacre costs on a per hectare basis, because a smaller proportion of the area (~30%) is actually treated with product.

6.3 Barriers to markets

There are a number of barriers which contribute to the negative differentials between current asking and buying prices for composted garden organics identified in the value chain analysis above. These barriers can be broadly categorised as policy/regulatory, economic, social or technical (PEST):

6.3.1 Policy and Regulatory

- State Government policies and strategies are needed to support the establishment of new markets for composted garden organics, particularly in the initial stages of development.
- Compliance with industry standards (eg. AS4454) is only voluntary, which creates an unregulated market with respect to product quality. This can result in:
 - low quality products in the market place, which contain weeds, pathogens and contaminants
 - Decreased market confidence and acceptance of recycled organic products.
- garden organics are often precluded from unrestricted uses when co-composted with biosolids and the final copper and zinc concentration in the final product are greater than 100 and 200 mg/kg, respectively (NSW EPA 1997).

6.3.2 Economic

- The cost of transporting composted garden organics outside the Sydney Basin is a major barrier to establishing new markets.
- Agricultural producers are typically price sensitive, particularly in market segments with low gross margins and are reluctant to adopt new products without better information on the economic returns associated with using it.

6.3.3 Social

- Consumers need to be educated to change the perception that composted garden organics are a low-value, waste product and recognise its resource value.
- Current grower practices need to be modified, especially in conservative industries.

6.3.4 Technical

- Processors need to ensure they consistently produce a high quality product, which is free of contaminants, particularly plastics.
- The key attributes of composted garden organics need to be quantified and promoted to meet the needs of consumers. These are likely to vary between consumers and products. For example:
 - the water saving characteristics of composted mulches should be determined for use in viticulture and perennial horticulture.
 - the potential of composted soil conditioners to improve soil chemical and physical characteristics should be determined for vegetable, turf, cotton and broadacre cropping systems.

In summary, this PEST analysis indicates there are six key barriers which need to be overcome in order to develop viable agricultural and horticultural markets for composted garden organics. These “critical success factors” are:

- Increase landfill and gate fee charges
- Improve product quality and consistency
- Quantify the key attributes and benefits of using composted garden organics

- Promote the key attributes to end users
- Reduce transport costs
- Participate in environmental initiatives
- Influence policy and decision makers in governments

6.4 Critical success factors for supplying composted garden organics into agricultural and horticultural markets

Whilst these “critical success factors” are common to all market segments, the relative influence they have on the viability of each market varies. Hence it is necessary to look at these factors in more detail to target the work that needs to be done to satisfy consumer demand for composted garden organic products and reduce the negative price differential which currently exists between the asking and buying prices in the composted garden organics value chain (Section 6.2).

This was achieved by prioritising the key attributes growers seek in production inputs (Section 4.3 and market research undertaken), establishing whether the characteristics of composted garden organics represent a strength, weakness, opportunity or threat (Section 6.1) with respect to this attribute and linking these priorities to the “critical success factors” (Section 6.3).

6.4.1 Conventional Broadacre

Table 11. Critical Success Factors for composted garden organic soil conditioners in Conventional Broadacre markets.

Key attributes sought by grower	SWOT	Priority	Critical Success Factors						
			Increase landfill and gate fee charges	Improve product quality and consistency	Quantify Key attributes and benefits	Promote Key attributes to end users	Reduce transport costs	Participate in environmental initiatives	Influence policy and decision makers in governments
Return on investment for user	W	1	✓		✓	✓	✓		✓
Increase crop productivity and yield	W/O	2			✓	✓			
Improve plant establishment	O	3			✓	✓		✓	
Improve FUE [§]	O	4			✓	✓		✓	
Improve crop WUE [‡]	S/O	5			✓	✓		✓	
Suppress weeds	O	6			✓	✓		✓	
Consistent/easy to use product	W/T	7		✓					
Ameliorate salinity, sodicity, acidity	O	8			✓	✓		✓	
Maintain the soil resource	S/O	9			✓	✓		✓	
Comply with Best Management Practices	O	10			✓	✓		✓	

[§]FUE – Fertiliser Use Efficiency

[‡]WUE – Water Use Efficiency

The greatest barriers for composted garden organics to gain entry into conventional broadacre markets are the low prices growers are likely to pay for composted garden organics and the high cost of transporting composted garden organic products to these markets (Table 11). The greatest opportunity for using soil conditioners made from composted garden organics, in this market is to conduct research into quantifying the benefits of using these products to ameliorate issues relating to salinity, sodicity and poor structural stability. Research should also focus on the agronomic benefits of using these products in combination with conventional inputs to improve fertiliser use efficiency and subsequent crop productivity to demonstrate the return on investment to growers. These benefits should be promoted to growers as forming part of best management practices, as well as to Catchment Management Authorities and Landcare groups as potential solutions to regional environmental problems (Table 11).

6.4.2 Conventional Vegetables

Transport is much less of a barrier in conventional vegetable markets because they are located within close proximity to the greater Sydney Metropolitan Area, where most composted garden organics are produced (Figure 9). The key opportunities in this market are to demonstrate how using soil conditioners made from composted garden organics can improve plant establishment, water use efficiency and fertiliser use efficiency. Participation in environmental initiatives within the Hawkesbury-Nepean Catchment, such as the South Creek nutrient trading scheme, is a key opportunity for gaining entry into this market (Table 12). Increasing landfill charges will also be necessary to reduce the price differential that exists between the asking and buying price for these products (Table 10).

Table 12. Critical Success Factors for composted garden organic soil conditioners in Conventional Vegetable markets.

Key attributes sought by grower	SWOT	Priority	Critical Success Factors						
			Increase landfill and gate fee charges	Improve product quality and consistency	Quantify Key attributes and benefits	Promote Key attributes to end users	Reduce transport costs	Participate in environmental initiatives	Influence policy and decision makers in governments
Return on investment for user	W	1	✓		✓	✓			✓
Increase crop productivity and yield	W/O	2			✓	✓			
Improve plant establishment	O	3			✓	✓			
Improve crop quality	O	4			✓	✓			
Consistent/easy to use product	W/T	5		✓					
Improve crop WUE [†]	S/O	6			✓	✓		✓	
Improve FUE [§]	S/O	7			✓	✓		✓	
Comply with BMPs	O	8			✓	✓		✓	
Maintain the soil resource	S/O	9			✓	✓		✓	

[†]WUE – Water Use Efficiency

[§]FUE – Fertiliser Use Efficiency

6.4.3 Cotton

The critical success factors for gaining entry for composted soil conditioners into the cotton market are similar to those for conventional broadacre markets. The cost of transporting these products to market would be higher (Section 6.2). However, cotton growers could be willing to pay a higher price for these products because of their relatively higher gross margins (\$/ha) (Figure 16). Further, the industry is well developed with respect to complying with Best Management Practices and addressing issues relating to environmental sustainability, which could be used as opportunities to promote the use of composted garden organics in this market (Table 13).

Table 13. Critical Success Factors for composted garden organic soil conditioners in cotton markets.

Key attributes sought by grower	SWOT	Priority	Critical Success Factors						
			Increase landfill and gate fee charges	Improve product quality and consistency	Quantify Key attributes and benefits	Promote Key attributes to end users	Reduce transport costs	Participate in environmental initiatives	Influence policy and decision makers in governments
Return on investment for user	W	1	✓		✓	✓	✓		✓
Crop productivity and yield	W/O	2			✓	✓			
Improve crop WUE [‡]	O	3			✓	✓		✓	
Improve plant establishment	O	4			✓	✓			
Ameliorate salinity &/or sodicity	S/O	6			✓	✓		✓	
Improve FUE [§]	O	7			✓	✓			
Comply with Best Management Practices	O	8			✓	✓		✓	
Maintain the soil resource	S/O	9			✓	✓		✓	
Consistent/easy to use product	W/T	10		✓					

[‡]WUE – Water Use Efficiency

[§]FUE – Fertiliser Use Efficiency

6.4.4 Organic Agriculture

Organic agriculture is a small but growing market with a need to use alternatives to inorganic fertilisers, herbicides, pesticides and fungicides as production inputs. This creates an opportunity to promote composted garden organics as substitutes for these conventional inputs. However, research is required to determine the effectiveness of composted garden organics in providing nutrients to and controlling pests, weeds and diseases in growing crops (Table 14).

Table 14. Critical Success Factors for composted garden organic soil conditioners in Organic Agriculture markets.

Key attributes sought by grower	SWOT	Priority	Critical Success Factors						
			Increase landfill and gate fee charges	Improve product quality and consistency	Quantify Key attributes and benefits	Promote Key attributes to end users	Reduce transport costs	Participate in environmental initiatives	Influence policy and decision makers in governments
Return on investment for user	W	1	✓		✓	✓	✓		✓
Crop productivity and yield	W/O	2			✓	✓			
Improve FUE [§]	O	3			✓	✓			
Suppress weeds	O	4			✓	✓			
Suppress diseases	O	5			✓	✓			
Improve crop quality	O	6			✓	✓			
Improve crop WUE [‡]	S/O	7			✓	✓		✓	
Comply with Best Management Practices		8			✓	✓			
Maintain the soil resource	S, O	9			✓	✓			
Ameliorate salinity, sodicity, acidity	O	10			✓	✓		✓	
Consistent/easy to use product	W/T	11		✓					

[§]FUE – Fertiliser Use Efficiency

[‡]WUE – Water Use Efficiency

6.4.5 Perennial Horticulture

Perennial horticulture and Viticulture are the markets with the least negative price differential between asking and buying prices for mulches made from composted garden organics. As with all of the market segments evaluated in this report, research is still required to quantify the return on investment growers can expect from using these products. This should be achieved by undertaking research into how using composting garden organics can improve crop water and fertiliser use efficiency, suppress weeds and diseases, tree establishment and early growth, as well as improve crop quality (Table 15).

Table 15. Critical Success Factors for composted garden organic mulches in Perennial Horticulture markets.

Key attributes sought by grower	SWOT	Priority	Critical Success Factors						
			Increase landfill and gate fee charges	Improve product quality and consistency	Quantify Key attributes and benefits	Promote Key attributes to end users	Reduce transport costs	Participate in environmental initiatives	Influence policy and decision makers in governments
Return on investment for user	W	1	✓		✓	✓	✓		✓
Increase Crop productivity and yield	W/O	2			✓	✓			
Improve crop WUE [‡]	S/O	3			✓	✓		✓	
Improve FUE [§]	O	4			✓	✓		✓	
Suppress weeds	O	5			✓	✓		✓	
Improve crop quality	O	6			✓	✓			
Suppress diseases	O	7			✓	✓		✓	
Improve tree establishment	O	8							
Comply with Best Management Practices	S	9							
Maintain the soil resource	S/O	10			✓	✓		✓	
Consistent/easy to use product	W/T	11		✓					

[‡]WUE – Water Use Efficiency

[§]FUE – Fertiliser Use Efficiency

6.4.6 Turf

The challenges and opportunities for gaining entry into the turf market are similar to those for Conventional Vegetable production. The differential between asking and buying prices are likely to be similar. One of the key attributes sought by growers is good product quality and consistency with respect to creating a uniform growing medium for turfgrass. Research is required to evaluate the effect of soil conditioners on turf establishment and growth and identify whether using these products leads to problems with hydrophobic conditions on the soil surface. As with vegetable production systems, turf producers rely on poultry litter to supply nitrogen to growing plants and so turf soils are also likely to have elevated P concentrations. Hence, opportunities exist to promote the use of composted garden organics as an alternative to poultry litter and reduce the potential for P transport to waterways. Likewise, soil conditioners made from composted garden organics could be promoted to industry as a means of replacing the topsoil and organic matter removed with each turf harvest (Table 16).

Table 16. Critical Success Factors for composted garden organic soil conditioners in Turf markets.

Key attributes sought by grower	SWOT	Priority	Critical Success Factors						
			Increase landfill and gate fee charges	Improve product quality and consistency	Quantify Key attributes and benefits	Promote Key attributes to end users	Reduce transport costs	Participate in environmental initiatives	Influence policy and decision makers in governments
Return on investment for user	W	1	✓		✓	✓	✓		✓
Quality/consistency of product Eg. Hydrophobicity	W/T	2		✓					
Maintain the soil resource	S/O	3			✓	✓		✓	
Improve crop quality	O				✓	✓			
Improve crop FUE [§]	S/O	4							
Improve crop WUE [‡]	S/O	5			✓	✓		✓	
Comply with Best Management Practices	S	6							

[§]FUE – Fertiliser Use Efficiency

[‡]WUE – Water Use Efficiency

6.4.7 Viticulture

The opportunities for using composted organic mulches in viticulture are similar to those for perennial horticulture. Research should focus on demonstrating the potential for mulches to improve crop water use efficiency, vine establishment and early growth, as well as reduce chemical usage by the viticultural industry (Table 17).

Table 17. Critical Success Factors for composted garden organic mulches in Viticulture markets.

Key attributes sought by grower	SWOT	Priority	Critical Success Factors for composted garden organics						
			Increase landfill and gate fee charges	Improve product quality and consistency	Quantify Key attributes and benefits	Promote Key attributes to end users	Reduce transport costs	Participate in environmental initiatives	Influence policy and decision makers in governments
Return on investment for user	W	1	✓		✓	✓	✓		✓
Improve crop WUE [‡]	S/O	2			✓	✓		✓	
Reduce chemical usage	O	3							
Suppress weeds	O	4			✓	✓		✓	
Improve FUE [§]	O	5			✓	✓		✓	
Improve vine establishment	O	6							
Reduce impacts of frosts	O/T	7							
Maintain the soil resource	S/O	8			✓	✓		✓	
Quality/consistency of product	W/T	9		✓					

[‡]WUE – Water Use Efficiency

[§]FUE – Fertiliser Use Efficiency

7 STRATEGY FOR CREATING NEW MARKETS FOR COMPOSTED GARDEN ORGANICS

An integrated approach is needed for establishing viable agricultural and horticultural markets for composted garden organics. Components of this integrated approach are discussed below.

7.1 Consistently producing a high quality product

- Producers should aim to produce a product that is consistent with AS4454 for composts, soil conditioners and mulches.
- Better source separation is the best solution for reducing contaminants, especially plastics in the end product.
- This could be achieved by educating the community and providing incentives or disincentives to households for separating waste streams. An example is a recent pilot project undertaken in Queanbeyan called “City to Soil” which successfully encouraged householders to keep contaminants out of garden organic collection

bins by barcoding the bins and randomly giving a prize to compliant households (G. Gillespie pers. comm.)

7.2 Quantifying the benefits

- Quantify the benefits of RO as a tool for improving crop productivity and soil health, as well as addressing broader environmental issues from a local and global perspective.
- Integrate the various benefits to increase the sustainability of agricultural production systems and address issues relating to disposing of garden organics.
- Assign an economic value to these potential benefits.
- Use sustainable agricultural production as the primary driver for establishing new markets, rather than the issue of disposing of garden organics in urban environments.
- There is a need to modify current practices in all market segments to include recycled organics.

7.2.1 Agronomic production and soil health

- Quantify the benefits of composted garden organics with respect to soil physical, chemical and biological health.
- Target research towards demonstrating how composted garden organics can help overcome specific crop syndromes, nutritional disorders or soil quality issues faced by producers.
 - For example, adding composted soil conditioner in combination with inorganic fertiliser to a vegetable crop grown on an acidic sandy soil, could increase soil organic matter, improve nutrient use efficiency, reduce aluminium toxicity, increase soil water holding capacity and possibly reduce the incidence of soil borne diseases.

7.2.2 Environmental issues in Catchments

- Identify the potential for composted garden organics to fit in with broader environmental issues in catchments and promote these to respective Catchment Management Authorities.
 - For example, the South Creek Nutrient Trading Scheme could be used as a mechanism to establish markets for composted garden organics within the South Creek Catchment.
 - Similarly, Section 94 contributions (EP&A Act 1979), from proposed urban developments in South Creek could be used to fund initiatives aimed at improving nutrient management in market gardens and turf farms using composted garden organics.
- Estimate the environmental savings/ value of composted garden organics within catchments. For example, quantify the benefits in terms of:
 - water savings,
 - reduced soil erosion
 - decreased nutrient exports
 - reduced impact on water quality.

7.2.3 Global warming and Greenhouse gas abatement schemes

- Quantify the potential benefits of applying composted garden organics to soil in terms of its ability to fix carbon and secure Greenhouse Credits.
- Establish long-term field experiments for different targeted farming systems to quantify these benefits.

7.3 Promoting the benefits to stakeholders

- Identify stakeholders and target potential consumers. Stakeholders include:
 - Households, farmers, environmental and agricultural consultants, Processors, Councils, Peak Industry Bodies, Primary Industry R&D funding bodies, decision makers in Catchment Management Boards, State Government Agencies.
- Improve stakeholder awareness of the benefits of using RO through education and extension campaigns
- Employ a specialist industry liaison/ project officer, funded by industry and located within NSW DPI to maximise the effectiveness of extension strategies using existing extension networks.

7.4 Identifying mechanisms to establish new markets

- Develop a collaborative approach with stakeholders including urban producers of garden organics, RO producers, RO consumers, government departments, councils and industry
- Secure funds for establishing new markets by:
 - Increasing landfill costs
 - Applying a special levy or gaining access to the Waste Levy;
 - Accounting for the true cost of sending garden organics to landfills.
 - Creating economic incentives for farmers to use composted garden organic products.
- Use policy drivers to help establish markets by:
 - Increasing the cost of disposing garden organics to landfill- this would enhance the value of composted garden organics and improve the feasibility of applying it to agricultural land.
 - Promoting public awareness of garden organics and issues associated with landfills to generate political and financial support for establishing new markets.
- Develop transport arrangements to overcome constraints relating to delivering composted garden organics to market.
- Participate in the South Creek Nutrient Trading Schemes. This could assist in establishing a market for market gardens and turf farms within the Sydney Basin.
- Establish a strategic alliance with the Fertiliser Industry Federation of Australia (FIFA) or Australian Fertiliser Spreaders Association (AFSA) to add value to composted garden organics and create a synergy with other products. This has the potential to utilise existing supply, distribution and advisory networks within the fertiliser industry.

8 CONCLUSIONS AND FURTHER RESEARCH

This report has evaluated the beneficial characteristics of mulches and soil conditioners derived from composted garden organics and assessed potential agricultural and horticultural markets for them.

Mulches and soil conditioners made from composted garden organics have the potential to improve the chemical, physical and biological characteristics of soils used for agricultural and horticultural production in New South Wales. Soil conditioners have the greatest potential to be used in combination with inorganic or organic fertilisers to increase soil organic matter and improve nutrient management or as soil amendments to ameliorate problems with soil structure.

Mulches have potential to improve water use efficiency in irrigated crops by reducing water loss from the soil surface through evaporation. However, research is required to quantify and assign an economic value to these benefits.

Viticulture and perennial horticulture have been identified as the markets with the greatest potential to consume composted garden organic mulches, which is consistent with the findings of other studies including Love and Rochfort (1998), (ROU (2003a) and ROU (2003b)). This is because large areas of high value irrigated grape, citrus, pome and stone fruit crops are grown in close proximity to Sydney, whilst decreased water availability will increasingly become an issue for growers.

Turf has immediate potential as a market for soil conditioners, given the industry is exploring low nutrient alternatives to chicken manure to supply organic matter and replace the topsoil removed each year when turf is harvested to improve the sustainability of the industry. The turf market is highly profitable, well organised and relatively homogenous meaning it should be easy to target with education and extension campaigns. Further, over 80% of the turf produced in New South Wales is grown in the Hawkesbury District, which means it is highly accessible to the source of composted garden organics. However, this is only a small market in comparison to the total quantity of composted garden organics produced and so other markets will also need to be developed.

Soil conditioners made from composted garden organics could also reduce the impact of vegetable production on water quality within the Hawkesbury-Nepean River. However, research is needed to confirm this benefit and to develop the optimal application strategy. Furthermore environmental initiatives such as green offsets and nutrient trading schemes will need to be used as the drivers for establishing this market, given there is currently little economic incentive for vegetable producers to change current nutrient management practices.

From a sustainability perspective, broadacre agriculture is the market with the greatest potential in the longer term. This is because large areas of agricultural land are low in soil organic matter and poorly structured, as a consequence of poor inherent fertility and/ or poor management under cropping in the past. Composted garden organics are potentially useful soil ameliorants to improve soil health and productivity. In addition, fertilisers and soil amendments are the major input costs and there is potential to identify the potential for composted garden organics to improve fertiliser use efficiency and increase crop gross margins. However, currently a large gap (-\$54/t) exists between the asking price for soil conditioners manufactured from composted garden organics and the price farmers would be willing to pay for them.

Central West New South Wales should be targeted as the most suitable region for establishing agricultural markets for composted garden organics outside the Sydney region. This area produces a diverse number of crops, including the majority of market segments evaluated in this study, which suggests a range of industries could be supplied with composted garden organic products.

Central West New South Wales also has large areas of soils which are prone to soil structural problems such as hard setting, compaction, surface sealing and sodicity and could respond to organic inputs. Further, the high rainfall in this region (>600 mm/yr) increases the soils capacity to retain carbon and increase soil organic matter. Additional work is required to identify responsive sites in this region, such as those located on poorly structured Red Earths or Red Brown Earths and research the benefits of using composted garden organics in these systems.

In all potential market segments, it is necessary to target specific issues which need to be addressed and demonstrate how using composted garden organics could provide multiple benefits to the production system. For example, adding composted soil conditioner in combination with inorganic fertiliser to a horticultural crop grown on an acidic sandy soil, could improve nutrient use efficiency, reduce aluminium toxicity, increase soil water holding capacity and possibly reduce the incidence of soil borne diseases.

A strategy is required to establish environmentally sustainable and economically viable markets for composted garden organics in these industries. The strategy should focus on quantifying the soil fertility, environmental and economic benefits of composted garden organics. Research should be targeted towards demonstrating how composted garden organics can help overcome specific crop syndromes, nutritional disorders or soil quality issues faced by producers. The outcomes of this research should then be promoted to consumers through education and extension campaigns, to highlight the economic value of using composted garden organics from a production and soil health perspective. Similarly, Government should be made aware of the value of composted garden organics as a tool in addressing waste management and soil and water quality issues in urban and agricultural catchments. This will improve the perceived value of composted garden organics and reduce the costs which currently act as the main barrier to delivering these products to agricultural and horticultural markets.

9 BIBLIOGRAPHY

- ABS (2001) '2001 Agricultural Census Data.' Australian Bureau of Statistics, www.abs.gov.au
- ANRA (2001) 'Australian Natural Resources Audit: Nutrient management in Australian agriculture.' Environment Australia, http://audit.ea.gov.au/ANRA/agriculture/docs/national/Agriculture_Nutrient.html
- Blair GJ, Sale P (1996) 'Plant Nutrition- feeding the plant, sustaining the soil.' (The University of New England: Armidale, NSW)
- Boon K, Taylor PJ, Pangagiotopolous B, Radford RW (1999) 'Seasons of Change: A guide to successful vineyard investment in a changing world.' (PIRSA Rural Solutions: Adelaide, SA.)
- Chan KY, Heenan DP, Roberts, WP (1992) Organic carbon levels and associated soil properties of a red earth after 10 years of rotation under different stubble and tillage practices. *Aust. J. Soil Res.* **30**, 71-83.
- Chan KY, Heenan DP, So, HB (2003) Sequestration of carbon and changes in soil quality under conservation tillage on lighter textured soils in Australia. *Australian Journal of Experimental Agriculture.* **43**, 325-334.
- Conteh A, Blair GJ, Macleod DA, Lefroy RDB (1997) Soil organic carbon changes in cracking clay soils under cotton production as studied by carbon fractionation. *Australian Journal of Agricultural Research* **48**, 1049-58.
- Conteh A, Blair GJ, Rochester IJ (1998) Soil organic carbon fractions in a Vertisol under irrigated cotton production as affected by burning and incorporating cotton stubble. *Australian Journal of Soil Research* **36**, 655-67.
- Dalal R, Chan KY (2001) Soil organic matter in rainfed cropping systems of Australian cereal belt. *Aust J Soil Res.* **39**, 435-464.
- DEC (2004) 'Draft aggregated analysis of the Department of Environment and Conservation's 2002/03 survey of organics processing in NSW.' Department of Environment and Conservation (NSW), Parramatta, NSW
- ESRI (1996). 'ArcView GIS v3.2'. Environmental Systems Research Institute. Redlands, CA, USA, 1996.
- Falivene S (2003) 'Farm budget handbook 2003: NSW Citrus.' (NSW Agriculture: Dareton, NSW)
- Geeves GW, Creswell HP, Murphy BW, Gessler PE, Chartres CJ, Little IP, Bowman GM (1995) 'The physical, chemical and morphological properties of soils in the wheat-belt of southern New South Wales and northern Victoria.' NSW Department of Conservation and Land Management/ CSIRO Division of Soils. No. Occasional Report., Sydney, NSW.
- Gibson TS, Chan KY, Sharma G, Shearman R (2002) 'Soil carbon sequestration using recycled organics- a review of the scientific literature.' NSW Agriculture, No. Project 00/01R-3.2.6A, Richmond, NSW
- Griffiths N (2004) 'Best practice guidelines for using poultry litter on pastures.' (NSW Agriculture: <http://www.agric.nsw.gov.au/reader/871>)
- Hardy S, Malcolm P, Napoli J, O'Malley K, Shearer D, Slack J, Ullio L (1999) 'Farm Budget Handbook 1999: NSW Fresh Stone Fruit.' (NSW Agriculture: Orange, NSW)
- Hassall & Associates (2000) 'The Domestic Market for Australian Organic Produce- An Update.'

- IBIS World (2004a). 'Fertiliser Manufacturing in Australia' IBIS World Pty Ltd. Report No C2531.
- IBIS World (2004b). 'Vegetable Growing in Australia' IBIS World Pty Ltd. Report No A0113.
- Jinadasa KBPN, Milham PJ, Hawkins CA, Cornish PS, Williams PA, Kaldor CJ, Conroy JP (1997) Survey of cadmium levels in vegetables and soils of greater Sydney, Australia. *Journal of Environmental Quality*. **26**, 924-933.
- Khu JF, Chan KY (1994) The influence of soil texture and organic carbon on hardsetting red soils in a semi-arid cropping environment and some implications for management. In 'Proceedings of the Second International Symposium on Sealing, Crusting, Hardsetting soils: Productivity and conservation.' Brisbane)
- Kirchoff G, Daniells I (2004) Soil management practices in northern New South Wales. In 'Proceedings of the International Soil Tillage Research Organisation 16th Triennial conference: Soil management for sustainability.' (International Soil Tillage Research Organisation: Brisbane)
- Kondinin Group (2000) 'Organic Farming in Australia.' Rural Industries Research and Development Corporation, No. RIRDC Publication No. 00/97, Canberra
- Little IP, Green TW, Young RR (1991) 'Exchangeable cations, pH, Mn and Al in 0.01M CaCl in samples from the Lachlan Shire, NSW.' CSIRO Division of Soils, No. Technical Memorandum 69/1991, Sydney, NSW.
- Love E, Rochfort CJ (1998) 'Markets for products containing recycled organic materials.' Waste Management Association of Australia, NSW Branch, Sydney, NSW
- McGahan E and Tucker R (2003) 'Resource Manual of Development of Indicators of Sustainability for Effluent Reuse in the Intensive Livestock Industries: Piggeries and Cattle Feedlots'. Project No. 1816, Australian Pork Limited, Canberra.
- McGarry D, Ward WT, McBratney AB (1989) 'Soil studies in the lower Namoi valley: methods and data.' CSIRO, Canberra, Australia.
- NSW Agriculture (2004) 'NSW Grains Report: Summary 1993-2004.' NSW Agriculture, www.agric.nsw.gov.au
- NSW EPA (1997) 'Environmental Guidelines: Use and disposal of biosolids products' NSW Environment Protection Authority, Sydney, NSW.
- OWRU (2000) 'Biosolids and green waste composts: development of safe sustainable markets.' NSW Agriculture, No. Project 6 Series 2, Richmond
- Post WM, Peng TH, Emanuel WR, King AW, Dale VH, DeAngelis DL (1990) The global carbon cycle. *American Scientist* **78**, 310-326.
- ROU (2003a) 'Life Cycle Inventory and Life Cycle Assessment for Windrow Composting Systems.' Recycled Organics Unit, Sydney, NSW.
- ROU (2003b) 'Recycled organics products in intensive agriculture. Volume 3: Fruit and orchard production.' Recycled Organics Unit, Sydney, NSW
- SALIS (2004) www.dlwc.nsw.gov.au/care/soil/salis
- SCARM (1998) 'Sustainable Agriculture: Assessing Australia's Recent Performance- A report to SCARM of the National Collaborative project on Indicators for Sustainable Agriculture' CSIRO Publishing., No. SCARM Technical Report 70., Collingwood, Vic.

Skjemstad JO, Spouncer LR, Beech A (2000) 'Carbon conversion factors for historical soil carbon data.' Australian Greenhouse Office, No. National Carbon Accounting System, Technical Report No. 15, Canberra, Australia

Standards Australia (2003) 'Australian Standard: Composts, soil conditioners and mulches.' Standards Australia International Ltd, No. AS 4454-2003, Sydney, NSW.

Verdonck O (1998) Compost specifications. *Acta Hort.* **469**, 169-176.

Wells AT, Chan KY, Cornish PS (2000) Comparison of conventional and alternative vegetable farming systems on the properties of a yellow earth in New South Wales. *Agriculture, Ecosystems and Environment* **80**, 47-60.

Whitbread AM, Lefroy RDB, Blair GJ (1998) A survey of the impact of cropping on soil physical and chemical properties in north-western New South Wales. *Australian Journal of Soil Research* **36**, 669-81.

Wilkinson K, Tee E, Hood V (2000) Does AS4454 adequately benchmark compost quality? In 'Compost 2000 Down Under Conference.' (Compost Australia: Melbourne).