To Raise a Toast:

Grain and Grape in the Swartland, South Africa—Trends, Causes and Implications of Agricultural Land Use Change

A report sponsored by the Department of Environmental & Geographical Sciences at the University of Cape Town,
under the auspices of the 'Globalisation & the Natural Environment' Programme of Macalester, Pomona & Swarthmore Colleges,
and completed on 31 May 2004.

~K. Dietrich, C. Fiske, K. McAlister, E. Schobe, I. Silverman & A. Waldron~

"The success of any geographical study depends largely on the ability to answer two questions: 'Where?' and 'Why there?' The second question involves interpretation of collected factual data, and the correlation of environmental, human, economic, political, and social factors."

~J. F. Holleman, "Experiment in the Swaziland"~

Contents

I.

PREFACE

The Swartland, located in the southwestern Cape, is one of the principal agricultural areas in South Africa. A Mediterranean climate with winter rainfall and reasonably fertile shale soils provide the necessary elements for cultivation (Lambrechts, 1998). The region is known primarily for its grain production and grazing land, which together cover 70 percent of its land area (Abstract of Agricultural Statistics, 2004). However, recent economic, political, and environmental events in South Africa have contributed to an emerging trend in the Swartland region toward another form of land use—viticulture.

The aim of this report is to identify the causes and extent of a gradual shift in land use from wheat cultivation to viticulture in the Swartland and to determine and discuss the socioeconomic and environmental impacts of this trend. Attainment of this aim occurs in a series of studies. A general overview of the physical difference in land use is generated through the analysis of a series of aerial photographs. Four case study sites are used to explore socioeconomic impacts, particularly in relation to labour, and environmental impacts, through field research on insect and bird biodiversity and soil characteristics.

Reference

Abstract of Agricultural Statistics. (2004) Pretoria, National Department of Agriculture.

Lambrechts, J.J.N. (1998) "Natural resources and farming in the Tygerberg." The Tygerberg: The Story of Tygerberg Hills and the towns of Parow, Bellville and Durbanville. Ed. N.M. DuPlessis. Cape Town: Tafelberg, pp 112-126.

II.
An Introduction to Land Use in the Swartland

~K. Dietrich~

1.
THE STUDY AREA: PHYSICAL CHARACTERISTICS OF THE SWARTLAND
~K. Dietrich~

The Swartland resides in the Western Lowlands of the Western Cape Province (Figure 1). It is bordered by the granitic soils and the Hottenttot Mountains to the East and the Sandveld, characterised by sandier soils, to the West. The Swartland includes the drier area to the North locally known as the Piketberg Karroo and the Tygerberg region to the South.

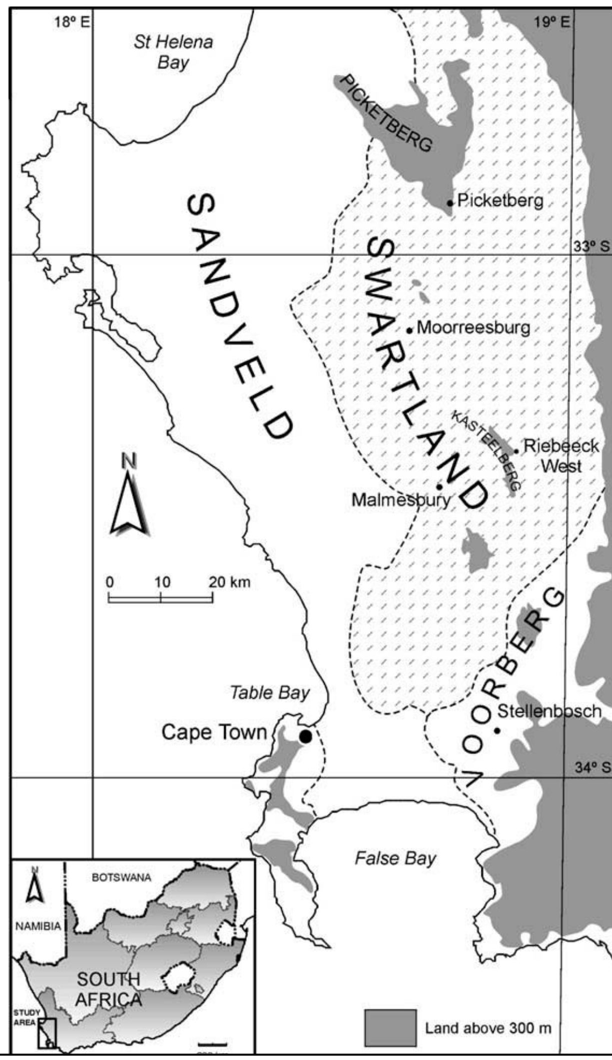


Figure 1: Map of Southwestern Cape distinguishing the Swartland Area (Meadows, 2003)

Climate

The Swartland is one of five sub-regions of the winter rainfall in the Western Cape (the other four being North-West, Boland, Little Karroo, and South Coast sub-regions). The area is characterised by Mediterranean climate consisting of mild temperatures with altitudinal variation. Summer temperatures can reach as high as 40 degrees Celsius, but tend to remain between 15-27 degrees Celsius. Winters are virtually frost free with the exception of some low lying areas that may fall below two degrees Celsius. According to Lambrechts (1998), an occasional frost has little effect on the winter crop.

About 80 percent of the rainfall occurs from April to September. Rainfall patterns are governed by frontal (cyclonic) systems. The frontal action is generated by seasonal changes in wind zones which create an unstable contact between warm temperate wind zones and a cool temperate zone. These unstable zones move north across the sourthernmost point of Africa in winter and south in the summer. Rainfall variation in the Swartland is related to altitude. Low lying areas receive as little as 400mm and the maximum rainfall in higher altitudes reaches about 700mm (Lambrechts, 1998).

The Swartland rarely experiences wind more than 20 kilometres per hour; however, the average daily wind run (amount of kilometre wind per day) is seasonal, being higher during the summer and lowest from April to July. Winter wind includes rain-bearing northwesterlies while summer wind consists of southerly wind to reasonably strong sourthwesterlies. The summer winds, which occur regularly in the afternoon, contribute to the cooling of temperatures (Lambrechts, 1998).

Geology and Soils

Native West Coast Renosterveld, which is found at the Tygerberg Nature Reserve, tends to grow on clay-loam soils of high agricultural potential (McDowell, 1988: p.30, 47). Soils in the Tygerberg region are suitable for renosterveld growth. They are largely homogenous, but vary slightly according to enviornment. Ferralitic soils are common to the more humid and moist areas, while siallitic soils are common to the cooler and drier areas, or to areas of poor drainage. Ferralitic soils are more highly weathered, and are kaolinitic; and siallitic soils have more nutrients, and are rich in the clay minerals illite and vermiculite (Lambrechts, 1998: p.92). The parent material of both the ferallitic and siallitic soils is from the Malmesbury group, and can include phyllite, schist, and shale (Schloms Ellis & Lambrechts, 1983: p.73). The soil forms found in the area of three study sites (the Tygerberg Nature Reserve, De Grendel, and Hooggelegen) are Swartland and Glenrosa. Though no horizons were exposed at Grasrug, the mineralogy of the soil is markedly different at this site (it is more quartzitic), and soil form is also likely to be different.

Natural Vegetation

The natural vegetation of the Swartland is characterised by diverse, highly flammable blue-green and grey-green renosterveld vegetation. Talbot (1947) describes this vegetation: "The flora as a whole is notable for the enormous number of species, many of which occur nowhere else in the world, but much of the variety of plant life is not immediately apparent to the casual observer owing to similarities in form and growth habit between many different species" (6).

The Swartland was once covered in West Coast Renosterveld. The most common plant is the renosterbos (*Elytropappus rhinocerotis)*, a low shrub with greyish-green shoot and cupressoid leaves (Talbot, 1947). Renosterveld includes semi-dense to dense evergreen plants with small leaves from the Astaraceae family. Additionally, small clumps of tall broad-leafed shrubs commonly occur. These include geophytes from the Iridaceae, Hyancthaceae, Oxalidaceae, and Asparagaceae families (Lambrechts, 1998; Wood and Low, 1998). Grasses are also present, especially in more frequently burned patches (Low, 1995).

The natural vegetation of the Swartland has been largely disturbed by agriculture. Only a few remnants of the natural vegetation remain on soil too poor for cultivation or steep slopes unsuitable for planting. These remnants are occasionally used for grazing (Lambrechts, 1998).

References

Lambrechts, J.J.N. (1998) "Natural resources and farming in the Tygerberg." The Tygerberg: The Story of Tygerberg Hills and the towns of Parow, Bellville and Durbanville. Ed. N.M. DuPlessis. Cape Town: Tafelberg, pp 112-126.

Low, A.B. (1995) "Preface." IN: Low, A.B. & Jones, F.E. eds. The Sustainable Use and Management of Renosterveld Remnants in the Cape Flouristic Region. Proceedings of a Symposium. FCC Report 1995/4. Flora Conservation Committee, Botanical Society of South Africa, Kirstenbosch, Cape Town. p. 0.

McDowell, C.R. (1988) Factors affecting the conservation of Renosterveld by private landowners. Ph.D. thesis, University of Cape Town.

Schloms, B.H.A. Ellis, F. and Lambrechts, J.J.N. (1983) Soils of the Cape Coastal Platform. IN: Deacon, H.J. Hendey, Q.B. and Lambrechts, J.J.N. eds. Fynbos palaeoecology: A preliminary synthesis. Cape Town, Mills Litho.

Talbot, W.J. (1947) Sandveld and Swartland. Cape Town: Oxford University Press.

Wood, J. and A.B. Low. (1998) "The ecology and conservation of the Tygerberg." The Tygerberg: The Story of Tygerberg Hills and the towns of Parow, Bellville and Durbanville. Ed. N.M. DuPlessis. Cape Town: Tafelberg, pp 127-150.

2.
HUMAN-ENVIRONMENT INTERACTIONS IN THE SWARTLAND
~K. Dietrich~

Traditional Uses

Archeological records in the form of stone tools suggest that humans have been in South Africa between 1.8 and 1.5 million years ago (Humphreys, 1998). However, some argue that human occupation of the southwestern cape has occurred for as much as three million years (Meadows, 2003). Earlier Stone Age (ESA) tools in the form of hand-axes and cleavers, covering the time period between 1.5 million and 150 000 years ago, were found in the Stellenbosch region. These provide definitive evidence of human activity in the southwestern cape (Humphreys, 1998).

Remains from the Later Stone Age (LSA), which began around 20 000 years ago and lasted through historical times, have been found all over the southwestern Cape. The LSA is characterised by two main groups of people, hunter-gatherers and pastoralists. Ancestors from the later period of this age can be linked with surviving groups, the San hunter-gatherers and Khoekhoe pastoralists (Humphreys, 1998).

The San and Khoekhoe represent the two primary economies and land uses which occurred in the southwestern cape prior to European arrival. The San hunter-gatherers likely survived on the southwestern Cape before the Khoekhoe pastoralists. Their survival depended on small group and nomadic living in order to exploit various resources during different seasons (Humphreys, 1998). Beyond everyday living, the San altered the natural environment by burning the foliage to attract animals (Wood and Low, 1998).

Archeological records suggest that the Khoekhoe pastoralists arrived in the Swartland and Cape Peninsula area around 2 000 years ago. The group likely travelled from Botswana after acquiring some sheep, and then migrated south, likely along the western coast and then towards the southern Cape coast. Cattle were probably acquired through contact with the Bantu-speaking communities of the Eastern Cape (Humphreys, 1998). These herds likely had affects on the natural vegetation but the extent of change is unknown. Additionally, the Khoekhoe set fire to old vegetation unsuitable for their herds (Wood and Low, 1998). The Khoekhoe lived in large groups and remained more or less in the same region, travelling seasonally in search of pasturage (Humphreys, 1998).

European Agriculture in the Cape

The arrival of Jan van Riebeek in 1652 produced many land use changes in the southwestern Cape. Van Riebeek quickly established a fort, living quarters, and the Company Garden (Spilhaus, 19--). The Dutch East India Company survived on trading meat with the Khoekhoe until both groups realised their mutual relationship would no longer work. The Khoekhoe were concerned with depleting their herds while the Company believed the Khoekhoe possessed land they required. The Khoekhoe refused to trade, forcing the Company to venture North in search of land beyond the Table view (Wesson, 1998).

Van Riebeek and his Company established some of the first farmland in the southwestern Cape, primarily in the Liesbeek watershed. This land was used as grazing land and vegetable gardens. It was not until the arrival of Simon van der Stel in1679 that agriculture became a primary concern and farmland spread north: "...realizing that a land-owning population was essential for making full use of the fertile soil and favourable climate, and for defending the burgeoning semi-colony, he persuaded the Company to pursue policies of exploration, settlement, and systematic colonisation" (Wesson, 1998: 36). van der Stel wanted the Cape to be self-sufficient, particularly in grain production. To attain this sufficiency, van der Stel gave away freehold land and access to four years' seed on loan.

van der Stel's methods worked to the point of overproduction. Large herds of sheep and cattle roamed the northern sections of the Swartland while mixed farming occurred in the southern sections. Mixed farming included mostly wheat and grape. Wine was produced in sizable quanitities for the households and their servants or slaves. The increase in farmland led to an increase in vines to such an extent that the Governor feared the decline of other crops and so decreed vines could only occupy up to a seventh of the farmer's productive land. Despite the regulation, the surplus of wine grew and exporting began in 1702. To curtail the surplus of products, the Company restricted the boundary of the Cape colony until 1743 (Wesson, 1998).

Pressure to increase land grants forced the Company to expand the Cape colony in the form of "loan farms" (Wesson, 1998). The new system and expansion led to the formation of small towns in the Swartland region. The town of Malmesbury was established in 1744, serving as the fifth Dutch Reformed Congregation in the Cape (Wilson, 1971).

France declared war on Britain and Holland near the end of the eighteenth century. To save the Cape colony, Britain took over, and agriculture in the southwestern cape went through a number of changes. First, a ban on French wine sparked the production of Cape wine to fill the void. Second, occupying sailors and soldiers needed to be fed and the increasing number of visiting ships required supplies. In 1800, subsidies were introduced and a year later internal duties on grain, wine, and brandy were eliminated. Also, grain sales were deregulated, except for wheat. By 1813, the British reduced the duty on wines, promptly doubling Cape wine production to the extent that one tenth of the wine consumed in Britain came from the Cape. The wine industry's success halted with the reopening of French wine exportation at the end of the

Napoleonic wars in 1825. Wheat farming then became more profitable than viticulture (Wesson 1998).

The middle and late nineteenth century contained a series of tribulations for the southwestern Cape. The Anglo-Franco trade agreement of 1861 caused wine production to collapse (Wendy Toerien's Wines and Vineyards of South Africa, 2000). Economic depression, coupled with several seasons of drought, led to a decrease in food production. Wool production became the only mildly profitable export. By 1869, diamonds were discovered and prices soared as the country's population increased. However, this period of profit only lasted till 1882 when the Cape experienced another major drought and an economic depression hit Europe. Two diseases hit the vineyards and an outbreak of the cattle disease rinderpest hit in 1896. Agriculture began to recover right as the Anglo-Boer War began. However, a reduction in imports and available funds stalled the recovery until 1907 (Wesson, 1998).

The Global Market and Protectionist Policies

Up until the World Wars, the northern Swartland participated mainly in mixed farming of grain, grape, vegetables, and stock (Wesson, 1998). A growing population, the development of diamond and gold mines, and the construction of railways created new markets for wheat consumption at the end of the nineteenth century. Slowly more and more land was cultivated with wheat in the Swartland. However, it wasn't until the threat of a bread shortage during the First World War that a major change in production occurred in the Swartland (Talbot, 1947). Grain production rapidly replaced sheep husbandry, and the four year crop rotation was reduced to two years. By 1919, the Departmental Committee on Wheat Growing claimed that practically all arable land was devoted to grain production (Talbot, 1947).

Prior to 1921, wheat farmers experienced little overseas competition due to the cost of marine transport and differential rail tariffs in favour of South African wheat. However, these transportation costs were greatly altered to the benefit of imports in 1920. Farmers responded by campaigning for protectionist policies which the Government granted in 1930 in the form of the Wheat Importation Restrictions Act. The act prohibited the importation of wheat, flour, or meal unless under permit from the Minister of Agriculture. Previously, between 25 and 30 percent of the year's wheat requirements were imported as high quality "strong" wheat to mix with the "weak" South African wheat. This stimulated even greater wheat production in the Swartland, expanding it beyond what the Departmental Committee on Wheat Growing estimated as a feasible area. This expansion occurred through further reduction of the crop rotation, using land typically set aside for other crops, and ploughing on steeper slopes. The outbreak of the Second World War required wheat production to remain high to provide sufficient wheat for the population and ships provisions (Talbot, 1947).

Protectionist policies were also instated in the wine market. In 1918, a wine grower cooperative, the KWV, established protectionist polices restricting Cape wine production. The KWV established two policies which proved detrimental to the growth of the wine industry as a market-driven, quality-oriented, competitive product. First, the cooperative fixed a minimum price for wine delivered to the KWV, allowing them to limit the wine they purchased. Second, they instated a quota system, which essentially required licensure for the cultivation of wine grapes and limited production to certain areas. These policies proved helpful to those already producing wine and detrimental to anyone who wished to enter the market (Wendy Toerien's Wines and Vineyards of South Africa, 2000). The KWV was granted ultimate statutory control over wine industry through the Wine and Spirits Acts of 1924 and 1940 making membership compulsory (Conservation International).

Government involvement in agriculture during the 1930s culminated in the passing of the 1937 Marketing Act. However, the act served as more than just protection as Wilson (1971) states: “The primary aim of the Marketing Act was not so much the short-term stabilisation of prices in a sector subject to violent fluctuations in output due to weather conditions, but rather a long-term social aim of keeping faming incomes more in line with those in town” (140). The act also further boosted membership of the cooperatives, like KWV.

The rise of the National Party in 1948 led to further agricultural policies which favoured the white Afrikaans-speaking population. Subsidies, export quotas, tariffs, and other controls were put in place to raise agricultural prices well above competitive levels. This resulted in uneconomic expansion of many products; however, socially, white farmers were receiving the same or greater wages than urban dwellers and therefore willingly supported the National Party. Such policies carried throughout the 1980s leaving agriculture in an economic crisis (Wilson, 1971).

Soil Erosion and the Swartland

Protectionist polices created high production levels which ultimately led to serious land degradation and overgrazing. In the late 1930s, Professor Bill Talbot of the University of Cape Town conducted an aerial photographic survey of the Swartland which indicated increasing soil erosion in the form of gullies (Talbot, 1947). His work, coupled with increasing concern over soil erosion in the USA, sparked a soil conservation movement which was led by the newly elected and racially skewed National party (Meadows, 2003; Delius and Schirmer, 2000).

The National Party began by revoking the Wheat Importation Restrictions Act. Their influence carried throughout the second half of the twentieth century with various Conservation Acts, ending with the Conservation of Agricultural Resources Act of 1983. This act established a soil conservation enforcement bureaucracy which includes a series of conservation committees on regional and district levels culminating in a Conservation Advisory Board which advises the Minister of Agriculture (Meadows, 2003). Members of these committees were appointed by the Minister, creating a highly skewed representation of predominately Afrikaans-speaking farmers.

Soil conservation in this era was further promoted by the use of subsidies to assist soil conservation works or restoration of degraded land (Meadows, 2003). Subsidies were granted primarily to Afrikaans-speaking farmers in order to secure political support (Meadows, 2003; Delius and Schirmer, 2000). Nevertheless, policy intervention in the form of education and engineering mechanisms has in fact decreased land degradation in the Swartland. The number of gullies documented in Talbot's original research has since declined as noted by current research completed by Meadows (2003), Morel (1998, dissertation), and Sebataolo (2003, thesis).

The end of the National Party's rule brought several changes to agriculture in the Swartland. The rise of a democratic system and the African National Congress as the ruling party brought the reopening of export markets previously closed by sanctions. The KWV cooperative was split up, reopening the wine market to independent distribution and quality wine production. Subsidies no longer favoured the white farmer, land resititution regimes posed a minor threat to land ownership, and black equality and empowerment initiatives were put in place for the empowerment of farm workers. Entrance into free trade on the international market brought new grain competition and a fall in the price of wheat. These changes are discussed in detail in the next chapter.

References

Conservation International. "Wine and Conservation: The Impact of Viticulture Expansion in the Cape Floristic Region."

Delius, Peter and Stefan Schirmer. (2000) "Soil Conservation in a Racially Ordered Society: South Africa 1930-1970." Journal of Southern African Studies. 29 (4) December, pp 719 – 742.

Humphrey, A.J.B. (1998) "The archaeology of the Peninsula and Cape Flats." The Tygerberg: The Story of Tygerberg Hills and the towns of Parow, Bellville and Durbanville. Ed. N.M. DuPlessis. Cape Town: Tafelberg, pp 22-29.

Lambrechts, J.J.N. (1998) "Natural resources and farming in the Tygerberg." The Tygerberg: The Story of Tygerberg Hills and the towns of Parow, Bellville and Durbanville. Ed. N.M. DuPlessis. Cape Town: Tafelberg, pp 112-126.

Meadows, Michael. (2003) "Soil erosion in the Swartland, Western Cape Province, South Africa: implications of past and present policy and practice" Environmental Science & Policy. 6: 17–28.

Sebataolo, Rahlao. (2003) "Land use changes and their effect on the extent and rates of soil erosion in the Tygerberg, Western Cape Province, South Africa – 1938 – 2000: A Re-evaluation. Honors Theses, University of Cape Town.

Spilhaus, M. Whiting. (19--) "They Planted the Cape." Reprint from Historia. S.I.: s.n.

Talbot, W.J. (1947) Sandveld and Swartland. Cape Town: Oxford University Press.

Wendy Toerien's Wines and Vineyards of South Africa. (2000) "A History of Wine Making in South Africa." Struik Cape Town. <http://bf.overstrand.co.za/history.htm>

Wesson, Alf. (1998) "The Tygerberg Hills 1652 to 1945." The Tygerberg: The Story of Tygerberg Hills and the towns of Parow, Bellville and Durbanville. Ed. N.M. DuPlessis. Cape Town: Tafelberg, pp 30-66.

Wilson, Francis. (1971) "Farming, 1866-1966." The Oxford History of South Africa II: 1870-1966. Eds. Monica Wilson and Leonard Thompson. London: Oxford University Press, pp.104-153.

Wood, J. and A.B. Low. (1998) "The ecology and conservation of the Tygerberg." The Tygerberg: The Story of Tygerberg Hills and the towns of Parow, Bellville and Durbanville. Ed. N.M. DuPlessis. Cape Town: Tafelberg, pp 127-150.

III.
Uncorking Change:
Changing Land Use in the Swartland, Trends and Causes

~K. Dietrich & I. Silverman~

1.
ALL THE PRETTY PICTURES: ANALYSING LAND USE CHANGE WITH AERIAL PHOTOGRAPHS

~K. Dietrich~

Before discussing the reasons or impacts, one basic question needs to be answered: is there a change from grain production to grape production? Various agricultural statistics support our hypothesis in regards to percentage of land devoted to various land use types; however, as Board (1962) discusses, land use surveys based solely on official statistics are inadequate. Statistics only provide the overall picture and some ideas of trends but are too large to reveal significant spatial variation (Board, 1962).

Sequential aerial imagery was analysed in order to focus our study on a certain spatial scale over time. This study area becomes our way of physically viewing and documenting any changes in production schemes in the southern Swartland. Board (1962) recognises this as a viable method to provide evidence for the basic pattern of land use in an area.

Methodology

The methodology for this study occurred in six steps. The first step consisted of photography acquisition. Black and white photos were purchased from the Department of Land Affairs: Surveys and Mapping in Mowbray, Cape Town. Five sets of photos spanning 40 years were available for the Swartland Region (Table I).

Date	Season	Scale
December 1960	Summer	1:36000
April 1968	Autumn	1:36000
Mar/April 1977	Autumn	1:50000
August 1988	Spring	1:50000
January 2000	Summer	1:50000

Table 1: Characteristics of Aerial Photography Sets

The interval between each set ranges from eight years to twelve years. Unfortunately, the sets were taken during different seasons, creating some difficulty in recognition of winter grains.

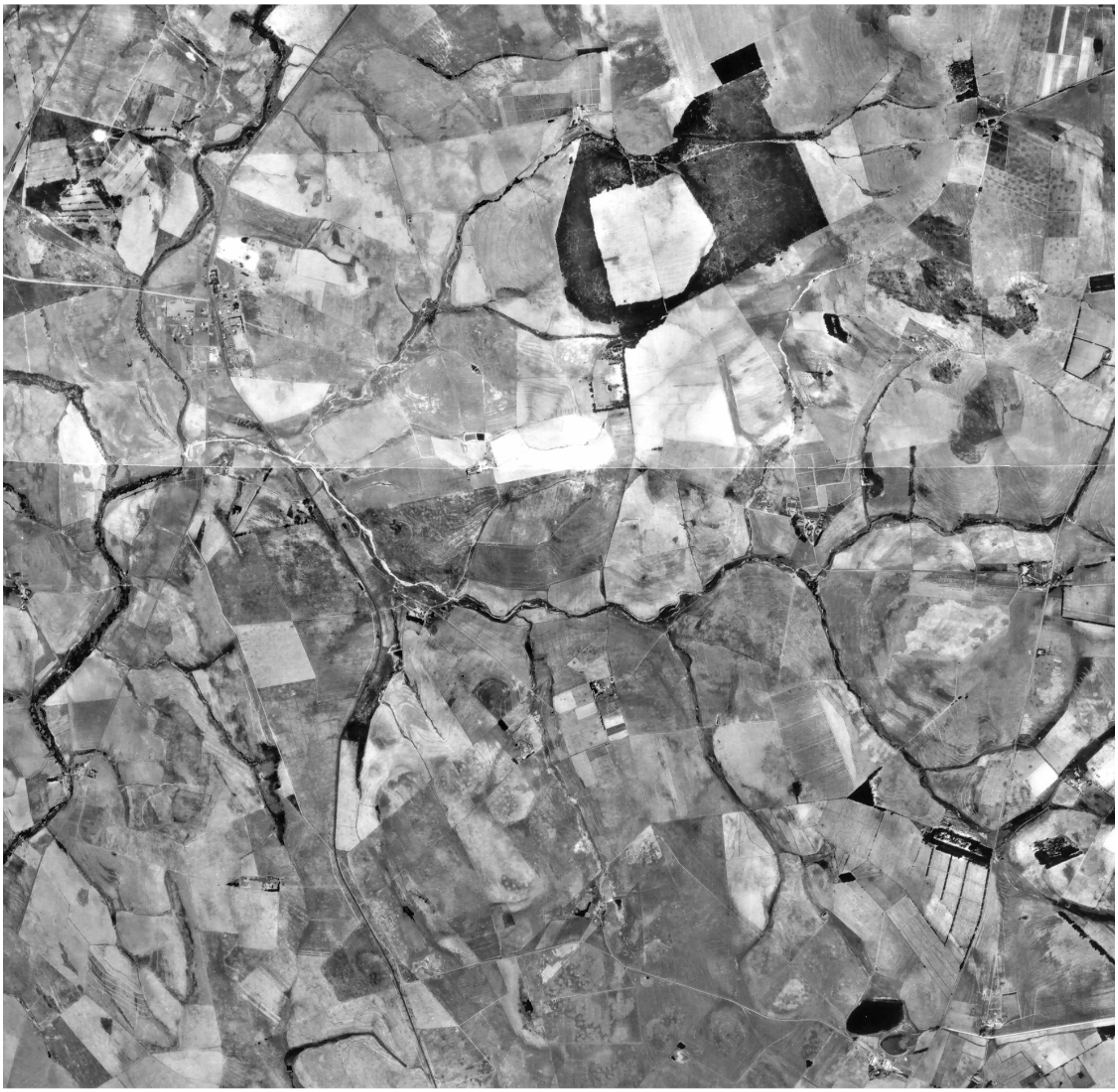


Figure 1: An aerial photograph of the study area.

Two scales occurred in the sample. The two earliest sets were taken at a scale of 1:36000 while the rest have a scale of 1:50000. This created some variance in detail; however, the greater scale made up for the low quality of the early photos.

The photos acquired covered a portion of the southern Swartland, moving south from a few kilometres north of the town of Malmesbury. The N7, when heading directly north, served as the west boundary while the 302 provided the east boundary. The southern boundary varied due to the misplacement of photos particularly in the 1977 set. Nevertheless, all sets cover the Philadelphia 1:50000 map (3318DA). Photos were not stereoscopic pairs due to limits of funding.

The second stage of this study included the determination and tracing of a sample area. A study area of ten kilometres by ten kilometres was established using the 1:50000 Philadelphia map. Determination of the location of this study area was aided by the Western Cape Agriculture Department 1000 point survey which recognises and highlights areas where ground truthing has documented a change in land use patterns (See Appendix 1). Definitive boundaries and corner points were identified for the study area.

The next step required creation of a photo mosaic of the study area for all five sets. According to Thomas Avery (1977), photo mosaics include the assembly of two or more aerial photographs which have been cut and matched systematically to give the appearance of a single photograph. The photographs were assembled in an uncontrolled mosaic which does not use the aid of ground truthing, and therefore can not be used for measurements (Avery, 1977).

Due to the varying scales and orientations of the sets, the photo mosaics included two to five photographs. Centres of photos were matched first, then careful attention was placed on matching elements within the study area. Upon completion of the mosaic, the four corners of the study were demarcated on each set. The marked study area for each set was then traced using tracing paper to create a basic map of the study area.

Fourth, photos were analysed to establish familiarity with land use identification and the development of a classification system. Identification occurred to level II as instituted by the United States Geological Survey (USGS) (Table II). Level II includes identification of types of agricultural land, including vineyards, orchards, grain fields, fallow land, etc (Avery, 1977).

Classification Level	**Sensor Platform or Altitudes**	**Approx. Range of Image Scales**
I	Earth satellites	1:500000 to 1:3000000
II	9000 – 12000 m	1:60000 to 1:80000
III	3000 – 90000 m	1:20000 to 1:60000
IV	1000 – 3000m	1:8000 to 1:20000

Table 2: Classification Levels and Scales (Avery, 1977)

The classification system instituted for this study includes three main land use or cover types. First, grain fields are characterised by continuous cover, ploughing along contours, and a lighter colour for wheat or a darker colour for oats. Second, vineyards are identified based on uniformly spaced rows with visible distance, a generally darker colour, and clusters of small fields which do not necessarily follow contours. Third, natural vegetation is recognized by absence of rows or contours and a mixture of colours. As noted by Holleman (1964) in his land use survey of Swaziland, there is great difficulty in classifying fallow land and natural vegetation. All other land uses, including buildings, water sources, etc., were classified as "other" in order to simplify the analysis and focus the classification.

The classification system was applied to the study area using a grid analysis. A grid of 100 squares, where each square covered one square kilometre, was placed upon the marked study area on each aerial photograph. Two girds were produced, one with 19.5cm by 19.5cm dimensions for the 1:50000 photographs and the other with 26cm by 26cm dimensions for the

1:36000 photographs. Due to inherent variances in scale, the grid was positioned with the northeast corner as a point of reference. Moving from right to left, each square was classified according to the land type that occupied the majority of the square. Most squares contained more than one land type; therefore, the land type in the majority was recorded with notes on the other land types.

Finally, correlations were completed using Microsoft Excel to compare the number of grids containing grain, grape, natural vegetation, or other with time and with each other. This indicates the strength of the linear relationship between each variable.

Limitations to Study

A number of complications arose throughout the course of this study which must be duly noted. First, photo acquisition was delayed due to the Department of Land Affairs: Surveys and Mapping digitising recent aerial photographs. Despite efforts to acquire photographs in early March, photos did not arrive until two weeks prior to the completion of this study.

The late arrival of the photographs created a number of limitations. Original intentions included the use of GIS to assess the study area. However, lack of time and knowledge limited this portion. Also, a larger study area was intended to provide a greater sample of the Swartland, but time also limited this aspect. Finally, the interpreter had limited time to spend analysing the photographs, adding to the possibilities for inaccuracies. These inaccuracies are particularly evident when defining livestock pasture and fallow land.

Photographs acquired were not stereoscopic pairs due to limited funds. Although single photographs are suitable for mapping efforts, not using stereoscopic pairs restricts the interpretation of land utilisation patterns. Stereoscopic pairs allow the interpreter to make measurements and enable the human eyes to better view the photographs (Holleman, 1964; Avery, 1977).

Some issues arose while tracing. Tracing was not completed using any tools or machines which would correct the inherent variances in photos altitudes. According to Holleman (1964), the altitude of the aircraft cannot always be maintained, especially in mountainous country; therefore, photographs do not match accurately. When creating the photo mosaics, some of the ten by ten kilometre study areas were skewed due to imperfections in matching photographs. These discrepancies created some inconsistencies in placement of the analysis grids.

Analysis was limited by the quality of photography and seasons represented. The most recent photography provides a crisp and detailed image while the photography from the 1960s has dull colour and less visible detail. Also, the photographs cover several seasons which makes distinguishing land cover more difficult, particularly in regard to the winter crops. Seasonal variation changes the colour tones of the photographs and may change the outlines of the fields (Avery, 1977).

Finally, late photo acquisition limited the time available for ground truthing which many researchers view as critical to any aerial photography study. Ground truthing is required to ensure accuracy of the study (Holleman, 1964; Avery, 1977).

Results

Results from this sample area suggest an emerging change in the amount of grain production areas, grape production areas, and natural vegetation in the Swartland. The number of squares with the majority of wheat production becomes progressively less over time (Table 1). The amount of grain land cover remained relatively static between 1960 and 1977, covering 80 to 84 percent of the study area. By 1988, the amount of wheat production fell slightly from 80 percent in 1977 to 77 percent. Grain land cover dropped ten squares, and therefore ten percentage points, in 2000 at 67 percent (Figure 2, Appendix 1).

Time	Wheat	Grape	Nat. Veg.	Other
1960	80	3	11	6
1968	84	3	12	1
1977	80	6	13	1
1988	77	8	12	3
2000	67	11	17	5

Table 3: Number of Squares per Land Cover Type over Time

The drop in wheat may be attributed to an increase in the area of both grape land cover and natural vegetation. Grape covered three percent of the study area in 1960 and 1968. A slight increase occured in 1977 to six squares of grape production. This number jumped two percentage points in 1988. By 2000, 11 percent of the study area was devoted to grape production.

Grape land cover was consistent in three areas through all five years. These areas include squares 1, 43, and 65. The increase in 1977 includes the expansion of grape production around square 1 into square 11 and new grape in square 61. Expansion in grape production around square 61 and squares 43 and 44 occured in 1988. In 2000, new grape appeared in squares 17 and 18 and expanded grape production occured in squares 43, 52, and 62.

The percentage of area covered by natural vegetation remained static around 12 percent throughout the first four sets of photographs. An increase in natural vegetation occured in 2000 to 17 percent. This increased occurs predominately around squares 25 and 35, as well as increasing areas of small islands of natural vegetation.

Variation of the ‘other’ category depended upon the placement of the grid. Of notable importance was the increase of the ‘other’ category between 1988 and 2000. This was due to an increase in buildings and industrial uses in that period.

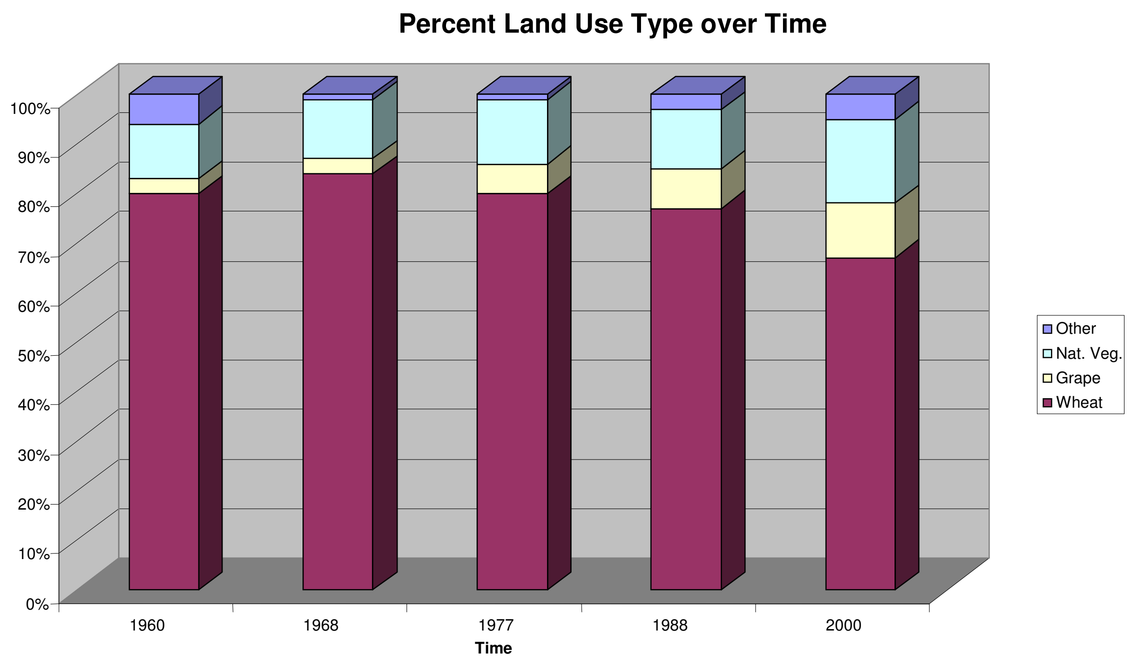


Figure 2: Percent Squares per Land Cover Type over Time

Correlations between each land cover with time and with each other indicated the strength of the linear relationship between the variables. Comparison between the number of wheat squares and the five years suggested a negative relationship between time and wheat production. Although a strong relationship at -0.85509, this result was not statistically significant at three degrees of freedom with 95 percent confidence (0.8783). Correlations between the five years and wine production indicated a strong positive linear relationship at 0.98291. This was statistically significant at 99 percent confidence (0.95873). The linear relationships between natural vegetation with time and the 'other' category with time were not statistically significant.

Comparison of grain land cover and grape land cover resulted in a statistically significant negative relationship at -0.91666 with 95 percent confidence (0.8783). Wheat production and natural vegetation areas also had a statistically significant negative linear relationship at -

0.87914 with 95 percent confidence (0.8783). Grape production does not have a statistically significant linear relationship with natural vegetation areas.

Correlations

	Time	*Wheat*	*Grape*	*Nat. Veg.*	*Other*
Time	1				
Wheat	-0.85509	1			
Grape	0.98291	-0.91666	1		
Nat. Veg.	0.833014	-0.87914	0.841452	1	
Other	0.078762	-0.53908	0.217949	0.186989	1

Table 4: Correlations Coefficients of Land Cover Type and Time

Discussion

The qualitative analysis and correlations suggest an emergent trend for land use in the Swartland. The strong and statistically significant positive relationship between grape land cover and time suggests an increase in the amount of grape production in the Swartland. These results are consistent with and further supported by statistics regarding grain, particularly wheat, and grape production in the Swartland. The study area was determined partly based upon a 1000 point survey completed by the Western Cape Department of Agriculture. This 1000 point survey distinguishes four areas, referred to as 18 Gemengde Boerderygebied in Afrikaans, where the number of points with grape surpasses the number of points with wheat (See Appendix 2). The 1000 point survey supports our results since wine production has increased, and surpassed wheat production, in these critical areas of the southern Swartland (Western Cape Department of Agriculture, 2003).

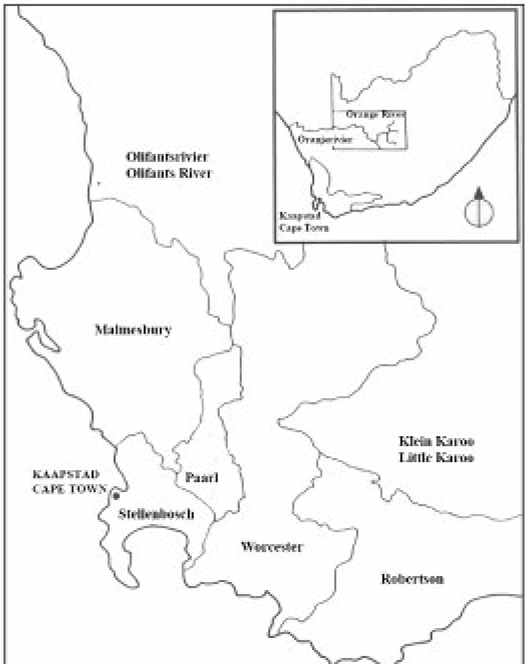


Figure 3: Western Cape Wine Regions

Looking more specifically to grape production, the southern Swartland, known as the region of Malmesbury (Figure 3), contains the third highest percentage of total vines less than ten years old out of the eight wine producing regions. Over 38 percent of the vines in the Malmesbury region are four to ten years old, and were thus planted planted after the end of Apartheid. The second largest age group is vines over 10 years old at 23 percent. Among the regions with a relatively high proportion of vines less than ten years old, Malmesbury trails only Worcester with regard to absolute acreage of less than ten year old vines. Worcester wine region is roughly twice the size of the Malmesbury region (SAWIS, 2003). The increase in grape land cover and the age of these Malmesbury vines supports the newness of this trend.

The statistically significant negative relationships between wheat and grape and wheat and natural vegetation suggest the increase in grape and natural vegetation areas occurs at the cost of grain production areas. A report commissioned by Conservation International regarding the impact of the expansion of viticulture on the Cape floristic region found that new vines were not being grown on virgin soil: “However, interviews with agricultural extension officers and an analysis of plough permit applications processed by the Provincial Department of Agriculture between 1990 and 2001 revealed that much of the expansion was on land previously used for other forms of agriculture, such as wheatfields or grazing pastures…” (7). Our results indicate an increase in vines at the expense of grain fields as noted by the strong negative correlation between grain and grape land cover.

Finally, throughout all of South Africa, the total area of planted wheat has decreased drastically from about 1 900 000 hectares in the 1970s to around 850 000 hectares in the late 90s to present. This opens up discussion to several other factors which affect the production of grain and grape. The remainder of this report discusses these factors and impact of this change.

References

Avery, T.E. (1977) Interpretation of Aerial Photographs. Minnesota: Burgess Publishing Co.

Board, C. (1962) The Border Region: Natural Environment and Land Use in the Eastern Cape. Cape Town: Oxford University Press.

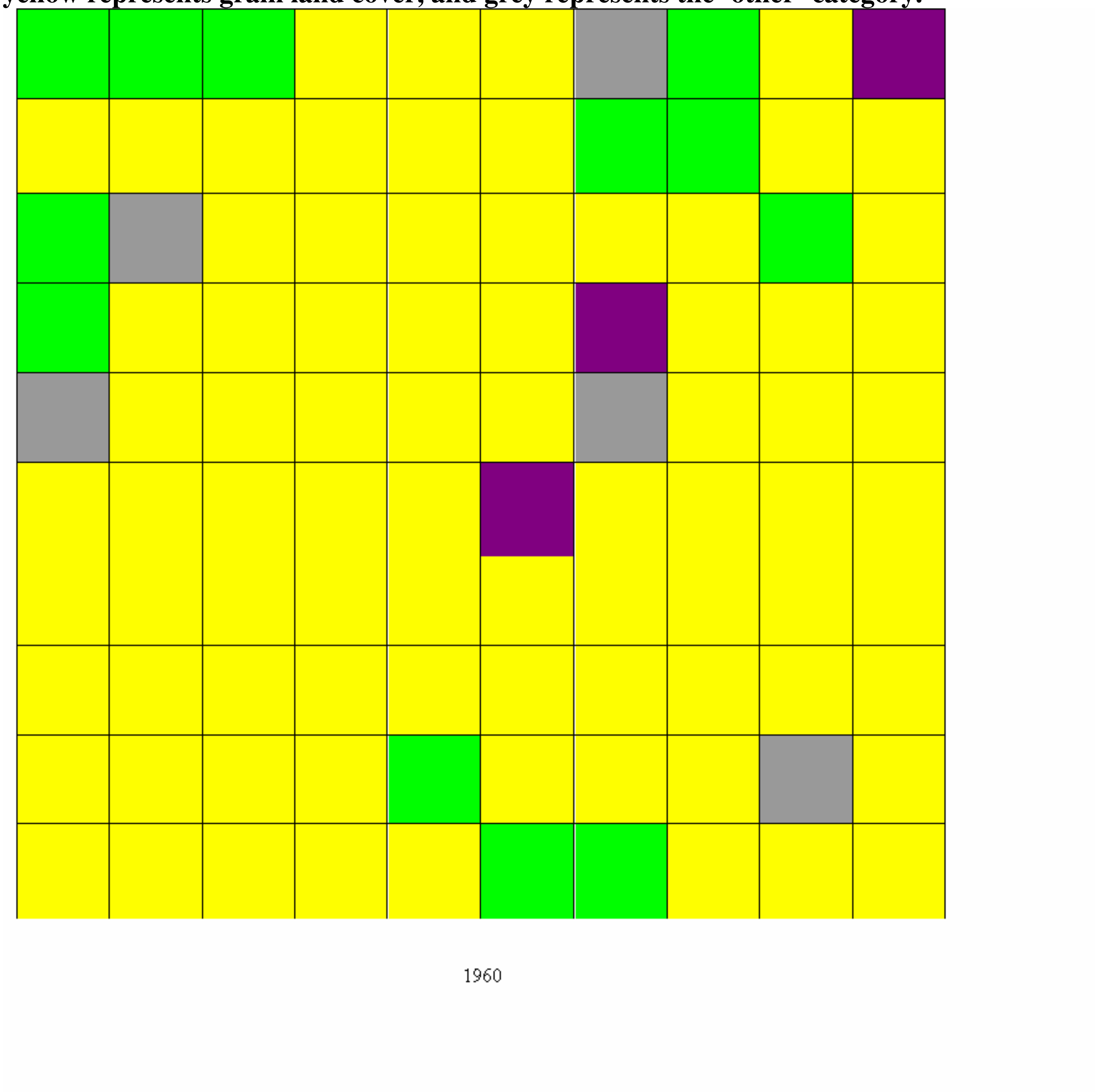
Conservation International. "Wine and Conservation: The Impact of Viticulture Expansion in the Cape Floristic Region."

Holleman, J.F. (1964) Experiment in Swaziland. Cape Town: Oxford University Press.
SA Wine Industry Information Systems – SAWIS. (2003) "South African Wine Industry Statistics." www.sawis.org.za.

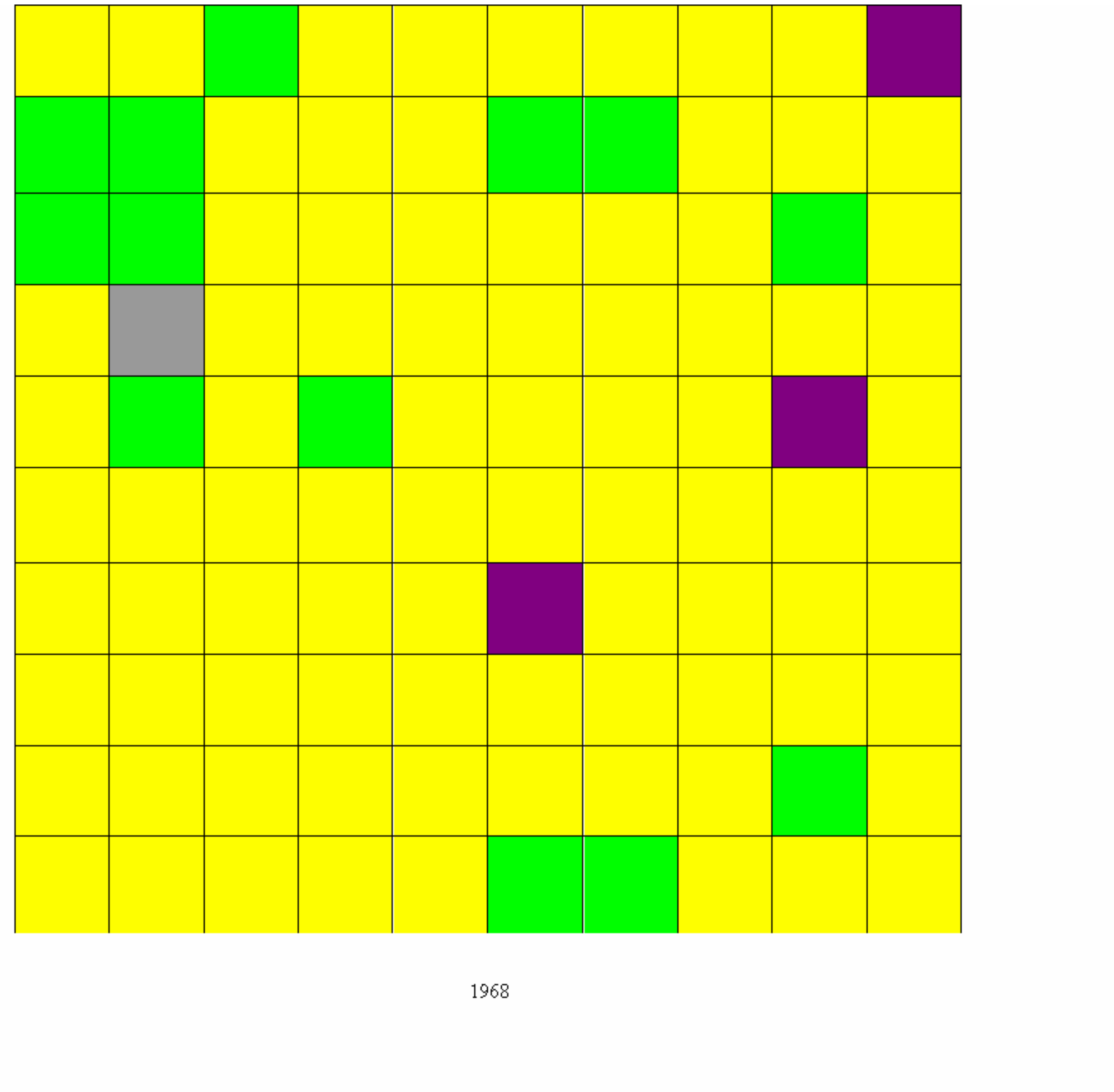
Western Cape Department of Agriculture. (2003) 1000 Punt Opnames Swartland-Substreek 2003. Acquired through personal communication with Antony Louw.

APPENDICES TO SECTION III.1

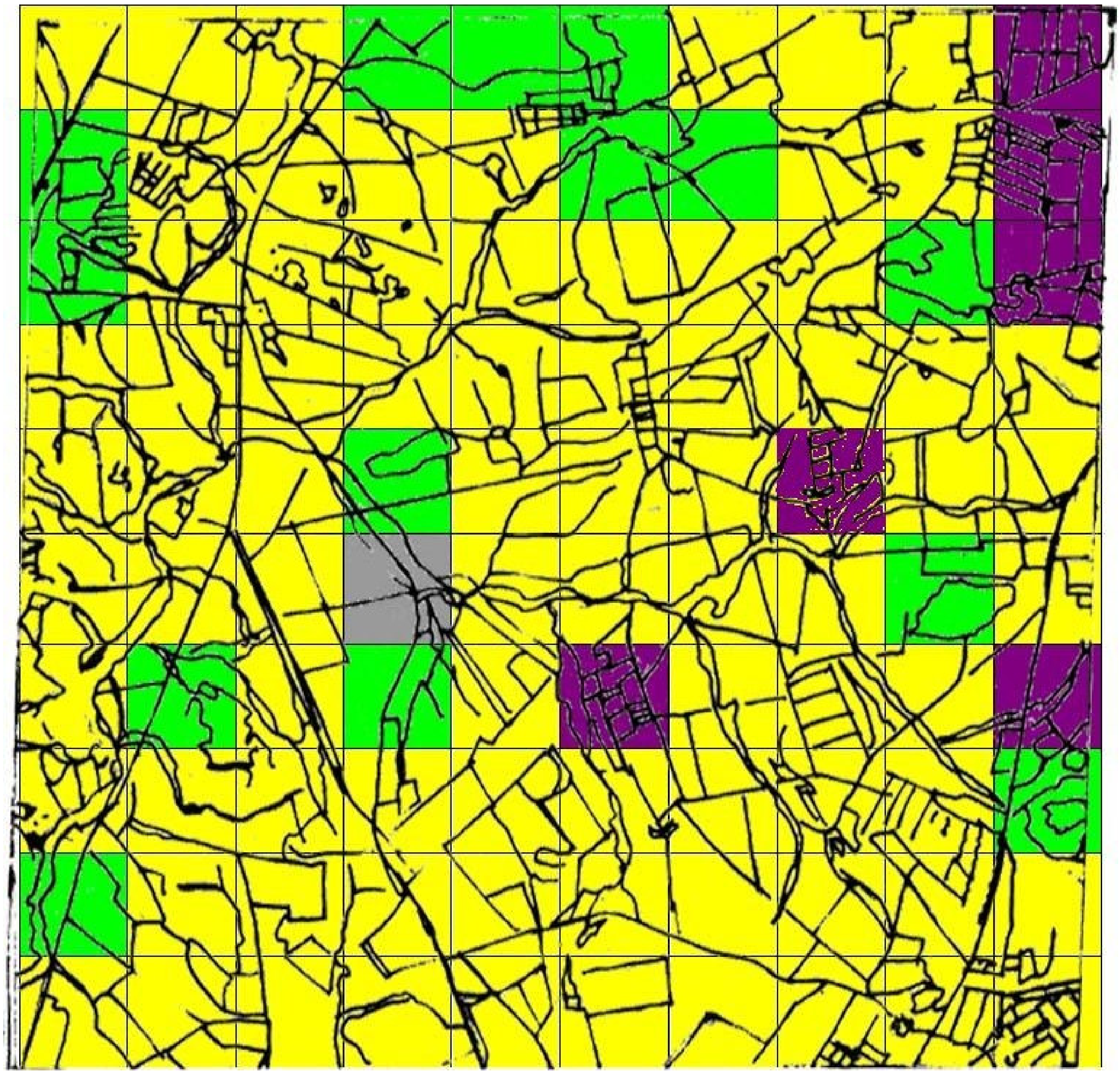
Appendix 1. Diagrammatic Representation of Grid Analysis
Where purple represents an area of grape, green represents an area of natural vegetation, yellow represents grain land cover, and grey represents the 'other' category.



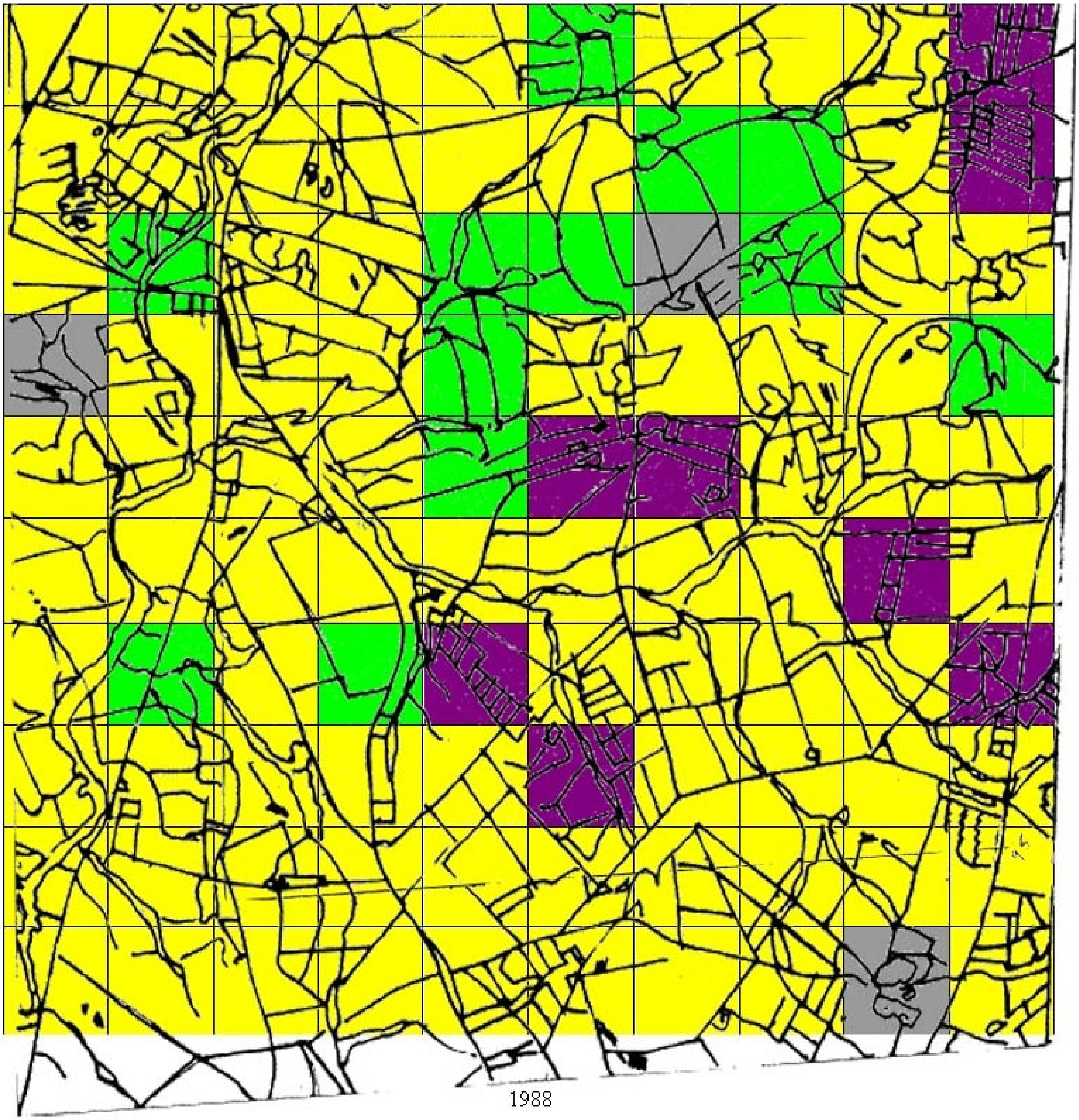
1960



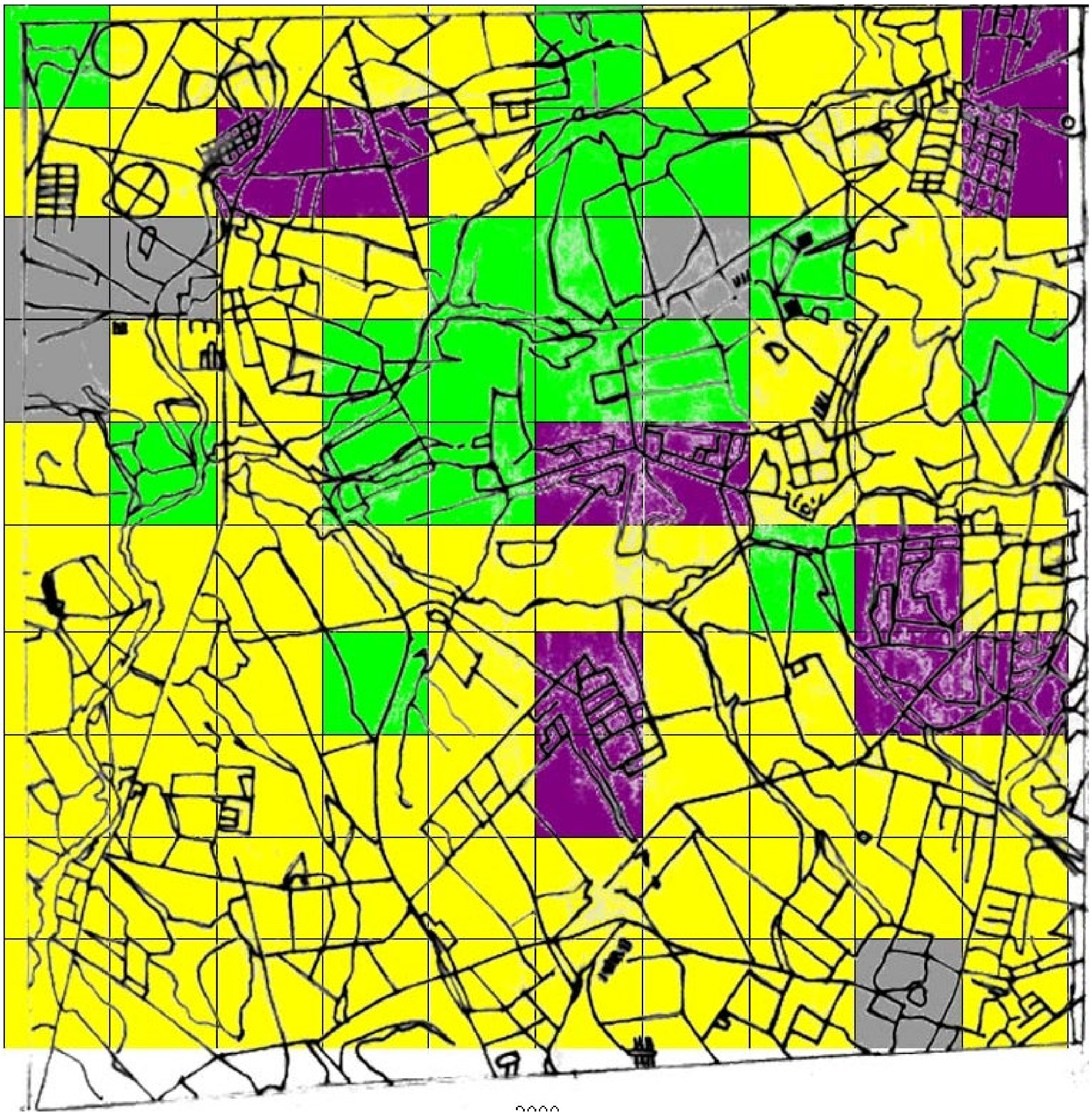
1968



1977



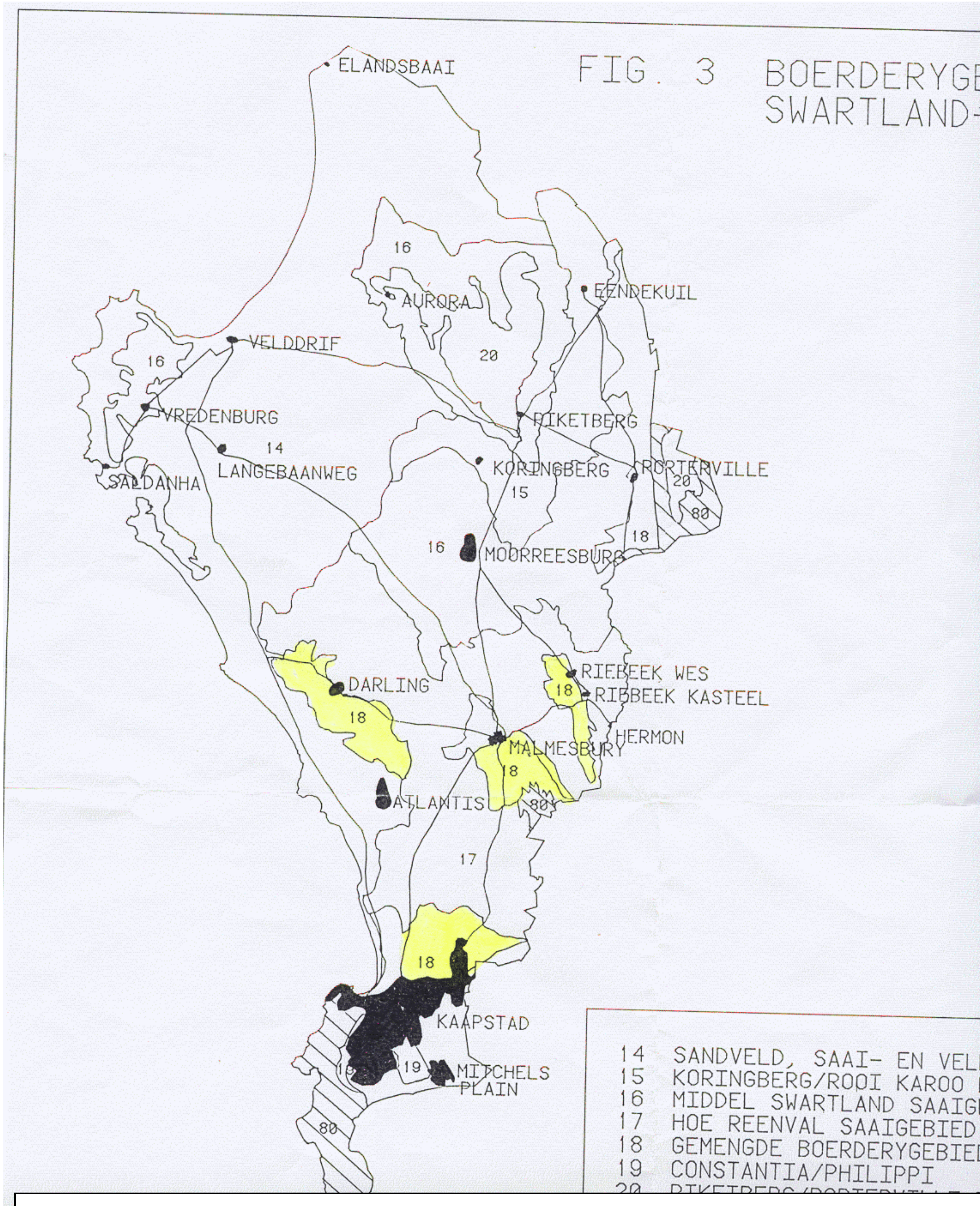
1988



2000

Appendix 2: 1000 Point Survey Results for Section 18 and map showing sections.

BEWERKTE GROND	Boerderygebied 0218 Punte	% van Tipe	% van Totaal
DROELAND			
Koring (Wheat)	186	26.09%	15.79%
Triticale	13	1.82%	1.10%
Canola	23	3.23%	1.95%
Graan en/of peulgewas-weiding/hooi/kuilvoer	155	21.74%	13.16%
Medics	33	4.63%	2.80%
Lusernweiding	1	0.14%	0.08%
Braakland	16	2.24%	1.36%
Ouland	286	40.11%	24.28%
SUBTOTAAL	713	100.00%	60.53%
BESPROEIING			
Wingerde (Grape)	302	87.28%	25.64%
Boorde	10	2.89%	0.85%
Weiding	15	4.34%	1.27%
Groente	19	5.49%	1.61%
SUBTOTAAL	346	100.00%	29.37%
ONBEWERK			
Veldweiding	42	35.29%	3.57%
Waterbaan- en vleiweiding	41	34.45%	3.48%
Bome/ plantasies	12	10.08%	1.02%
Werf,geboue,uitval,paaie	24	20.17%	2.04%
SUBTOTAAL	119	100.00%	10.10%
TOTAAL	1178		100.00%



Appendix 2: Western Cape Department of Agriculture 1000 point survey. The yellow region represents area 18 where grape production has surpassed grain production.

2.
EAT, DRINK AND MAKE MONEY: SWARTLAND AGRICULTURE IN CHANGING MARKETS

~I. Silverman~

Do This, Do That: South African wheat and wine policy before deregulation

Agriculture in South Africa during the end of Apartheid rule was characterized by the active intervention of the national government. The regulatory regime peaked in the early 1980s with the institution of a new set of laws that extended regulation to nearly every aspect of agricultural production. At its most pervasive, this policy dominated the agricultural economy, "including prices of, access to and use of natural resources, finance, capital, labor, local markets, foreign markets, and foreign exchange, etc" (Jooste, 1999: p.7). Total transfers to agriculture expressed as a percentage of per capita income were on par with highly subsidized North American agriculture (Fenyes and Meyer, 1998: pp.63,64).

The specific mechanisms of government support varied both by crop and by the specific Agricultural Marketing Act. In the early 1980s, common mechanisms included price supports above the international price, numerous types of subsidies often in the form of low interest loans, and tax breaks. In addition to the direct subsidies levied by the national and provincial governments, white commercial farmers benefitted from the apartheid land tenure and labor laws which significantly depressed their costs for both inputs and produced false economies of scale (Fenyes and Meyer, 1998: pp.66,71).

The highly distorting agricultural policies were a direct contradiction to the free market system the government purported to be supporting. Instead, agricultural policy of the early 1980s was driven by the goals of self-sufficiency with respect to food, textiles, and industrial raw materials as laid out in the 1984 White Paper on agriculture (Jooste, 1999: p.11). The wheat crop of the Western Cape formed an integral part of the government's food self-sufficiency strategy. Even though the average share of the national wheat crop was less than a third (31.6%) between 1986 and 1996, the coefficient of variation for wheat yields was only 17.2% compared to the national average of 40.5% (Troskie Vink and Wallace, 2000: p.11). Because of their key role in food self-sufficiency, government regulation of national wheat markets was exceptionally supportive.

Subsidies to wheat reflect the value of food self-sufficiency to the South African government. Wheat subsidies were targeted at consumer prices of domestic wheat products in order to keep them as low as possible (Jooste, 1999: p.15). These subsidies peaked at R276.6 million during 1984, and averaged R175.05 million between 1980 and 1990 (NDA, 1994). Further subsidies were administered through a single channel fixed price scheme in which a state-controlled wheat board purchased wheat crops (Jooste, 1999: p.12) at a guaranteed price determined on a cost plus basis (Williams et al., 1998: p.7). In the Western Cape, these subsidies stimulated the production of consistent annual provincial surpluses that were marketed domestically to feed the rest of the nation (Troskie Vink and Wallace, 2000: p.11).

Although it receives scant attention from contemporary agricultural economists, supportive farm policies also played an important role in promoting support from the white, Afrikaans-speaking population for the ruling National Party, especially in the early 20th century (Talbot, 1947: pp.35,36). While this changed significantly as the democratic transition of the 1990s approached, the market was only allowed to operate within the strict confines of these dual political imperatives.

If food security was most likely the driving force behind the protectionist cereal policy in South Africa, specific political interests undoubtedly played a primary role in the formulation and perpetuation national wine regulation. The Wine and Spirit Act of 1924 marked the government's first steps in what would become extensive regulation of South African viticulture. The Wine and Spirit Act handed over statutory control of the South African Wine industry to the Ko-operatieve Wijnbouwers Vereniging van Zuid-Afrika Beperkt (KWV), a cooperative composed of primarily Afrikaans-speaking winemakers and grape farmers in the Western Cape. The act empowered KWV to fix the price paid by wholesalers and sell arbitrarily determined wine and brandy surpluses outside of the domestic market. This system granted KWV an export monopoly and guaranteed grape farmers and winemakers a market for their products (Williams et al., 1998: p.3,4). The statutory powers vested in KWV amounted to a giveaway to the rural white Afrikaans-speaking constituency consistent with similar politically motivated policies with regards to wheat (Talbot, 1947: pp.35,36) and soil conservation aid during the same period (Delius and Schirmer, 2000; Meadows, 2003: p.27).

While a detailed description of the evolution of wine and spirits policy until deregulation in the 1990s is both beyond the scope, and tangential to the main focus, of this study, it is important to understand the basic driving principles. According to Williams et al. (1998), KWV continued to use its political influence to both extend its statutory powers and eventually gain controlling interests in the growth, manufacture, and distribution of wine and spirits. In addition to a vertically and horizontally integrated monopoly, by 1989 KWV had obtained the following additional statutory powers: the ability to set minimum wholesale prices for different grades of wines, set farm production quotas, the exclusive right to import distilling wine, and the ability to restrict new entrants to the market to specific geographic areas (1998: pp.4,5,15). This was despite an independent enquiry in the 1930s which determined that a cooperative of producers was "not an appropriate body to exercise statutory control over an industry" (Viljoen Commission, 1934: pp.89-92 cited in Williams et al., 1998: p.4).

Big Markets, Little Farmers: The restructuring of Swartland agriculture by the global agro-food complex

The deregulation of wheat markets that began in the late 1980s culminated in 1990 with removal of government subsidies and the dissolution of the state-controlled wheat board (Jooste, 1999: pp.12,14). Wine markets eventually followed suit with the 1992 abolition of the production quota system (Jooste, 1999: pp.15) and the 1997 privatization of KWV (Williams et al., 1998: p.12). The extensive deregulation closely coincided with the end of apartheid rule and the resultant lifting of strict international trade sanctions in the mid 1990s (Maykuth, 1997). The effect of these two forces was to roll back agricultural protection and expose agriculture in the Swartland, the Western Cape and South Africa in general to a set of radically new conditions.

Accustomed to extensive government regulation, protection, and subsidy, suddenly the structure of agriculture in the Swartland was determined by the vagaries of the global agro-food complex. According to McMichael (1994), globalization has become the dominant force in the restructuring of agricultural production worldwide. In countries integrated into global markets connected by new communications and transport technologies, "all manner of local and regional responses occur" (McMichael, 1994: pp.278,279). The emerging trend of vineyards displacing wheat fields in the Swartland is one such response.

Expensive Trade: The marginalization of Swartland wheat farmers in international markets

Although the state controlled wheat board was dissolved in 1990, the legacy of a century of price supports and protectionism remained. While difficult to quantify precisely, the distortions caused by apartheid land and labor acts, price fixing by state Marketing Boards, and subsidies levied on agricultural inputs resulted in the non-optimal use of scarce inputs and encouraged inefficiencies in South African agriculture (Jooste, 1999: p.65). Western Cape wheat was no exception, and these distorted market conditions most likely encouraged the proliferation of wheat production beyond economically viable levels.

Given these distortions, it is not surprising that wheat production in the South Africa fared poorly across a variety of indicators when compared with wheat production in other nations. The average yield of South African wheat between 1990 and 1994 was 1.45 tons per hectare, less than the African average of 1.65 tons per hectare and only 60 percent of the world average of 2.45 tons per hectare. Furthermore, average wheat yields in South Africa have grown more slowly than the average yields in the rest of the world since 1960, when South African yield per hectare was 63 percent of global averages (Vink Kleynhans and Street, 1998: pp.257, 258).

The inefficiencies generated by old market structures are highlighted when historical wheat planting trends are compared to the trends in wheat crop yields per hectare. The comparison clearly shows that wheat planting peaked between 1970 and 1989 at exactly the same time that comparative wheat yields were at their lowest. According to Vink, Kleynhans, and Street (1998), this pattern was " probably indicative of an over-extension in area planted, beyond the limits to profitable wheat production," at least under less supportive market conditions (1998: p.258).

Further evidence of an over-expansion in acreage devoted to wheat production stimulated by historical incentive structures is generated by a spatial model developed by Troskie Vink and Wallace (2000). The spatial model uses resource attributes, crop characteristics, and financial data in order to assess the viability of wheat under a variety of conditions. Their spatial analysis assuming deregulated markets and rain-fed wheat production (current market conditions) identified six grain silos in the Western Cape located in areas "unsuitable for the production of wheat" under the stated assumptions (2000: pp.10,22).

This interpretation is supported by recent negative trends in acreage devoted to wheat planting. Wheat plantings have declined steadily from just below 2000 hectares throughout the 1970s and 1980s to a 6 year average of 845 hectares between 1998 and 2003. Production figures in the Western Cape have also declined since the 1980s and early 1990s (NDA, 2004). It is certainly true that declining total yields figures are highly sensitive to other factors such as intensity of farming practices, rainfall, and disease. However, they are also consistent with a general contraction in hectares planted in response to less favorable market conditions.

While falling wheat acreage and output certainly suggest that Western Cape wheat is struggling to compete under new market conditions, Vink Kleynhans and Street's (1998) analysis of input costs and net margins seems to confirm it. They compared the costs of 5 agricultural inputs—seed, fertiliser, plant protection, contract work, and machinery—between South Africa and other relatively low yield per hectare wheat producers (Australia, Canada, and the USA). Their results showed that Western Cape wheat farmers paid more per hectare for every input (1998: p.262).

South African wheat farmers faired even worse in an international comparison of net profit margins. The 8 Western Cape wheat farmers included in the study reported net margins that ranged from -R66.41 to R614.36 per hectare and averaged R209.81 per hectare. Although there was a large range, the net margin of 6 out of the 8 farms fell between R100 and R300 indicating a relatively meaningful average. In comparison the lowest net margin reported by an international region was R844.43 in Australia, more than 4 times the Western Cape value. Furthermore, capital expenditures were excluded from the study due to the lack of reliable data.

Because of relatively high real interest rates in South Africa this amounts to an overstatement of South African net margins relative to the other international study members (Vink Kleynhans and Street, 1998: p.260-261).

Without discounting the effect of high input costs on the net margins of Western Cape wheat farmers, another body of work suggests that farm size plays an important role in determinting the competitiveness of Western Cape wheat. The previously outlined governmental interventions in land, labor, and capital markets also created false economies of scale. This promoted the creation of large-scale commercial farms at the expense of small-scale farmers (Fenyes and Meyer, 1998: p.71). Due to variation in input mix as farm size changes, large-scale farms are on average less efficient than smallholdings when social opportunity costs replace market prices as the measure of output value (Van Zyl, 1995 cited in Fenyes and Meyer: 1998: p.71). In the case of Western Cape wheat, this is due in large part to governmental subsidization of irrigation water, which diverts it from other possible uses.

Despite the extensive inefficiencies stimulated by historical interventions by the South African government, the economic profitability of Swartland wheat producers is also influenced by the agricultural structure and policies of major wheat importers and exporters that directly affect available markets and prices. Due to the complexity and heterogeneity of agricultural structures and policies of the major players in international wheat markets, a detailed country by country analysis is not feasible within the limitations of this study. Instead, general dynamics of the international wheat market will be explored using policy indicators and case studies from major producing and importing nations, specifically as they relate to the competitiveness of Western Cape wheat.

South Africa may have rolled back governmental distortions of domestic wheat markets through the dissolution of state wheat boards and price controls; however, it would be naive to assume that Swartland wheat farming now operates according to free market principles. Instead, the removal of trade sanctions and increasing openness of South African markets to international trade exposed wheat producers to the distorting effects of other nation's agricultural subsidies. Deregulation and integration into international markets amounted to an abdication of sovereignty over wheat markets to the international community.

An analysis of international producer support estimates (PSEs), an OECD-developed measure that represents the percent of farm income received from state sources, makes this abundantly clear. The PSE for South Africa in 1998 was 2.7 percent compared with 21.6 percent, 45.3 percent, and 63.2 percent in the USA, EU, and Japan respectively. While the USA, EU, and Japan have some of the highest PSEs in the world, the South African PSE is lower than Australia and near to that of New Zealand, nations where agricultural subsidies are traditionally the lowest in the world (Vink and Kirsten, 2002: p.10).

The presentation of agricultural policy in the United States translates the abstract concept of a 21.6 percent PSE into real world practice. In response to hard lobbying by United States agricultural interests, the 2001 farm bill called for the implementation of the full $73.5 billion increase in agricultural spending allocated by the fiscal budget resolution for 2002. This includes an increase in commodity support programs as well as the reinstitution of counter cyclical payments that come into effect when commodity prices fall below federally predetermined levels (Martinez, 2002).

These demands were followed by farmer pleas to limit the amount of Canadian wheat allowed into the U.S. market. United States farmers argued that the exemptions to high tariffs against foreign wheat entering U.S. markets granted by the Canadian Free Trade Agreement and the North American Free Trade Agreement (NAFTA), combined with the anti-competitive activities of the Canadian Wheat Board, "have helped to depress U.S. wheat prices and undercut U.S. wheat sales abroad" (ibid). According to the administrator of the North Dakota wheat commission, closing loopholes created by NAFTA would reduce the level of subsidies required to support U.S. wheat production. This interaction creates what Martinez has labeled the "uneasy mingling" of U.S. farm bills with trade policy (ibid).

These results are particularly damaging when viewed alongside strategic market research on South African agricultural exports conducted by Steenkamp (1999) for the National Department of Agriculture. Steenkamp (1999) found that the largest untapped markets were located in the USA, followed distantly by Japan, several nations within the EU, and Australia among others. Since the relaxation of trade sanctions, these same nations, excluding Japan, have dominated South African agricultural imports (NDA, 2004). Some of this can certainly be explained by the differential between these nations' and South African PSEs that suggests that Swartland wheat producers operate at a significant disadvantage to wheat producers in the very markets they hope to penetrate.

Protectionism is also rampant within the European Union, where exporting African nations face high agricultural tariffs. However, the various Lome conventions created a series of preferential trade agreements between European nations and their former colonies. Due in part to these discriminatory and country-specific agreements, the EU is still the world's largest importer of African agricultural products and, barring a drastic restructuring of international tariff levels, this does not appear likely to change in the immediate future (Van Dijk, 2001:

p.528). While Swartland wheat farmers benefit in cases where the Lome convention grants them tariff-free access to markets, overall access to the EU markets is severely limited.

The agricultural policies of highly developed nations exerting economic pressure on Swartland wheat farmers are not limited to domestic policies of protectionism and subsidy. The United States, along with many other nations throughout the industrialized North, have distributed food aid and sponsored agricultural development projects throughout the less developed third world. These programs were so extensive that a significant amount of world wheat trade was orchestrated through international agreements as opposed to markets. In fact, during the early 1960s, 35.6 percent of the global wheat trade was directly attributable U.S. food aid (Friedman, 1994: pp.259,261). The distribution as well as the nature of these programs have negatively impacted the competitiveness of Swartland wheat production.

Sub-Saharan Africa has traditionally received scant attention in U.S. foreign policy, and agricultural aid proves no exception. Johnston et al. (1991) characterized U.S. aid to Sub-Saharan African agriculture as “a) limited, b) relatively late, and c) subject to huge variations over time and in country focus” (p.317). This is most likely due to the fact that aid to African agriculture lacks a clear political constituency within the United States. To the contrary, certain powerful lobbies such as agribusiness vehemently oppose agricultural development projects in Africa, especially to nations such as South Africa whose wheat exports could potentially compete with their own (Lele and Jain, 1991: pp.578, 585,595). Instead of developing the capacity of African nations to feed themselves, food aid to starving African nations provided a way for the U.S. to dispose of the massive surpluses generated by the aforementioned domestic subsidies while simultaneously fostering international goodwill (Vogeler, 1981: p.261).

Development aid to other parts of the world has been both more prolific and more successful in boosting production of cereal crops. The Green Revolution in India, which was composed of massive transfers of technology and expertise, is an excellent example. China also took massive strides towards improving their wheat production. The development of more efficient cereal production in areas like India and China undoubtedly contributed to Asia's nearly 400 percent increase in wheat yields per hectare between 1961 and 1994 (Vink Kleynhans and Street, 1998: p.258). These emerging wheat producers served to bolster world supply of wheat, exerting downward pressure on world wheat prices and further undermining the competitiveness of Swartland wheat farmers.

Why Wine?: New opportunities for Swartland viticulture

The above examination of national and international agricultural policies explores the powerful forces that have led to the declining competitiveness of Swartland wheat. However, a general decline in area devoted to wheat production is only half of the land use story. During the same period that the declining competitiveness of Swartland wheat has led to declines in hectares of wheat fields, the acreage devoted to viticulture has increased with growing rapidity (SAWIS, 2004). For a more in-depth look at land use patterns in the Swartland please refer to section III.1 of this report.

In contrast to Swartland wheat farms, vineyards have enjoyed huge economic successes since the democratic transition in the early 1990s. Part of this can be attributed to differences in the deregulation of the two industries. Although vine farming also suffers from a history government intervention, the negative effects of past were mitigated by the pace of the deregulation and liberalization process in the South African vine industry.

Deregulation in the wine industry occurred much more slowly than in the wheat industry. When the state wheat boards were abolished in 1990, KWV used its considerable political influence to maintain statutory control over the wine industry until 1996. During this time, KWV phased out production quotas in 1992 and minimum price levels for good wine as booming export markets rendered them irrelevant (Ewert and Hamman, 1999: pp.202). In 1996, KWV applied to transfer its assets to a private corporation under threats from the government to repeal its statutory powers (Williams et al., 1998: p.15).

The relatively slow pace of this process allowed vine farmers to gradually adapt to changing market conditions. Domestic demand stagnated during the 1980s and trade sanctions resulted in limited ability for the KWV to market surpluses abroad (Williams et al., 1998: p.9). The end of trade sanctions in 1994 removed the restrictions to exports and radically expanded the markets available to South African wine. In contrast to heavily subsidized and protected wheat markets, international trade in wine is relatively unhindered by protectionist trade policies. The reason that Swartland vine farmers and winemakers enjoy easy access to international markets is that wine (unlike wheat) is not a strategic commodity in the national food self-sufficiency policies of the major world economies.

In response to nearly free access to markets in the industrialized north, the volume of grape exports nearly quadrupled from 65,627 tons in 1991 to 231,192 tons in 2003 (NDA, 2004). Much of this increase was concentrated in wine industry, where liters of wines exported doubled from 118,407,948 liters to 239,501,562 liters between 1998 and 2003 (SAWIS, 2004), and the value of wine exports rose from R122,112 in 1992 to R3,000,114 in 2002 (NDA, 2002). In fact, the final impetus for the privatization of the wine industry in 1996 came from the vine farmers looking to exploit the booming export industry (Williams et al., 1998: p.15).

As "Mandela Magic" swept the world in the form of worldwide enthusiasm for South Africa and consequently its products, winemakers found that production could not keep up with international demand (Maykuth, 1997). Excess international demand exerted upward pressure on wine prices, which increased by just over 275 percent between 1993 and 2003. This in turn helped wine farm incomes increase more rapidly than production costs over the same period, boosting net margins (SAWIS, 2004).

The success of the Swartland wine industry is consistent with the application of comparative advantage theory to the South African context. According to Thoburn, "an apparently obvious area of potential industrial comparative advantage lies in the further processing of African primary commodity exports" (2001: p.61). Because final prices include transportation as well as production costs, relatively high transportation costs, estimated 8.7 percent higher in Africa than other regions, must also be considered in determining the competitiveness of a particular industry. Transportation costs from the Swartland are likely to be considerably lower than this regional average due to relatively good transportation infrastructure and its proximity to Cape Town, a major international port. Furthermore, this disadvantage is significantly mitigated when a large amount of weight loss occurs during the production process (Thoburn, 2001: pp.61,62) as is the case in wine production.

The comparative advantage of vineyards over wheat fields in the Swartland is also predicted by an analysis of South African agricultural returns to water and land resources. A comprehensive study of South African agriculture found that irrigated crops consistently held comparative advantages over rain-fed field crops in the Western Cape (Jooste, 1999: p.65). Given this result, the fact that largely irrigated vineyards out-compete rain-fed wheat is unsurprising. As this analysis makes clear, Swartland wine's competitiveness against other types of land use is based upon local comparative advantages in grape cultivation as well as international comparative advantages in wine crafting; Swartland vine farmers are uniquely situated to exploit natural regional and local comparative advantages.

The comparative advantages enjoyed by the South African wine industry is both the partial result and current driver of the exceptionally high returns to wine grape research and extension projects in South Africa. Townsend and Van Zyl (1998) found that research in technology and extension investments in the SA wine grape industry yielded marginal internal rates of return of around 42-45 percent in terms of quality-adjusted yield. Despite these exceptionally high rates of return, investment in South African wine industry as a percentage of grape production costs is considerably lower than the expenditures of other major wine-producing nations such as the U.S. and Australia (1998: pp.205,206). This may be due to the still uncertain future of the South African wine industry (Van Zyl and Zink, 1997) and general uneasiness among investors about the South African agricultural industry stimulated by land seizures in neighboring Zimbabwe as well as land the implications of future land redistribution as promised in South Africa.

Doing Better than Jesus?: Turning less water into more wine

The major source of investor uncertainty in wine markets is the prospect of changing availability and pricing of water resources in the Western Cape. Climate modeling using the Hadley Centre for Climate Prediction and Research general circulation model (GCM) has projected a significant decrease in precipitation in the Western Cape within the next half century and most likely much sooner. While there is a degree of uncertainty associated with all climate models, the Hadley model is generally accepted as being reliable (Erasmus et al., 2000: p.261).

Using the predictions of decreasing precipitation generated by the Hadley GCM, Erasmus et al. (2000) then modeled the effects on Western Cape agriculture. As total availability of water decreases, irrigation projects with the lowest rates of return will be eliminated first (Erasmus et al., 2000: pp.567,568). Due to the high rates of return of irrigation to vines this scenario is unlikely to effect Swartland viticulture while irrigation water is first diverted from other uses with lower rates of return. It could, however, mean an increase in wheat production as rain-fed wheat may still be a viable, albeit risky, given increasing rainfall variability, alternative in fields left idle by decreasing availability of irrigation water. These effects would be especially pronounced in areas like the Swartland where the substitutability of irrigated and rain-fed crops is high (Erasmus et al., 2000: pp.268,269).

Decreasing precipitation in the Western Cape will most likely result in some governmental intervention to ensure the rationing of a decreasing water supply to its highest priority. Under a regime of exceptionally high water tariffs, both vines and wheat would be expected to increase in the Swartland. As irrigation water is diverted to high return activities such as wine grapes, and the total amount of irrigation water decreases, the availability of land for rain-fed wheat increases (Van Zyl and Vink, 1997: pp.581,582). This would add an interesting twist to current land use trends as wheat and vines work together displace all other forms agriculture in the Swartland

If, instead, the government makes agriculture a residual user of water supplies, the outcomes are quite different. Given the precipitation predictions of the Hadley GCM model and the still rapidly expanding population of greater metropolitan Cape Town, the prospect of an urban drought is not unlikely. This scenario resembles the previously explored example where water is rationed to the use with the highest returns. However, the social returns to drinking water are treated as greater than those for irrigation regardless of economic returns. This means that vineyards would no longer be protected by their high rate of economic return and would face severe contractions in production and acreage due to lack of irrigation. In the Swartland, the reduction in irrigated vineyards would be replaced by a commensurate increase in wheat fields which has historically dominated the rain-fed agricultural production in the region.

Is No Policy Good Policy?: South African agricultural objectives, policy, and the nature of world markets

Recent South African agricultural policy has exposed agricultural markets to the harsh realities of world trade. As mentioned previously, this has effectively shifted control over agriculture to the global market. In the Swartland this has resulted in a general shift from the production of grain to the production of wine. What is not clear is whether or not this is in the best interest of the South African public.

Current global markets have moved away from concepts of competitive trade towards a new paradigm of adversarial trade. Adversarial trade is characterized by attempts to control an entire industry through the destruction of adversaries and domination of an industry to the extent that new entrants to the market will find it impossible to compete with the market leaders (Groenewald, 1998: p.529). Essentially, adversarial trade is the pursuit of global monopolies.

According to Groenewald the answer to adversarial trade does not lie with traditional paradigms of trade policy. Instead nations must adopt policy that "transcends both protectionism and free trade"(1998: p.530). In the developing world, this can only be achieved through the development of trading blocks to balance the massive economic entities such as NAFTA and the EU that characterize markets in the Northern hemisphere. Only through negotiation as an economic equal can the South hope to achieve reciprocity in trade agreements (Groenewald, 1998: p.530). What Groenewald is suggesting is that in order to benefit in the world of adversarial trade a nation must be economically powerful enough to fight back, and no developing nation can do that on their own. The decline of Swartland wheat markets in the face of U.S. subsidies and EU protectionism is an excellent example of how South Africa is currently at the mercy of more economically powerful nations.

The South African Development Communnity (SADC) and the recently launched New Partnership for African Development (NEPAD) reflect an awareness of the new character of global trade and the global trend towards regional integration. Unfortunately, these structures do not challenge the U.S. or the EU in the arena of adversarial trade. This demonstrates a major problem with Groenewald's analysis, specifically that any integration of lesser developed nations large enough to challenge the trading blocks of the Northern hemisphere would represent such a variety of interests as to prove unworkable.

Despite this, South Africa must find some way to promote its national interests. Entrance into the global market has been kind to some sectors of South African agriculture as demonstrated by the performance Swartland viticulture. However, if those interests include a level of food self sufficiency, South African cereal farmers require protection from the unfair trading policies of the industrialized North. Land use changes and agricultural production statistics from the Swartland clearly show that trade liberalization creates losers as well as winners in South African agriculture. However, the essential choice which remains to be made is whether agricultural policy should promote the production of bread or wine.

References

Abstract of Agricultural Statistics 2004. (2004). Pretoria: National Department of Agriculture

Cleaver, Kevin M. (1993). A Strategy to Develop Agriculture in Sub-Saharan Africa and a Focus for the World Bank. Washington D.C.: International Bank for Reconstruction and Development (The World Bank).

Delius, Peter and Schirmer, Stefan (2000). Soil conservation in a racially ordered society: South Africa 1930-1970. Journal of Southern African Studies, 26(4) December.

Erasmus, B., Van Jaarsveld, A., Van Zyl, J., and Vink, N. (2000). The effects of climate change on the farm sector in the Western Cape. Agrekon, 39(4) December, pp.559-572.

Ewert, Joachim and Hamman, Johan. (1999). Why paternalism survives: Globalization, democratisation and labour on South African wine farms. Sociologia Ruralis, 39(2), pp.202-222.

Fenyes, T.I., and Meyer, N.G. (1998). Agricultural policy and macroeconomic issues in South Africa in perspective. Agrekon, 37(1) March, pp.63-81.

Friedman, Harriet (1994). Distance and Durability: Shaky Foundations of the World Food Economy pp. 258-276 in The Global Restructuring of Agro-Food Systems ed. McMichael, Phillip. Ithaca: Cornell University Press

Groenewald, J.A. (1998). Reconsidering the role of government in Southern African agriculture. Agrekon, 37(4) December, pp.527-536.

Johnston, Bruce F., Hoben, Allan, Jaeger, William K. (1991) United States Activities to Promote Agricultural and Rural Development in Sub-Saharan Africa pp. 277-324 in Aid to African Agriculture: Lessons from Two Decades of Donors' Experience ed. Uma Lele. Baltimore and London: John Hopkins University Press.

Jooste, Andre (1999). Regional Agricutlural Trade and Changing Comparative Advantage in South Africa. Pretoria: National Department of Agriculture

Lele, Uma and Jain, Rahul (1991). Aid to African Agriculture: Lessons from Two Decades of Donor's Experience pp574-609 in Aid to African Agriculture: Lessons from Two Decades of Donors' Experience ed. Lele, Uma. Baltimore and London: John Hopkins University Press.

Martinez, Gebe (2002). Issue of price supports forces uneasy mingling of farm bill, trade policy. Congressional Quarterly Weekly, 60(4) January

Maykuth, Andrew (1997). End of Apartheid Uncorks Good Times for Wine Makers of South Africa. Philadelphia Inquirer, May 9.

Meadows, Michael E. (2003). Soil Erosion in the Swartland, Western Cape, South Africa: implications of past and present policy and practice. Environmental Science and Policy, 6, pp.pp.17-28

McMichael, Phillip (1994) Global Restructuring: Some Lines of Inquiry pp. 277-295 in The Global Restructuring of Agro-Food Systems ed. McMichael, Phillip. Ihaca: Cornell University Press.

South African Wine Industry Information and Statistics. (2004) SA Wine Industry Statistics no 28. Paarl: SAWIS

Steenkamp, Ezra (1999). Strategic market research on SACU exports: a focus on agriculture. Pretoria: National Department of Agriculture

Talbot, W.J. (1947). Swartland and Sandveld. Cape Town: Oxford University Press

Thoburn, John T. (2001) Developing International Industrial Competitiveness in Africa 55-74 in African Development Perspectives Yearbook 2000/2001: Africa's Reintegration into the World Economy Part A: Basic Issues.ed.Wolmuth, Karl; Bass, Hans-Heinrich; Grawert, Elke; Gutowski, Achim; Kappel, Robert; Konig, Angela; Wauschkukn, Markus. Piscataway: Transaction Publishers, Rutgers University

Townsend, R. and Van Zyl, J. (1998). Estimation of the rate of return ot wine grape research and technology development expenditures in South Africa. Agrekon, 37(2) June, pp.189-208.

Troskie, D.P., Vink, N., and Wallace, M. (2000). Implications of a deregulated wheat market for the Western Cape province: Evaluation with the aid of a spatial model. Agrekon, 39(1) March, pp.11-25.

Van Dijk, Meine Pieter.(2001 Post-Lome IV: New Opportunities for African Countries? 521-535 *in* African Development Perspectives Yearbook 2000/2001: Africa's Reintegration into the World Economy Part A: Basic Issues.ed.Wolmuth, Karl; Bass, Hans-Heinrich; Grawert, Elke; Gutowski, Achim; Kappel, Robert; Konig, Angela; Wauschkukn, Markus. Piscataway: Transaction Publishers, Rutgers University

Van Zyl, J., and Vink, N. (1997). The effects of water policies on the farm sector in the Western Cape. Agrekon, 36(4) December, pp.573-584.

Vink, N., Kleynhans, T.E., and Street, K. (1998). The competitiveness of Western Cape wheat production: an international comparison. Agrekon, 37(3) September, pp.255-267.

Vink, Nick, Kirsten, Johann (2000). Pricing behavior in the South African food and agricultural sector. Pretoria: National Treasury

Vogeler, Ingolf (1981). The Myth of the Family Farm: Agribusiness Dominance of U.S. Agriculture. Westview Press, Inc.: Boulder.

Williams, Gavin, Ewert, Joachim, Hamman, Johann and Vink, Nick (1998). Liberalizing markets and reforming land in South Africa. Journal of Contemporary African Studies, 16(1), pp.65-92.

IV.
The Study Sites

~K. Dietrich~

Figure 1: De Grendel

Figure 2: One of the authors at Hooggelegen

Figure 3: A view of Grasrug.

Figure 4: Roads in Tygerberg.

5.
THE STUDY SITES
~K. Dietrich~

Four case study sites have been used throughout this cumulative study to consider the socioeconomic and environmental differences between grain and grape production. The sites represent different land uses. DeGrendel Farm recently changed from grain production to grape production within the past four years. Hooggelegan Farm serves as the long-standing grape production while Grasrug Farm functions as the wheat production. Finally, Tygerberg Nature Reserve serves as the control for the scientific components. The following section provides a brief description of each study site.

DeGrendel Farm

De Grendel Farm was established in 1720 on the northwest side of Tyberberg Mountain. The deed for this freehold farm was given to Claas Mayboom in May with 53.473 Morgen roods (45.8 hectares). In 1843, Daniel van Reenen received the deed for DeGrendel under the British quitrent land system. The farm size was increased to 363.579 morgen roods (311.4 hectares) (Wesson, 1998). The farm was bought by the current owners, the ----- family, prior to the Anglo-Boer War of the early twentieth century. It has remained in this family passing down to three generations (de Flamingh, pers. comm.).

The current farm participates in mixed farming. Oats are produced on 220 hectares of the farm primarily for cattle which graze on 90 hectares. Currently 110 hectares of land have been devoted to grape production, a recent endeavour for the current owners; however, grape production has occurred on this land in the past. Grape production began in 2000 and plans are in place to expand. DeGrendel also contains natural vegetation which is located on the top of the

Tygerberg Mountain. Efforts have been put in place for the conservation and restoration of these natural areas (de Flamingh, pers. comm.).

Hooggelegen Farm

Hooggelegen was established on the northeast side of Tygerberg Mountain in 1704 according to the owners; however, freehold farm records suggest the farm existed under a different farm name in 1702. The first owner was Adriaan van Brakel and the farm consisted of 65.32 morgen roods (55.9 hectares). The farm size increased to 194.589 morgen roods (166.7 hectares) in 1863 under the quitrent land system and the owner changed to Philip Heinrich Kramer (Wesson, 1998). The farm currently resides in the de Wit family where it has remained for 121 years (de Wit, pers. comm.).

The current farm is 209 hectares of mixed farming. Grapes constitute 64 hectares and have been planted on the farm for 120 years. Natural vegetation covers 50 hectares with plans on converting this land into a game farm. Pasture land cavers the rest of the farm, with 45 hectares being irrigated. Wheat has previously been grown on the farm.

Grasrug Farm

Grasrug farm was first registered in September of 1704 to the north of Malmesbury. It is unclear who received the first registration; however, Michiel Smuts Martinuszoom received the farm in April of 1786. Sir John Cradock was the second owner of the farm around the early 1800s. In 1905, part of the neighbouring Dassheuvel farm was transferred to Grasrug. The farm in its entirety was sold in September of 2001 by the power of attorney for Michiel Smuts (the later M. Smuts) (South African Surveyor General's Office).

Grasrug currently contains 600 hectares of mixed farming. About 380 to 400 hectares a year are devoted to wheat production which has occurred for more than two centuries. About 60 to 85 hectares are sown with canola, and about 100 hectares are left fallow. The rest is used for animal grazing. No natural vegetation remains on the farm (Smuts, pers. comm.).

Tygerberg Nature Reserve

The Tygerberg Nature Reserve is located near the top on the south end of Tygerberg Mountain. The Reserve was originally established in 1974 by the Bellville Municipality. It constituted 70 hectares and was referred to as the Tygerberg Local Authority Nature Reserve. In 1997, Anglo American Properties donated 50 hectares and the Parow municipality donated another 150 hectares of Public Open Space to create the Tygerberg Nature Reserve (Friends of the Tygerberg Hills, n.p.).

The reserve currently contains 68 hectares of mostly renosterveld remnants with some alien tree species. The area contains an environmental education centre, picnic areas, and several hiking trails. The highest point in the reserve is currently being used for communication antennas.

References

de Flamingh, J. Personal Communication. 30 April 2004.

de Wit, R. Personal Communication. 24 May 2004.

Friends of the Tygerberg Hills. (n.p.) "Tygerberg Hills—A Special Place." Brochure.

Smuts. Personal Communication. 8 May 2004.

South African Surveyor General's Office. Deeds of transfer and cadastral survey diagrams. Accessed March 2004. Cape Town.

Wesson, Alf. (1998) "The Tygerberg Hills 1652 to 1945." The Tygerberg: The Story of Tygerberg Hills and the towns of Parow, Bellville and Durbanville. Ed. N.M. DuPlessis. Cape Town: Tafelberg, pp 30-66.

V.
The Dirty Truth:
Characteristics of Soils at Four Sites in the Swartland

~A. Waldron~

INTRODUCTION

The main objective of this section is to produce qualitative case studies of the soil at four different sites: the Tygerberg Nature Reserve, and the De Grendel, Hooggelegen and Grasrug farms. All of the sites are cultivated land, except for the Tygerberg Nature Reserve, where native West Coast Renosterveld grows. Fields at De Grendel have recently been switched from grain to grape cultivation, while Hooggelegen has produced grapes for a longer period of time (for details see section IV of this report). At Grasrug, wheat is grown. Because of the different land-use types, soil at each site was expected to vary. The purpose of qualitative case studies is therefore to provide a base of information on soil characteristics at each site, from which future, more refined studies can be framed. Soil information, in combination with findings from other sections of this study, also has the potential to provide a preliminary and qualitative idea about the environmental implications of different land use types.

This section combines background information on soils in the Tygerberg area, a qualitative description of the soil at each site, information provided by individual farm owners/managers, and the results of lab analyses on samples collected from each site. Lab analysis techniques were simple, as this is a preliminary study, and variables were chosen for their likelihood to characterize (even qualitatively) the different soils, and thus allow for comparison. Moisture content, organic content, pH, and particle size analyses were conducted in the laboratory.

BACKGROUND

A basic understanding of soils in the study area is important to have when assessing the results from each study site. However, as the mineralogy of the soil at Grasrug was visibly different from that of the soils at the other three sites, and Grasrug was spatially removed from the other three sites, the following description only pertains to soils in the area of the Tygerberg Nature Reserve, De Grendel, and Hooggelegen.

Most soils in this area have been formed as the result of current weathering conditions, but some paleosols, soils that were formed in the past under different environmental conditions, also can be found. They have not been destroyed by weathering or erosion, but exist in disequilibrium with the current environment. Paleosols in the fynbos biome were predominantly formed in the early Cenozoic. In the southwestern Cape, this time was typified by a warm and humid climate and weathering characteristic of a tropical or subtropical region (Lambrechts, 1983: p.62). Most paleosols in the region therefore exhibit a high degree of weathering. Iron hardpans and kaolinite-rich soils are two common types of paleosols found in the Tygerberg region (Lambrechts, 1998: p.95).

Although paleosols are not uncommon, the West Coast Renosterveld is currently restricted to growth on clay-loam soils of either granitic or shale-rich parent material (McDowell, 1988: p.30). For non-relict soils in the Tygerberg area, the parent material is mostly shale, phyllite, or schist from the Malmesbury Group (Schloms Ellis & Lambrechts, 1983: p.73). Active soil forming processes in the region include: the reduction and oxidation of iron, clay movement, and oxide leaching from upper soil horizons (Lambrechts, 1998: pp.93-94). However, as environmental and weathering conditions vary, a range of different soils are produced.

In relatively cool and dry areas, or in areas that have poor drainage, siallitic soils are common. The clay minerals in siallitic soil are primarily illite and vermiculite, and thus the soils often have a prismatic structure (Lambrechts, 1998: p.92). Soils which are enriched in clay (and so may exhibit prismatic structure) in the lower B horizon, relative to the upper A and E horizons, are called duplex soils, and are common in the Tygerberg region (Schloms Ellis & Lambrechts, 1983: p.71). In contrast, ferralitic soils, which are formed in warmer and more humid conditions, are more highly weathered, and include mostly kaolinitic clays. Ferralitic soils have a characteristic red-brown color, and are more oligotrophic than siallitic soils (Lambrechts, 1998: p.92).

It is important to note that cultivated soils with low organic matter and iron concentrations in the area are at particular risk for erosion damage (Rahlao, 13). Also important to note is the fact that "pure" West Coast Renosterveld tends to grow on soil with high agricultural potential (McDowell, 1988: p.47).

METHODS

Non-laboratory components.

Information on individual farms was provided by farm owners/managers, and qualitative observations on slope angle and soil characteristics were made at each site.

At each site, 9 soil samples were taken on a north-facing 9 m^2 grid. K. McAlister and C. Fiske chose the grid for placement of insect traps (see section VI.2 of this report), and we decided to use the same grid for soil sampling so that, if possible, qualitative comparisons could easily be made between the two studies. Samples were all taken above plowing depth and were stored in zip-lock plastic bags.

Laboratory components.

In order to measure moisture content, the method presented by G. Williams (1987) was used. Approximately 10g of each sample was weighed and dried overnight at 105ºC. The samples were then reweighed, and the percentage of moisture lost was calculated. To determine organic content, the dried samples were then ground with a mortar and pestle and transferred to crucibles. Each sample was 8-10g. Soil was not sieved to exclude large particles based on the rationale that large particles are part of the soil. However, this is a possible source of error. The samples were left in an oven overnight at 375-380ºC and reweighed after cooling in a dessicator the next morning (Smith & Atkinson, 1975: pp.174-175). The weight lost on ignition is assumed to be equal to the weight of the organic matter in the sample (Smith &Atkinson, 1975: p.174), and percent organic content was thus calculated.

All sub-samples analyzed for moisture and organic content were grab samples. However, two quartered sub-samples were also taken from each site in order to assess possible differences in results due to sub-sampling technique. Quartered samples were from grid positions 1 and 9. However, one sub-sample was taken from position 2 on the Hooggelegen grid because there was a hole in the bag containing the first Hooggelegen sample. Quartering involves making a flattened cone of the entire soil sample, splitting it into four equal parts, and returning two opposite quarters to the sample bag. Another flattened cone is then made with the remaining soil, and the process is repeated until the desired amount of soil is left. Non-quartered sub-samples are a possible source of error. Another possible source of error for both the moisture and organic content analysis is the fact that samples were not left in the oven for the same amount of time each night. Moisture content may also have been skewed by holes in individual zip-lock bags (the sampling containers). However, whenever holes were visible in sample bags, the samples were excluded from the analysis.

pH was measured according to the method recommended by Smith and Atkinson (1975). 20-30g sub-samples were air dried overnight for the purposes of the pH test. 20g (± 1g) of each sample was then combined with 50ml of a .01M $CaCl_2$ solution and mixed with a mechanical shaker for five minutes. pH was determined with an electrical pH meter, and after every fourth sample was tested, all the remaining samples were re-mixed for one minute. Two of the sub-samples from each site were quartered (from positions 1 and 9, and one from Hooggelegen position 2 instead of position 1), while the rest were grab samples. Possible sources of error include the fact that the distilled water used for the .01M $CaCl_2$ solution had a pH of 9-10, and the $CaCl_2$ solution was not made with analytical grade precision. However, for the purposes of these analyses, these methods were considered acceptable because $CaCl_2$ acts as a buffer, and the solution was made in 1L quantities, so error was minimized. Also, although pH was measured directly after the mixing process according to the methodology set out by Smith and Atkinson, it was noted that pH changed after the mixture was allowed to sit for a period of time.

Particle size analysis was conducted by both wet sieving and dry sieving. Both techniques involve filtering soil through a stack of sieves. The uppermost sieve has the largest openings, and the mesh aperture size gets successively smaller in each sieve lower in the stack.

φ value	**aperture measurement**
-2	4mm
-1	2mm
0	1mm
1	500μm
2	250μm
3	125μm
4	63μm
Grain-size Classification	
more than -2φ	pebble (or cobble or boulder)
-2φ to -1φ	granule
-1φ to 0φ	very coarse sand
0φ to 1φ	coarse sand
1φ to 2φ	medium sand
2φ to 3φ	fine sand
3φ to 4φ	very fine sand
less than 4φ	silt or clay

Table 1. Adapted from Sengupta, 1994: p. 21.

-2, -1, 0, 1, 2, 3 and 4φ sieves were used for wet sieving, and all but the 4φ sieve (due to the sensitivity of the 4φ mesh) were used for dry sieving. The φ scale is a log base 2 scale that relates to the aperture measurement of the sieve. Table 1 shows the equivalent aperture measurement for each φ value, and the grain-size classification for each φ range.

Two quartered sub-samples from each site were analyzed for particle size composition. The sub-samples were taken from grid positions 1 and 9 from each site, as these samples were as far apart as possible. However, due to error in wet-sieving the first sample, the entire sample from position 1 at De Grendel was lost, and a sub-sample from position 2 was used instead. Also, the bag containing the sample from position 1 at Hooggelegen had a hole in it, so a sub-sample from position 2 at Hooggelegen was also used instead.

The first sample from each site was loosely broken up with a mortar and pestle (in order to prevent particles from sticking together in the presence of water) and washed through the stack of sieves. The second sample from each site was dried overnight at 105ºC, and then mechanically shaken through the stack of sieves for five minutes. After the wet-sieving, the contents in each sieve were dried overnight at 105ºC, and weighed the next morning. Dry sieve contents were weighed immediately after sorting. The finest material was then washed through a 4φ sieve, dried overnight, and re-weighed. In both cases, particles with a radius of less than 63µm (the aperture of the 4φ sieve) were washed down the drain. However, in the case of the dry sieved samples, the weight of this material could be determined because the original dry weight of the material washed through the 4φ sieve was known.

One possible source of error in the particle size analysis, common to all sieve analyses, is that of fine particles remaining stuck to coarser particles, or to the walls of sieves, and not making it through to the proper sieve. Old, perhaps damaged, sieves are another possible source of error, as is non-uniform loosening of soil with the mortar and pestle (for wet sieving).

RESULTS

Site information: observations and information from farm owners/managers.

A preliminary understanding of the nature of the sites is important to have when considering the results of the laboratory soil analyses.

De Grendel. We took samples from De Grendel on a grape field with a slope angle between 5 and 15º. The slope faced southwest. The soil was a light orange-brown color, and had recently been plowed.

Two locations visited on the De Grendel property showed exposed soil horizons. The first location was down-slope from the grape fields, where the ground was relatively flat. The soil visibly had a higher sand content than the soil that the grapes were grown in, although it was similar in color. The exposed soil was generally darker near the surface (in the O horizon), and showed no structure anywhere. Many angular clasts were included in the matrix.

A much larger soil profile was exposed farther up the hill, but still down-slope from the grape fields. The uppermost horizon below the O horizon was similar to that at the first location. The next horizon down was grey and lacked clasts, while the horizon just below it was again more of an orange color, and had a hummocky texture. Below this horizon was a red-brown unconsolidated layer. The lowermost exposed horizon had prismatic structure, was almost completely lithified, and included orange, red and yellow colors. Ferricretes (iron hardpans) were also exposed at this location. Soil forms at the farm were, on the basis of observations as well as map interpretation (Lambrechts, 1998), most likely Glenrosa and Swartland (see MacVicar et al., 1977, for a more detailed discussion of these forms).

The De Grendel farm currently devotes 110ha of land to viticulture. The fields have been used for grape production for 4 years (de Flahming, 2004). Nitrogen fertilizer (19 kg/ha) and chlorpyrifos are applied to the grape fields (de Flahming, 2004). Chlorpyrifos are organophosphorus insecticides, which have potentially dangerous or lethal side effects, but only if a person is exposed to them in extreme amounts (ATSDR, 1998). Four years ago, dieldrin was used as a pesticide on the farm. Dieldrin was banned partially by the U.S. Environmental Protection Agency in 1974 and completely in 1987 because it is severely hazardous to health (ATSDR, 2002).

Grape fields at De Grendel are irrigated with a drip irrigation system. $42m^3$ of water per hectare per year is supplied by this irrigation system (de Flahming, 2004).

Several erosion control measures are taken at De Grendel. The manager of the farm (J. de Flahming) explained that native vegetation is left on steep slopes as an erosion control measure. Other erosion control measures include windbreaks in the form of planted trees, and culverts, which empty excess runoff into sand at the bottom of the hill. Also, there is a gully on the property, which the farm workers are currently filling with cleared alien tree brush in order to prevent further erosion damage.

The Tygerberg Nature Reserve. The samples from the Tygerberg Nature Reserve were taken from an area of native Renosterveld vegetation, with a slope angle between 0 and 10º. The slope faced south. The soil was darker and less red than the soil at De Grendel, and appeared to include more stones and other large particles.

There were no locations at the nature reserve where exposed soil horizons were visible. However, some of the uppermost soil was exposed (generally about 50cm) along paths and roads in the reserve. The soil was an orange-gray color, and appeared to be slightly more clay-rich than the soil at De Grendel, but no structure was visible anywhere. Clasts in the soil were generally angular, and of quartzitic or shale-derived mineralogy.

Hooggelegen. Soil samples were taken from a field of 13-year-old grapes with a 0-10º slope. The slope faced southeast. The soil had a markedly red color, and had recently been plowed.

Soil horizons were exposed to some extent in a road-cut behind the farmhouse. The top horizon (below the O horizon) had an orange color and hard surface that appeared to be weathering features. Behind the outside covering the soil was more gray and unconsolidated. Some shale clasts were present in this horizon. The lower horizon was very dark brown, and much more clay rich. On the basis of these observations and map interpretation (Lambrechts, 1998), the soil form was most likely Swartland (for a more detailed description of this form, see MacVicar et al., 1977).

Sixty-four ha at Hooggelegen are used for viticulture. The grape fields are not irrigated, but the owner (R. de Wit) plans to install a drip irrigation system in the near future. The owner also indicated that erosion is not a major problem, but tiers are used as a preventative measure.

Fertilizers (lime and phosphate) are only applied to grape fields at Hooggelegen when replanting occurs. Pesticides are applied from September to January. These include mancozeb and copper sulfate. Mancozeb is a fungicide, and is not acutely toxic, but is listed as a carcinogen as well as a developmental or reproductive toxin (Orme and Kegley, 2004). Copper sulfate is a pesticide which is classified as moderately hazardous by the World Health Organization. Inhalation of copper sulfate can have mild adverse reactions, such as cough and sore-throat (Orme and Kegley, 2004).

Grasrug. We collected samples from Grasrug on a freshly plowed east-facing wheat field with a slope angle between 0 and 10º. The soil at Grasrug was markedly different than the soil at the other sites. The mineralogy of almost all the clasts and smaller particles in the soil was quartzitic rather than shale-derived (shale mineralogy was common to the other sites). A gully on the property had large chunks of both shale and granite in it. The soil was pallid gray, and had recently been plowed. The soil was also noticeably drier than the soil at the other sites. No exposed soil horizons were found at the site.

Grasrug devotes 380-400ha a year to wheat cultivation. Fertilizers that the owner of Grasrug (M. Smuts) plans to use this year are urea, mono-ammonuimphosphate, and ammonium sulfate. These nitrogen fertilizers are currently applied in the amount of 110-120 kg/ha. Dimeto, a pesticide, is applied in the amount of 500 ml/ha. Dimeto, or dimethoate, is rated by the World Health Organization to be highly or extremely hazardous, and is listed by the Pesticide Action Network as a cholinesterase inhibitor, a reproductive/developmental toxin, and a possible carcinogen (Orme & Kegley, 2004). Up to 18 different herbicides are also applied to the wheat fields (Smuts, 2004).

Moisture content analysis.

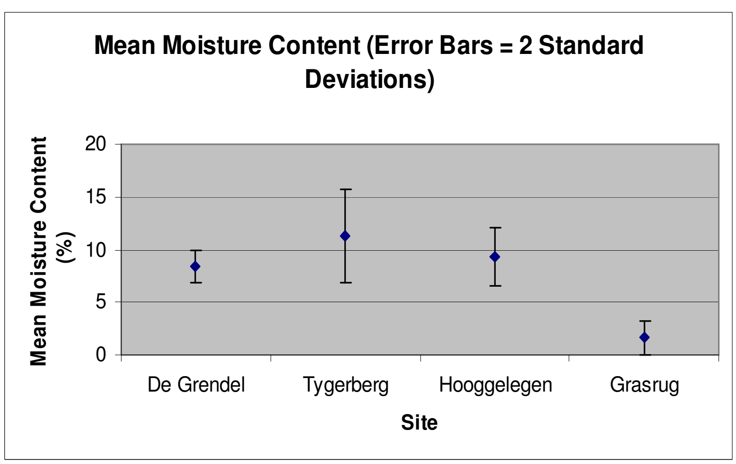


Figure 1.

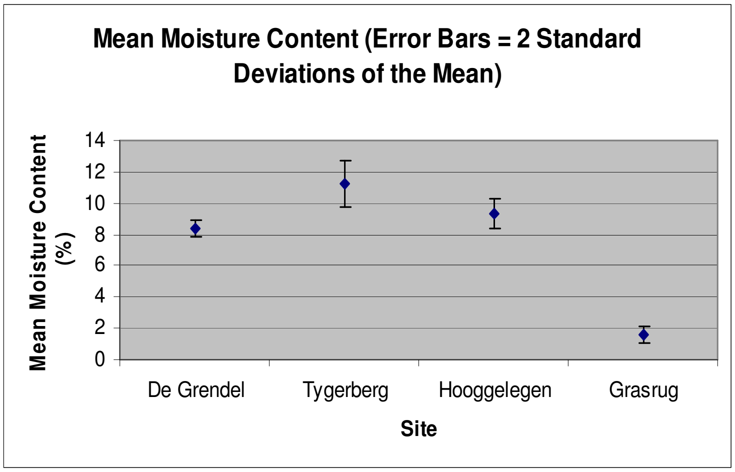


Figure 2.

Figure 1 shows the mean moisture content for each site, and the range within which 95% of the samples taken lie. Figure 2 also shows the mean moisture content for each site, and it shows the range in which the true value of the moisture content lies, with 95% confidence. While the data collected for De Grendel and the Tygerberg Nature Reserve has been presented, it rained within the 24 hours prior to taking the soil samples at these sites, and therefore the numbers should be disregarded (Williams, 1987: p.60). The numbers presented for Hooggelegen and Grasrug can be considered representative. It is clear that there was more moisture in the soil at Hooggelegen than in the soil at Grasrug. Exact values are provided in the appendix (tables A-E).

Organic Content Analysis.

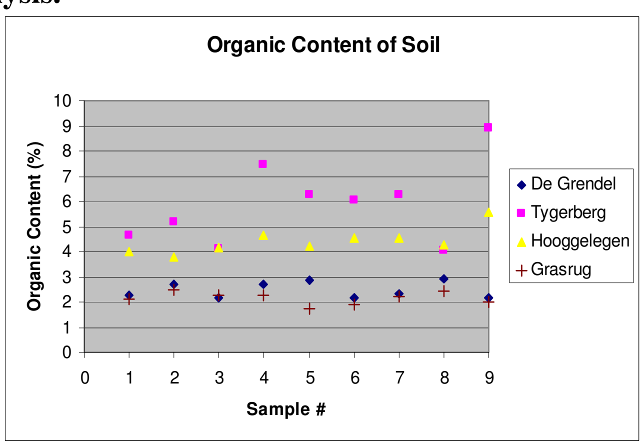


Figure 3.

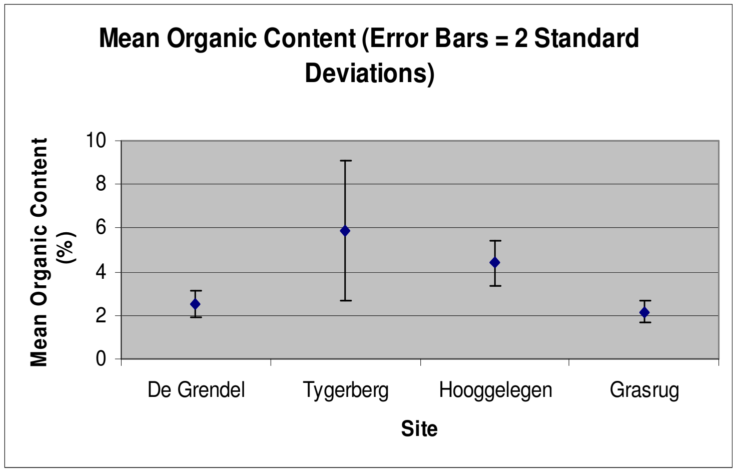


Figure 4.

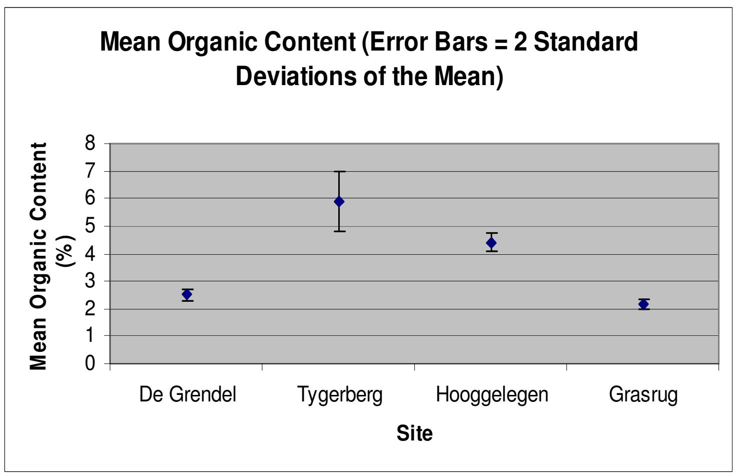


Figure 5.

Figures 3-5 show the results of the organic content analysis. Figure 3 shows the individual measurements for each sample from each site. There is one hole in the data where the sample was spilled before re-weighing. Figure 4 shows, for each site, the mean of the organic content and the range within which 95% of the measurements fall. Given this range, De Grendel and Grasrug both have less organic content than Hooggelegen, but no other conclusions can be drawn. Figure 5 is the same as figure 4, but the range shown by the error bars is the range in which the true value of organic content for each site lies, with 95% confidence. The graph shows that there is a 95% probability that the organic content at each site is distinct from every other site, except for Grasrug and De Grendel, which overlap slightly (over an interval of .02%).

The soils at Grasrug and De Grendel have the least organic content, while the soil at the Tygerberg has the most. Exact values are shown in the appendix (tables A-E).

Organic Content (%)

Sample #	Quartered	Not Quartered	Difference
DG1	1.96	2.27	0.31
DG9	2.02	2.16	0.15
TYG1	5.30	4.67	-0.63
TYG9	9.04	8.94	-0.10
HG2	4.17	3.78	-0.38
HG9	4.14	5.57	1.43
GR1	1.98	2.11	0.13
GR9	2.05	2.02	-0.03

Table 2.

Table 2 shows the difference between the results of the quartered and non-quartered sub-samples. The difference between two values for the same sample is generally low. Also, quartered samples do not tend to show systematically either higher or lower values than non-quartered samples.

pH analysis.

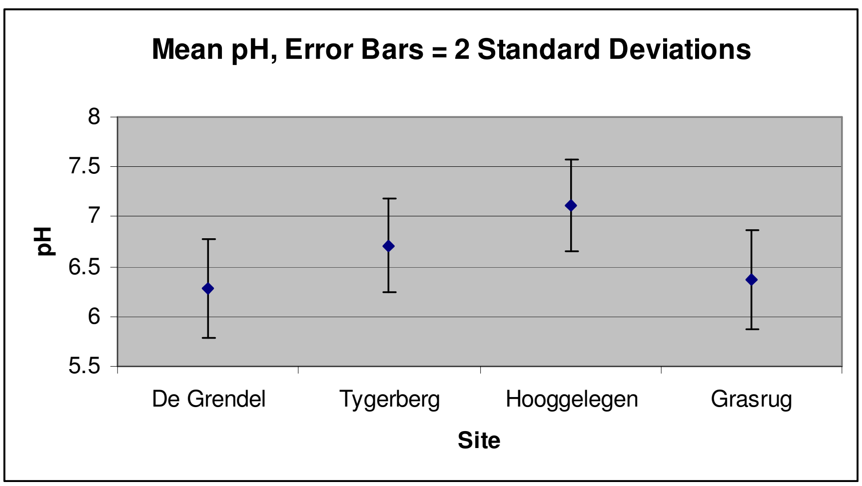


Figure 6.

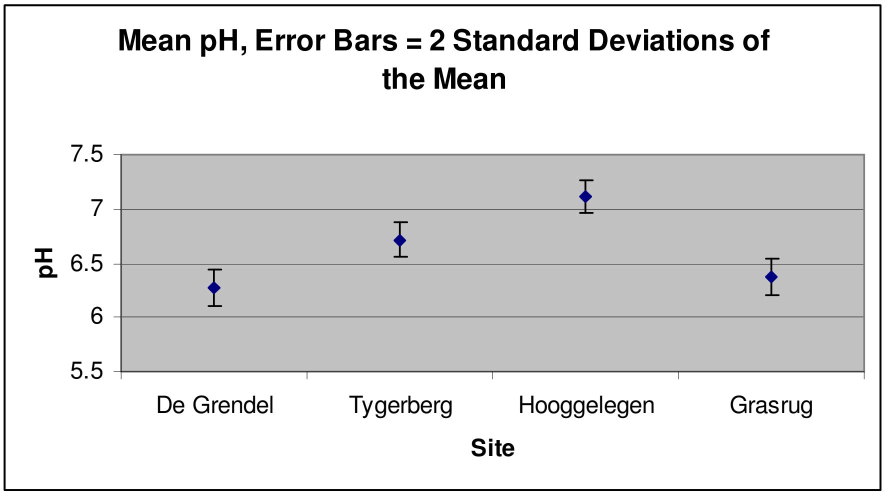


Figure 7.

Figure 6 shows the mean pH value at each site, and the range within which 95% of the measurements lie. Figure 7 shows the mean pH value at each site, and the range within which the true value for each site lies, with 95% confidence. Given the results shown in figure 7, the soil at Hooggelegen has the highest pH, followed by the soil at the Tygerberg, followed by the soils at De Grendel and Grasrug, between which there is no qualitative difference. Exact values are provided in the appendix (table F).

Particle size analysis.

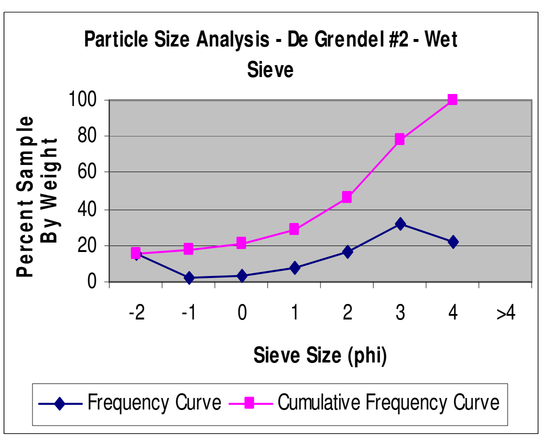


Figure 8.

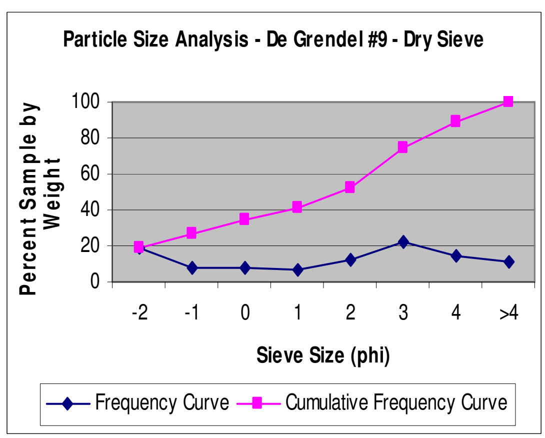


Figure 9.

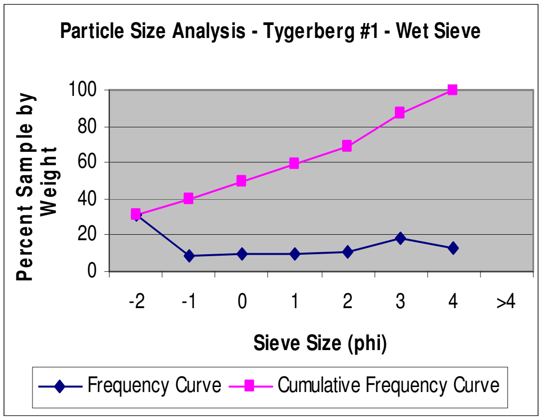


Figure 10.

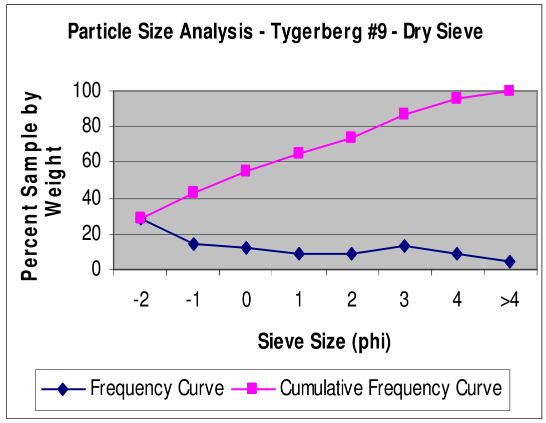


Figure 11.

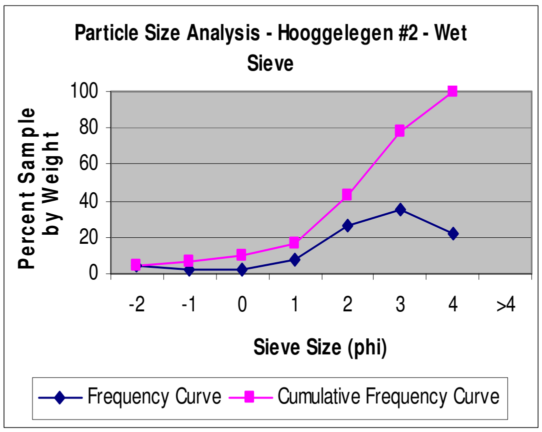


Figure 12.

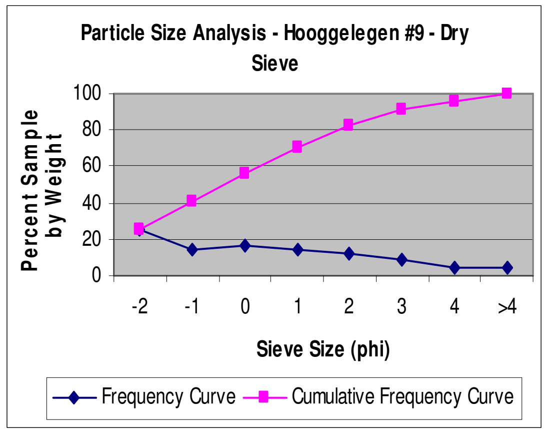


Figure 13.

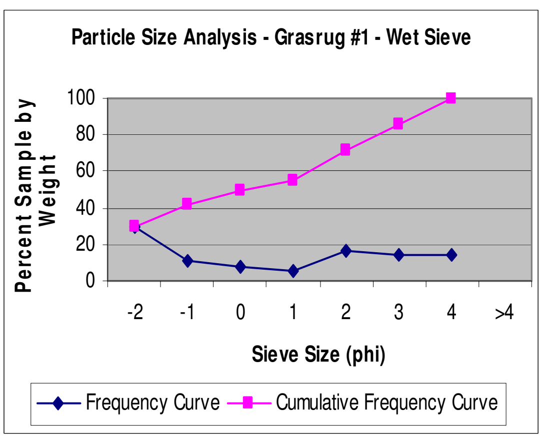


Figure 14.

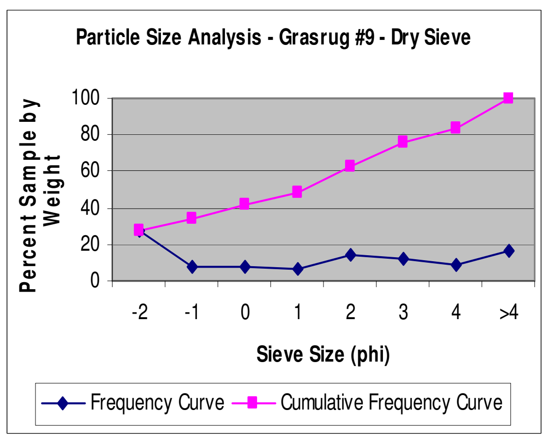


Figure 15.

Figures 8-15 show the results of the sieve analyses. Qualitatively, the De Grendel, Tygerberg, and Hooggelegen frequency curves look similar. They all show a spike in material in the 3φ sieve (the fine sand) except for the dry-sieved sample from Hooggelegen position 9, which actually looks quite dissimilar from the rest. The dry sieving results show that the soil from Grasrug has the highest silt and clay content. For both the wet sieve and the dry sieve tests, the Tygerberg Nature Reserve shows the highest proportion (by weight) of particles of pebble size or larger. However, the proportion of large particles found in the Grasrug soil is extremely similar to that of the Tygerberg soil. Exact values are shown in the appendix (Tables H and G).

DISCUSSION

Laboratory analyses of different samples from the same site generally yielded similar results. However, in general, the data collected on the samples from the Tygerberg Nature Reserve had a wider range of values. This indicates that at the reserve, within a small area, a more variable and patchy environment exists than at other sites.

Although some quantitative values have been determined in the laboratory, it is important to keep in mind that this is a qualitative study. It is a preliminary study and there are many uncontrolled variables. For example, slope azimuth was different at the various sites, different pesticides and fertilizers are used on each of the farms, the soil at Grasrug is different mineralogically from the other soils, and slope angle varies by site. Also, if truly representative rather than qualitative information was desired from each site, than samples would need to be taken over a much larger area. Therefore, comparisons drawn between sampled soils are primarily useful for providing a framework for future studies, and for providing an idea about what the potential land-use implications of the different sites might be.

One of the most obvious environmental concerns related to agricultural usage of land is with the use of pesticides. All three farms use pesticides (as well as fertilizers), but they have varying toxicity and the severity of associated hazards also varies. However, no ill effects are associated with native renosterveld vegetation, and pesticide use must be considered a drawback to agricultural land-use.

Another possible drawback of agricultural land-use is loss of organic matter. Organic matter is one of the most important components of soil. It provides important nutrients for plants, and is often composed of a gelatinous substance that helps bind soil particles together. Cultivation of land causes a loss of vegetation cover, and thus the temperature of the soil is increased. This speeds up the rate of decay of organic matter, as does plowing (Talbot, 1947: p.12). Therefore, organic matter can be depleted rapidly within the first few years of cultivation. While fertilizers can replace soil nutrients to some extent, the gelatinous colloids are lost with the original organic matter (Talbot, 1947: p.13).

Often, as a result of a decrease in organic matter associated with cultivation, unbound fine particles are lost to wind and sheet erosion. Also, permeability, and thus aeration of the soil, can decrease because the soil particles act individually, and the fine particles migrate into pore spaces instead of sticking to other soil particles (Talbot, 1947: pp.10-11). This study shows that the samples from the Tygerberg Nature Reserve had the highest proportion of organic matter. The soil samples from Hooggelegen had an organic matter content close to that of the Tygerberg, and the samples from Grasrug and De Grendel had a relatively low proportion of organic matter. It is likely that, as our analysis suggests, soil associated with native vegetation has more organic content than cultivated soil. However, the difference between soils used for grape cultivation and soils used for grain cultivation is not clear. The presence of fertilizers is likely to effect measurements of organic content. Future study is recommended.

Organic content also plays an important role in moisture retention. Humus, or organically decomposed material, can retain up to four times its dry weight in water (Ellis and

Mellor, 1995: pp.207-208). Therefore, we expected that soils with more organic content would likely also have more moisture content. Unfortunately, only the results from Hooggelegen and Grasrug can be considered relevant in terms of moisture content. The samples from Hooggelegen did have both a higher organic matter and moisture content than the samples from Grasrug, as was expected.

Organic matter content is also related to pH. pH is a logarithmic scale for the representation of hydrogen-ion concentration. Soils with a high proportion of organic material have a higher buffering capacity than other soils, and thus generally have a pH that tends more towards neutral (Winegardner, 1996: pp.180). Standard pH values for soil range from approximately 5.5 to 8 (Winegardner, 1996: p.180). The pH values measured for the soils in this study were all close to neutral, and there was little variation between the sites. Thus, because pH seems to be relatively constant in soils in the area, it may be a variable that can be relatively controlled in future studies.

Particle size analyses were the last laboratory measurements conducted. Because low organic content is sometimes associated with increased wind and sheet erosion, we expected that Grasrug and De Grendel would have less fine material than the other sites. Interestingly enough, the soil at Grasrug actually had the highest proportion of silt and clay out of all the sites, and the soil at De Grendel had the second highest proportion (based on the dry sieve analyses).

Because some of the soils sampled had similar particle size breakdowns, particle size analysis could potentially be used to determine suitable sites for comparison. Then, after sites with soils of relatively similar particle size compositions have been chosen, other variables can be focused on.

Soil erosion was not considered in depth in this study as required field work would have taken more time than we had, as well as technical instruments (though aerial photograph interpretation has been a successful analysis tool in the past – see Talbot, 1947). However, land use change does have potential implications for soils in terms of erosion, and an exploration of erosion at various sites could be beneficial to future studies.

CONCLUSION

The results of this study can provide a preliminary basis for future work. When assessing different land use types and how they relate to soil, we recommend that variables such as organic content and moisture content are focused upon, while variables such as pH and particle size distribution are controlled to some extent, and used in site selection. Thus, future work should include preliminary site investigations in order to determine the best sampling locations. Also, if possible, slope angles and slope azimuths at various sites should be approximately the same in future studies. Soil mineralogy should also be similar. Therefore, while Grasrug provided interesting data for this study, a site of wheat cultivation closer to the Tygerberg Nature Reserve would be more desirable for future work. We also recommend that if adequate time exists, a larger area at each site should be sampled. In addition, other aspects of soils could be investigated, such as erosion rates, or chemical compositions (for example, the nitrogen, phosphorus or potassium content of various soils would be interesting to explore).

While many improvements and expansions can be made on this preliminary study, it has provided a good qualitative comparison of four different land-uses: nature reserve, cultivation of fairly young grape vines, cultivation of fairly old grape vines, and cultivation of wheat. The characteristics of each site are unique, and there are many uncontrolled variables, but future work will benefit from this preliminary analysis.

REFERENCES

Agency for Toxic Substances and Disease Registry, United States Department of Health and Human Services. (1998) Public Health Statement for Chlorpyrifos. [Internet] Atlanta, United States Department of Health and Human Services. Available from: <http://www.atsdr.cdc.gov/toxprofiles/phs84.html> [Accessed 24 May, 2004]

Agency for Toxic Substances and Disease Registry, United States Department of Health and Human Services. (2002) ToxFAQs™ for Aldrin/Dieldrin. [Internet] Atlanta, United States Department of Health and Human Services. Available from: <http://www.atsdr.cdc.gov/tfacts1.html> [Accessed 24 May, 2005]

de Flahming, J. (30 April, 2004) Personal Interview.

de Wit, R. (24 May, 2004) Personal Interview.

Ellis, S. and Mellor, A. (1995) Soils and Environment. London and New York, Routledge.

Lambrechts, J.J.N. (1983) Soil, Soil Processes and Soil Distribution in the Fynbos Region: An Introduction. IN: Deacon, H.J. Hendey, Q.B. and Lambrechts, J.J.N. eds. Fynbos palaeoecology: A preliminary synthesis. Cape Town, Mills Litho

Lambrechts, J.J.N. (1998) Soils of the Tygerberg Region. IN: Du Pessis, N.M. ed. The Tygerberg: The story of the Tygerberg Hill and the towns of Parow, Bellville and Durbanville. Cape Town, Tafelberg Publishers Limited.

MacVicar, C.N. et al. (1977) Soil classification: a binomial system for South Africa. Pretoria, Department of Agricultural Technical Services.

McDowell, C.R. (1988) Factors affecting the conservation of Renosterveld by private landowners. Ph.D. thesis, University of Cape Town.

Orme, S. and Kegley, S. (2004) PAN Pesticide Database: Basic Chemical Information for Dimethoate. [Internet] San Francisco, Pesticide Action Network. Available from: <http://www.pesticideinfo.org> [Accessed on 24-26 May, 2004]

Rahlao, S. (2003) Land use changes and their effect on the extent and rates of soil erosion in the Tygerberg, Western Cape Province, South Africa-1938-2000: A re-evaluation. Unpublished honours thesis, University of Cape Town.

Schloms, B.H.A. Ellis, F. and Lambrechts, J.J.N. (1983) Soils of the Cape Coastal Platform. IN: Deacon, H.J. Hendey, Q.B. and Lambrechts, J.J.N. eds. Fynbos palaeoecology: A preliminary synthesis. Cape Town, Mills Litho.

Sengupta, S. (1994) Introduction to Sedimentology. Brookfield, VT, A.A. Balkema Publishers.

Smith, R.T. and Atkinson, K. (1975) Techniques in Pedology: A handbook for environmental and resource studies. London, Elek Science.

Smuts, M. (8 May, 2004) Personal Interview.

Talbot, W.J. (1947) Swartland and Sandveld: A Survey of Land Utilization and Soil Erosion in the Western Lowland of the Cape Province. Cape Town, Geoffrey Cumberlege, Oxford University Press.

Williams, G. (1987) Techniques and Fieldwork in Ecology. London, Bell & Hyman Limited.

Winegardner, D.L. (1995) An Introduction to Soils for Environmental Professionals. Boston, Lewis Publishers, CRC Press, Inc.

APPENDIX TO SECTION V.

DE GRENDEL

Sample #	Moisture Content (%)	Organic Content (%)
1	7.32	2.27
2	9.60	2.72
3	No Data	2.15
4	8.51	2.73
5	8.25	2.86
6	7.97	2.18
7	9.19	2.32
8	8.30	2.92
9	7.60	2.16
1 (day 2)	7.35	No Data
1, quartered	7.15	1.96
9, quartered	6.57	2.02

Table A.

TYGERBERG

Sample #	Moisture Content (%)	Organic Content (%)
1	11.17	4.67
2	8.94	5.18
3	11.56	4.10
4	10.78	7.47
5	10.27	6.26
6	10.96	6.03
7	13.91	6.27
8	8.49	4.03
9	15.45	8.94
1 (day 2)	11.71	No Data
1, quartered	11.14	5.30
9, quartered	14.21	9.04

Table B.

HOOGGELEGEN

Sample #	Moisture Content (%)	Organic Content (%)
1	No Data	4.00
2	8.60	3.78
3	10.50	4.16
4	10.02	4.67
5	No Data	4.21
6	7.89	4.53
7	9.15	4.55
8	No Data	4.27
9	11.69	5.57

2, quartered	8.49	4.17
9, quartered	9.77	4.14

Table C.

GRASRUG

Sample #	Moisture Content (%)	Organic Content (%)
1	0.92	2.11
2	2.31	2.50
3	3.08	2.27
4	1.21	2.26
5	0.46	1.72
6	1.35	1.88
7	1.33	2.20
8	1.37	2.45
9	2.45	2.02
1, quartered	0.65	1.98
9, quartered	1.85	2.05

Table D.

Moisture Content

Site	Mean (%)	1 Stand. Dev.	2 S.D.	1 S.D. of the mean	2 S.D. of the mean
De Grendel	8.34	0.76	1.53	0.27	0.54
Tygerberg	11.28	2.21	4.42	0.74	1.47
Hooggelegen	9.34	1.37	2.73	0.46	0.91
Grasrug	1.61	0.83	1.66	0.28	0.55

Organic Content

Site	Mean (%)	1 Stand. Dev.	2 S.D.	1 S.D. of the mean	2 S.D. of the mean
De Grendel	2.52	0.32	0.64	0.11	0.21
Tygerberg	5.88	1.61	3.22	0.54	1.07
Hooggelegen	4.42	0.51	1.03	0.17	0.34
Grasrug	2.16	0.26	0.51	0.09	0.17

Table E.

pH Measurements by Site

Sample #	De Grendel	Tygerberg	Hooggelegen	Grasrug
1, quartered	6.00	7.18	6.97	6.60
2	6.06	6.95	6.76	6.14
3	6.18	6.60	7.15	6.76
4	6.24	6.89	6.93	6.58
5	6.80	6.62	7.36	6.01
6	6.49	6.52	7.12	6.30
7	6.10	6.56	7.25	6.17
8	6.37	6.59	7.49	6.45

9, quartered	6.26	6.51	6.97	6.32

Table F.

	Wet-Sieving Results: % by Weight			
Sieve Size (φ)	De Grendel #2	Tygerberg #1	Hooggelegen #2	Grasrug #1
-2	15.88	31.43	31.43	30.05
-1	1.66	8.33	8.33	11.49
0	3.76	10.02	10.02	7.56
1	7.75	9.27	9.27	5.77
2	16.74	10.24	10.24	16.60
3	32.26	17.79	17.79	14.35
4	21.97	12.92	12.92	14.17

Table G.

	Dry-Sieving Results: % by Weight			
Sieve Size (φ)	De Grendel #9	Tygerberg #9	Hooggelegen #9	Grasrug #9
-2	19.15	28.16	25.52	27.21
-1	7.75	14.74	14.67	7.26
0	7.32	12.32	16.26	7.50
1	6.50	9.34	13.92	6.83
2	11.82	9.29	12.30	14.37
3	22.36	12.85	8.96	12.32
4	14.33	9.04	3.92	8.30
>4	10.75	4.26	4.46	16.21

Table H.

VI.
Creatures Great & Small:
Two Biodiversity Perspectives on the Recent Trend from Grain to Grape

~C. Fiske & K. McAlister~

1.
A PREFACE TO THE BIODIVERSITY SECTIONS OF THE REPORT
~C. Fiske & K. McAlister~

Conservation has often been interpreted strictly as the preservation of "natural" areas. Consequently, any human modification of the landscape has been interpreted as antithetical to conservation goals. However, alternative perspectives have begun to surface in recent years in both scientific and agricultural communities. Studies of the interactions between agriculture and local flora and fauna have revealed that these interactions can be mutually beneficial, detrimental or anything in between. Interest in understanding the variables affecting agroecosystems has risen as a result of these findings, and the importance of such an understanding is increasingly apparent as the face of global agriculture continues to change and landscapes in many parts of the world come under increasing pressure from agriculturalists. It is now clear that the environmental movement may ignore agroecosystems only at its own peril.

It is from this perspective that we approach the study of biodiversity as it relates to agriculture in the Swartland, South Africa. The Swartland is an agricultural region originally occupied primarily by renosterveld, a habitat type within the Cape Floristic Region (CFR) characterised by shrubs such as renosterbos (*Elytropappus rhinocerotis*) as well as geophytes and grasses (Kemper et al., 2000). Renosterveld is generally found on moderately fertile soils derived from shales, as opposed to the regionally dominant fynbos habitat which is associated with less fertile soils (Kemper et al., 2000).

The relatively high fertility of renosterveld soils helps to explain its high degree of transformation to agriculture. It has been estimated that, today, 82.56% of coastal renosterveld has been transformed by human activities, while nearly 90% of the Swartland subhabitat has been transformed, mostly for agricultural purposes (Rouget et al., 2003). Agriculture in the former renosterveld consists mostly of grain cultivation (mostly wheat), livestock husbandry and viticulture (see section II of this report).

Site Descriptions

As discussed previously in this report, we visited four sites: De Grendel, Hooggelegen, Grasrug and the Tygerberg Nature Reserve (henceforth "Tygerberg"). De Grendel is an agriculturally diversified farm estate which is in the process of converting much of its land area to viticulture. The area we sampled was occupied by 4-year-old vines and bordered on a substantial renosterveld fragment, as well as other vines, cattle pasture, and built structures. The vines are seasonally treated with an organophosphate pesticide and 19kg/ha/yr of a nitrogen-based fertiliser (de Flamingh, pers. comm.). Irrigation of vines amounts to 42m^3/ha/yr. At the time of sampling, grapes had been recently harvested, although some remained on the vines. Weather over the sampling period ranged from overcast with light rain to clear.

Hooggelegen is an agriculturally diversified farm estate with a long history of viticulture. Livestock husbandry, mostly sheep, is also practiced. The area we sampled was occupied by 14-year-old vines and bordered on other vines and sheep pasture. The vines are treated with copper sulphite and other pesticides during the summer (September through January), but the soil is only fertilised (with lime and phophate) at times of deplanting and replanting (de Wit, pers. comm.). The vines are not irrigated. At the time of sampling, grapes had been recently harvested, although some remained on the vines. Weather was clear and warm over the avifauna sampling period but may have included heavy rain during the invertebrate sampling period.

Grasrug is a farm devoted primarily to wheat on a 4 to 5 year rotation with lupin, although it devotes a small portion of its area to livestock pasture and canola. The area we sampled was a wheat field bordered by other wheat fields, both fallow and active. Fallow fields were in use as sheep pasture. Fields are treated with a majority of nitrogen-based fertilisers and a minority of phosphorous-based fertilisers, as well as with an organophosphate pesticide at 500mL/ha/yr and various herbicides (Smuts, pers. comm.). Wheat fields at Grasrug are not irrigated. At the time of sampling, the fields had been ploughed but not yet planted, and the only visible vegetation consisted of very young, sparsely distributed grass shoots. The weather during the sampling period ranged from overcast with light rain to clear conditions.

Tygerberg is a nature reserve comprising a significant amount of remnant native West Coast Renosterveld, along with some non-native pines and herbaceous species. The reserve is located on the slopes and crest of a hill of the same name. It is bordered on most sides by suburbs of Cape Town. Sampling was conducted on and near the crest of the hill at the southern end of the reserve in an area mostly covered with renosterveld but also containing some built structures and grassy areas. Weather during the sampling period was mostly clear.

Discussion of Results

The invertebrate study used the Shannon-Wiener diversity index, species richness, specimens per trap, and taxon richness to characterise the invertebrate communities at our study sites. Few significant differences were detected among the three farm sites, although the indices generally suggested a decline in diversity and abundance from the vineyards to the wheat-field. As expected, the invertebrate community at Tygerberg was found to be much more abundant and diverse, usually to a significant degree.

The bird study characterized the avian communities using the Shannon-Wiener index, species richness, number of individuals, Berger-Parker dominance index, and number of species not observed at other sites. No differences were found between sites in abundance. Among farm sites, richness and evenness measurements tended to indicate that the wheat farm was more diverse than the vineyards, although this was only significant for species richness between Grasrug and Hooggelegen. The vineyards had a marked tendency to be dominated by a single species, and possessed fewer species not found at other sites. As expected, Tygerberg surpassed all the agricultural sites in both species richness and Shannon-Wiener index.

There are a number of possible explanations for the difference in trends observed for invertebrate diversity and avian diversity. Foremost among these are weaknesses in the methodologies employed. For example, the transect method employed to measure avian diversity is much better suited to open areas such as the unplanted wheat fields at Grasrug than to vegetation which limits visibility, as is the case at the vineyards. Thus the avian diversity at the vineyards may have been underestimated by our sampling technique. The relatively small sample sizes used may have exacerbated this problem.

Another important variable is the difference between active and fallow fields at Grasrug. The latter were unploughed and occupied by sheep, two factors which could have significant impacts on both invertebrate and avian communities. For example, input of manure onto farmland has been shown to significantly increase the abundance of some bird species which feed on invertebrate decomposers (Tucker, 1992). In support of this idea, more birds were observed in fallow fields than in active fields at Grasrug. Additionally, agricultural practices such as ploughing have been shown to decrease invertebrate populations (e.g. Bandyopadhyaya Choudhuri & Ponge, 2002; Ponge et al., 2003). In this context, it is important to note that transects used to sample avian diversity crossed both active and fallow fields, while invertebrate diversity was sampled only in an active field. However, it is very likely that invertebrates, like birds, would have been more abundant and perhaps more diverse in the fallow fields. Thus, the results of the bird sampling may be more representative of the overall habitat provided by a wheat farm than are those from the invertebrate samples.

It is also possible that the varieties of invertebrates sampled by pitfall trapping methods do not overlap significantly with those utilised by local invertebrate-feeding bird species. For example, it is unlikely that the abundant Collembola sampled provide a significant food source for the avian community. If this is the case, alternative concrete reasons to expect our avian and invertebrate population samples to follow similar trends would need to be established. Other invertebrate sampling methods are necessary to determine if the portion of the invertebrate community representing avian food sources mirrors more closely the trends observed in the avian communities.

Avian and invertebrate communities utilise habitats at notably different scales, and our results therefore suggest that structure and resource availability may vary significantly at different scales in an agricultural landscape. When considering an agroecosystem, it is thus important to incorporate the issue of scale in the design of methodologies and the interpretation of results. It is significant that these considerations would not have arisen had we used only one taxonomic group as a bioindicator, as is the usual practice. Despite the complications arising from using two taxonomic groups, however, our results support the general consensus that greater spatial heterogeneity allows for the conservation of greater overall biodiversity in a landscape.

References

Bandyopadhyaya, I., D. K. Choudhuri & J.-F. Ponge. (2002) Effects of some physical factors and agricultural practices on Collembola in a multiple cropping programme in West Bengal (India). European Journal of Soil Biology, 38(1) February, pp.111-117.

de Flamingh, J. Personal communication. 30 April 2004.

de Wit, R. Personal communication. 24 May 2004.

Kemper, J., R. M. Cowling, D. M. Richardson, G. G. Forsyth & D. H. McKelly. (2000) Landscape fragmentation in South Coast Renosterveld, South Africa in relation to rainfall and topography. Austral Ecology, 25, pp.179-186.

Rouget, M., D. M. Richardson, R. M. Cowling, J. W. Lloyd & A. T. Lombard. (2003) Current patterns of habitat transformation and future threats to biodiversity in terrestrial ecosystems in the Cape Floristic Region, South Africa. Biological Conservation, 112, pp.63-85.

Smuts. Personal communication. 8 May 2004.

Tucker, G. M. (1992) Effects of agricultural practices on field use by invertebrate-feeding birds in winter. Journal of Applied Ecology, 29(3), pp.779-790.

2.
THE IMPLICATIONS OF A TREND FROM GRAIN TO GRAPE FOR INVERTEBRATE COMMUNITIES OF THE SWARTLAND
~C. Fiske~

Introduction

Invertebrates are a diverse and ecologically sensitive economic group, and as such are widely considered appropriate bioindicators of ecological change (Büchs, 2003). Since MacArthur and Wilson's (1967) classic treatise on island biogeography heightened conservation concerns over the biodiversity effects of shrinking habitat "islands," invertebrates have especially featured in a large number of studies of the ecological effects of habitat fragmentation (Webb & Hopkins, 1984). Invertebrate diversity in human-influenced and managed landscapes, such as grazed grasslands, has also been a subject of some conservation interest (e.g. DiGiulio Edwards & Meister, 2001; Kruess & Tscharntke, 2002; Gibson Hambler & Brown, 1992). It is perhaps the combination of this interest in the use of invertebrates as bioindicators for conservation and management with the perennial interest in pest control which has resulted in a number of recent invertebrate diversity studies on agroecosystems. Those studies not concerned with pest species have focused mainly on the impact of different horticultural or grazing practices on invertebrate communities (e.g. Benton et al., 2002; DiGiulio Edwards & Meister, 2001; Kruess & Tscharntke, 2002; Gibson Hambler & Brown, 1992) or, occasionally, on invertebrate interactions with vertebrate species (e.g. Benton et al., 2002; Tucker, 1992).

Despite this relatively significant body of research, study of invertebrates in agroecosystems has tended to neglect comparisons of invertebrate communities associated with different crops. It may seem obvious, and therefore uninteresting, that invertebrate communities associated with one crop type will be different from those associated with other crops. However, there are at least two significant arguments for research of this type to go forward.

First, the probable ability or tendency of different crops to support different levels of biodiversity or to favour certain guilds or taxa above others could have a significant impact on population and community dynamics in the kinds of native landscapes fragmented by agriculture, a topic which is already relatively well-studied. That is, the ability of habitat "islands" in agricultural landscapes to support native fauna is almost certainly dependent at least in part upon the crop(s) being cultivated. Thus, comparison of invertebrate communities associated with different crops is important not only to the study of agriculture-dependent species but also to the study of residual native faunas in agriculturally modified landscapes.

A second reason for interest in characterising and comparing invertebrate communities associated with different crops is that new knowledge of non-conflicting or mutually supportive coexistences of agriculture and biotic communities could contribute to the development of crop-specific sustainable management practices in pest control and other areas of agricultural interest.

Thus, a study today of the implications of changing crop regimes over an ecologically sensitive region is in a somewhat unique situation. It is possible at this time to use the invertebrate communities of the relevant agroecosystems to at least partially characterise the ecological impact of the current changes. This characterisation can be supported at a basic level by a growing body of academic and applied research, as noted above. Moreover, the particular use of invertebrate communities as indicators to compare two different crop regimes is not common practice, and even a broad survey can suggest possible directions for further fruitful research. Thus, characterisation of the ecological impacts of ongoing agricultural changes in the Swartland and identification of agroecological issues in need of further study in the region are two of the goals of this section of the report.

A third goal is to add to the limited body of knowledge on insects of the renosterveld. Research on invertebrates in the Cape Floristic Region overall is relatively sparse, the most relevant being a recent literature review which suggests that insect biodiversity in the region is not as high as plant diversity (Giliomee, 2003). As concerns renosterveld more specifically, even a basic characterisation of the macrobiotic community seems to be missing from the literature. The few available studies which do treat renosterveld invertebrates have generally been very limited in scope (e.g. Wright & Samways, 2000; Donaldson et al., 2002). It is hoped that our broad survey work in the region, particularly within the Tygerberg Nature Reserve, may contribute to the available knowledge of the renosterveld invertebrate community.

Methods

This part of the study, as with the others, was conducted in late autumn at the farms De Grendel, Grasrug and Hooggelegen and at the Tygerberg Nature Reserve. Specimens were collected using simple, modified pitfall traps, buried with the lip level with the surface of the soil. Trap openings were approximately 3-4cm in diameter, limiting the size of specimens collected. At each site, nine traps were laid out on a 30m square grid, facing north, with an arbitrary starting point. All traps were placed at least 50m from any field edge in order to limit ecological and other edge effects. Traps were collected 24 hours after their placement.

It has recently become popular to attempt to characterise overall insect or invertebrate diversity by extrapolating from data with high taxonomic resolution within a single taxonomic group (e.g. Andersen et al., 2002). However, such approaches are not well tested, and some data cast doubt on the appropriateness of applying them in all circumstances (Heino et al., 2003). Further, such an approach was considered too narrow in scope for the purposes of the present study. Morphospecies methodologies have been found to produce very good data for terrestrial invertebrates (Pik Oliver & Beattie, 1999) and are a "quick-and-dirty" way for non-experts to collect invertebrate data. For these reasons, a basic morphospecies methodology was used in this study.

Specimens were separated into morphospecies, and specimens within the Classes Insecta and Arachnida were usually identified to Order, although a significant number remain unidentified. Specimens were preserved for possible further taxonomic resolution in the future.

From the morphospecies data, Shannon-Wiener diversity indices and morphospecies richness values were calculated. These were calculated for each site as well as for each trap. The number of specimens per trap was also calculated. When possible, values from different sites were compared using ANOVA and *t*-tests. To provide some additional information, a rougher index of "taxon richness" was also derived, which summed positively identified taxa, usually at the Order level. Relationships between the four indices used were examined using correlation analyses. Finally, taxon compositions of the samples were qualitatively compared. This approach follows the recommendations of Büchs et al. (2003), who suggest that examination of agroecosystems utilise both the Shannon-Wiener index and additional approaches for analysing shifts in species relative dominance positions.

Results

There were no significant differences found in Shannon-Wiener diversity index scores

	Shannon-Wiener Index, St. Dev.	*Morphospecies Richness, St. Dev.*	*Specimens per Trap, St. Dev.*
De Grendel	0.528, 0.128	4.667, 1.500	12.222, 14.948
Hooggelegen	0.669, 0.123	5.111, 1.453	7.111, 3.257
Grasrug	0.561, 0.105	4.222, 1.093	6.556, 1.424
Tygerberg	0.673, 0.229	7.222, 3.492	18.667, 11.969
ANOVA: P-value	**0.119**	**0.024**	**0.045**

Table 1: Average values and standard deviations of the Shannon-Wiener diversity index, morphospecies richness and specimens per trap for the four sites, as well as the P-values resulting from ANOVAs among values of each index at the four sites.

among sites (Table 1). However, morphospecies richness and number of specimens per trap at the Tygerberg Nature Reserve (hereafter "Tygerberg") did differ significantly from those at other sites (Table 1). Specifically, two-sample *t*-tests revealed that the Tygerberg had significantly

Morphospecies Richness					*Specimens per Trap*				
	GR	DG	HG	TY		GR	HG	DG	TY
GR		0	0	*	GR		0	0	*
DG			0	*	HG			0	*
HG				0	DG				0
TY					TY				
* = significant difference (P = 0.05); 0 = no significant difference (P = 0.05)									

Table 2: Differences between morphospecies richness scores and specimens per trap at the four sites based on one-tailed *t*-tests. Sites are arranged from lowest value to highest, left to right and top to bottom. GR = Grasrug, DG = De Grendel, HG = Hooggelegen, TY = Tygerberg.

higher morphospecies richness scores than either of the farms Grasrug or De Grendel and more average specimens per trap than the farms Grasrug and Hooggelegen (Table 2).

Apparent differences between trends in the three indices led to correlation analyses being performed among the indices. All were strongly correlated with the exception of specimens per trap and the Shannon-Wiener index, where the relationship was very weak and not significant (Figures 1-3).

Site	*Whole-Site Shannon-Wiener Index*	*Whole-Site Morphospecies Richness*
De Grendel	0.782	21
Hooggelegen	1.236	25
Grasrug	1.037	18
Tygerberg	1.071	30

Table 3: Shannon-Wiener indices and morphospecies richness values calculated for whole sites from the combined contents of all traps at each site.

Values of the Shannon-Wiener diversity index and morphospecies richness were also calculated for each site as a whole, using total counts of morphospecies from combined trap contents (Table 3). As large amounts of variation among traps in invertebrate diversity and abundance were noticed at some sites, particularly at Tygerberg, correlation analyses were performed between site values and standard deviations for the Shannon-Wiener index and

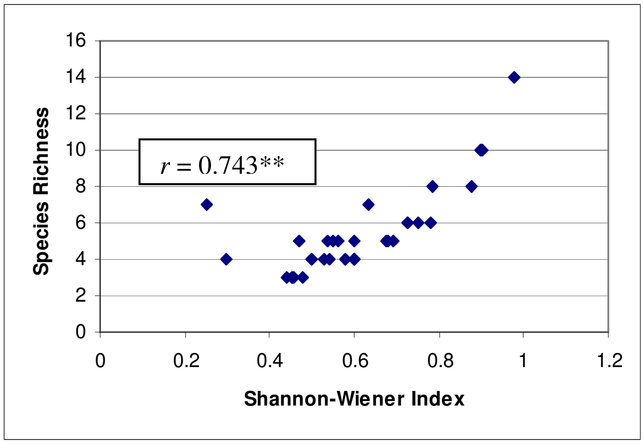


Figure 1: A highly significant (P<0.01) correlation between morphospecies richness values and Shannon-Wiener indices.

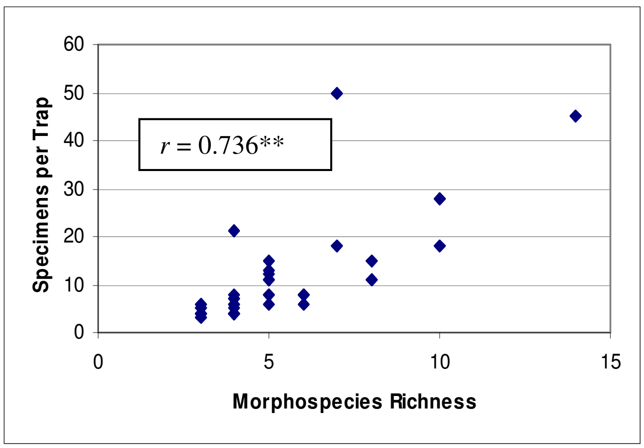


Figure 2: A highly significant (P<0.01) correlation between specimens per trap and morphospecies richness values.

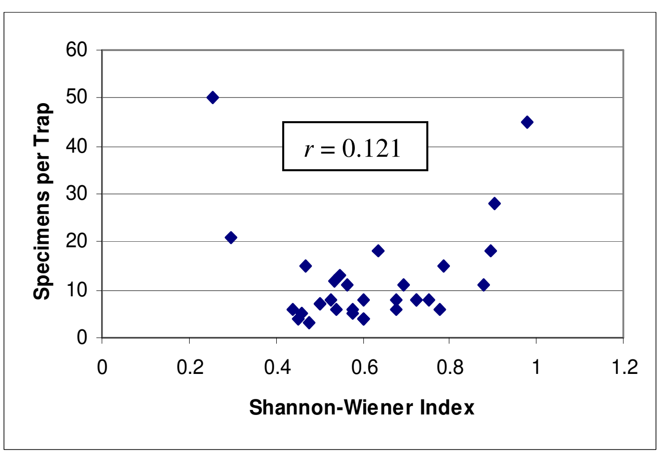


Figure 3: A non-significant correlation between specimens per trap and Shannon-Wiener indices.

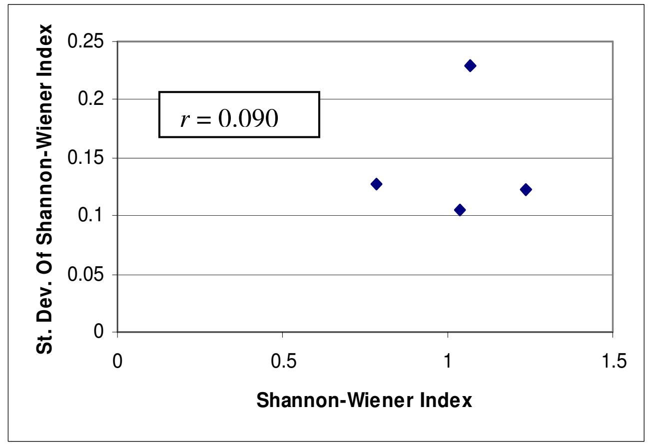


Figure 4: A non-significant correlation between the Shannon-Wiener index and the standard deviation of Shannon-Wiener indices among traps at each site.

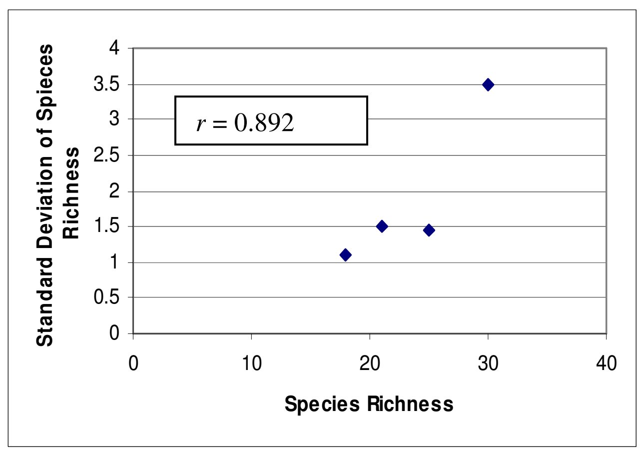


Figure 5: A non-significant but notable correlation between morphospecies richness and the standard deviation of morphospecies richness values among traps at each site.

morphospecies richness (Figures 4, 5). Standard deviations were derived from the within-sites trap results. Neither index was found to have a significant relationship with standard deviation. However, a strong possible correlation between morphospecies richness and standard deviation, which perhaps could have been detected with a larger sample size, was noted (Figure 5).

In an attempt to add more specific taxonomic information, an additional rough index which we labelled "taxon richness" was calculated (Table 4). Each "taxon" was one of the following: an Order within the Classes Insecta or Arachnida; another Class of invertebrate; or an unidentified morphospecies. The reliability of this ad hoc index was supported by a finding of

Average Taxon Richness	*Site*	Grasrug	Hooggelegen	De Grendel	Tygerberg
2.778	Grasrug		0	0	**
3.444	Hooggelegen			0	**
3.444	De Grendel				**
5.556	Tygerberg				
		* = significant difference (P = 0.05); **significant difference (P = 0.01); 0 = no significant difference (P = 0.05)			

Table 4: Average taxon richness per trap and the significance of differences between taxon richness scores for the four sites based on one-tailed *t*-tests.

highly significant correlations with the other three indices already calculated (Figures 6-8). An ANOVA found significant difference among the sites for this index, and further analysis with *t*-tests revealed that the Tygerberg had significantly higher taxon richness values than any of the other sites, but none of the three farms differed significantly from each other (Table 4).

Overall taxon compositions at the four sites were compared using the combined trap contents for each site. Collembolans (springtails) constituted a significant proportion of specimens at each site, dominating specimens collected at De Grendel and contributing between one-fourth and one-half of specimens collected at Hooggelegen and Tygerberg (Figure 9). This is the result of a sampling method which favoured small fauna near the soil surface. Dipterans (flies) were absent at De Grendel and rare at Tygerberg (Figure 9) but contributed the largest

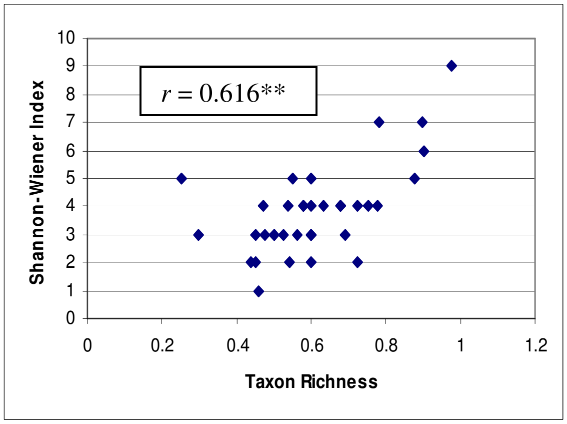


Figure 6: The highly significant (P = 0.01) correlation between taxon richness and the Shannon-Wiener index.

Figure 7: The highly significant (P = 0.01) correlation between taxon richness and morphospecies richness.

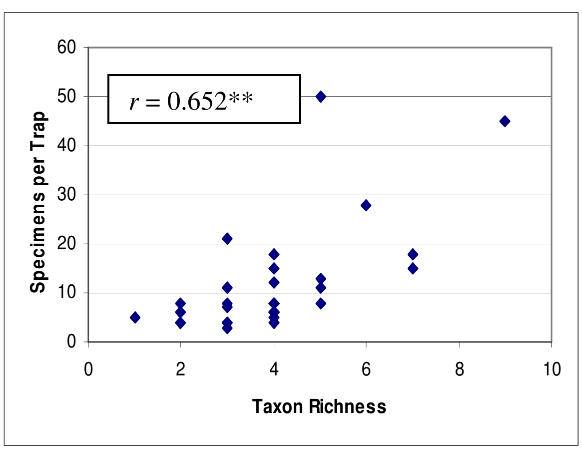
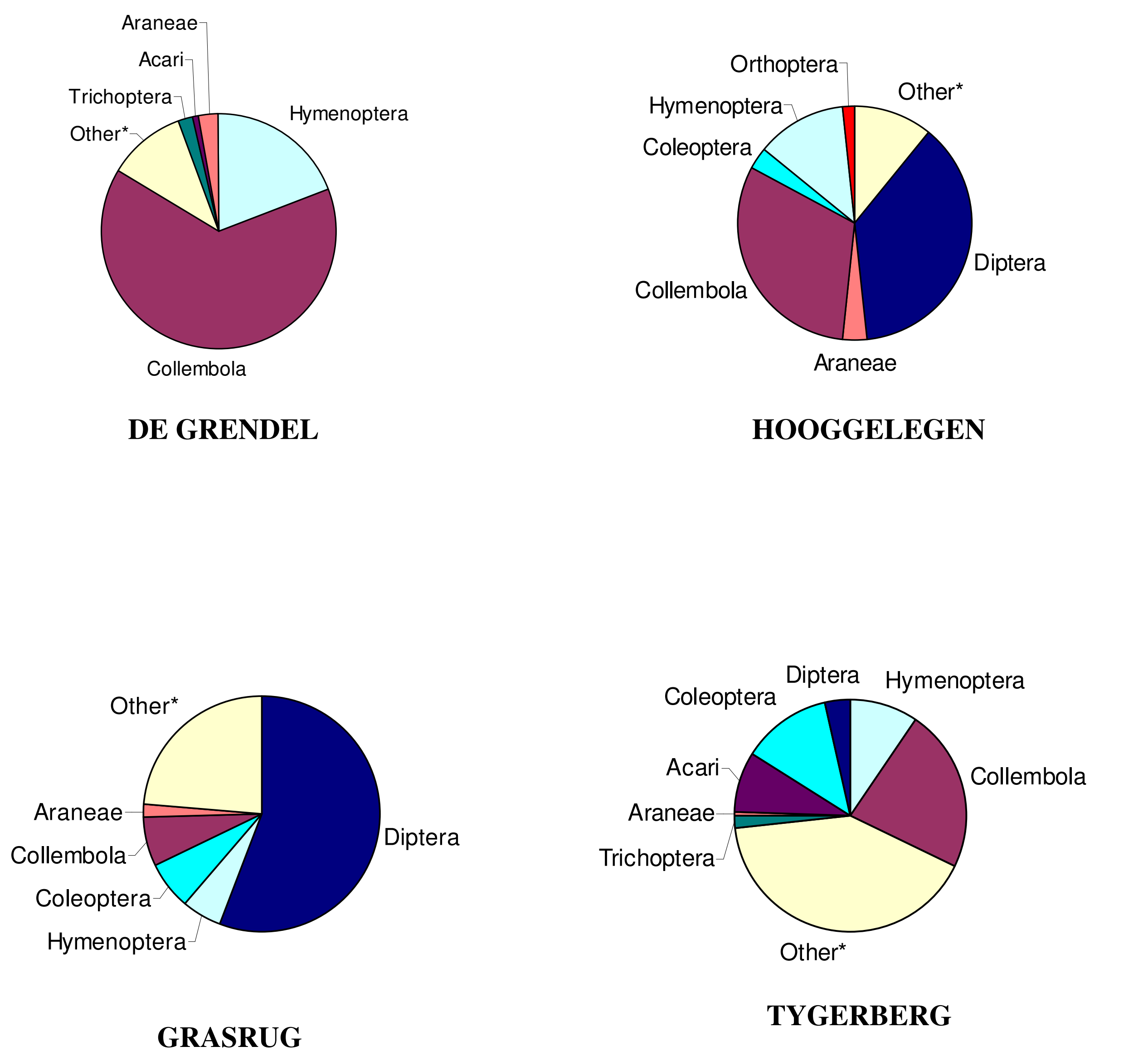


Figure 8: The highly significant (P = 0.01) correlation between taxon richness and the number of specimens per trap.

portion of specimens at Hooggelegen and over half of specimens at Grasrug (Figure 9). Hymenopterans (mostly ants) were an important component of samples at all sites, most notably at De Grendel (Figure 9). Coleopterans (beetles) were present in relatively small numbers in all sites except De Grendel, where they were absent (Figure 9). Araneae (spiders) were present in small numbers at all sites (Figure 9), while Acari (mites) were represented only at De Grendel and Tygerberg (Figure 9).

At Hooggelegen, one small Orthopteran (grasshopper) was found (Figure 9). It may be important to note, however, that at De Grendel and particularly at Hooggelegen, large Orthopterans were abundant and active at the time the traps were laid. However, their large size prevented them being caught in the traps.



*"Other" refers to unidentified morphospecies as well as Classes other than Insecta and Arachnida, such as Myriapoda and Crustaceae.

Figure 9: Species compositions of the four sites.

Discussion

In the broadest terms, the results of this survey of invertebrate communities seem to indicate that wheat farming supports a lower invertebrate diversity and abundance than does viticulture. Grasrug scored lower than either vineyard on all of the indices used. Statistically testable differences among Grasrug and the two vineyards were never significant (Tables 2, 4). However, Grasrug had scores significantly lower than Tygerberg for 3 of 4 indices used, while De Grendel and Hooggelegen had scores significantly lower than Tygerberg for 3 of 4 and 1 of 4 indices, respectively (Tables 2, 4). The results from Grasrug also suggest an invertebrate community which is very different from that of the native renosterveld, as it is dominated by Dipterans, a taxon which represents only a very small portion of the sample from the Tygerberg (Figure 9). In addition, two positively identified taxa represented in the Tygerberg samples—Acari and Trichoptera (caddisflies)—are missing entirely from the Grasrug samples.

In contrast, although the Hooggelegen sample also contains a large portion of Dipterans, the two vineyards both have large portions of Collembolans, which are also well-represented at the Tygerberg (Figure 9). Combined, the two vineyards contain representatives of all positively identified taxa found in the Tygerberg sample and even one taxon, Orthoptera, missing from the Tygerberg sample (Figure 9). However, the latter may be due simply to a vineyard sample twice the size of both the wheat-field and Tygerberg samples.

Given the context of this study, the most obvious conclusion is that a trend away from wheat farming and toward viticulture is beneficial for the Swartland's invertebrate community. However, it is important to go beyond this simplistic, initial interpretation of the data and examine the results from each site more closely.

Grasrug. Perhaps the most important thing to note at Grasrug is that of the two major field types present, active and fallow, only an active field was sampled. The fallow fields were unploughed, contained significant amounts of new vegetation and old crop residue, and were used as sheep pasture. All of these things suggest that invertebrate diversity was probably higher in the fallow fields than in the active fields at the time of sampling. Thus, the sample described here does not accurately portray the full spectrum of conditions at the wheat farm. With this in mind, however, it is still important to interpret the results from the active field.

The abundance of Dipterans at Grasrug may at least partially be due to their high mobility. That is, the small amount of vegetation in the newly-ploughed but unplanted field at the time of sampling seems unlikely to have supported many resident invertebrates on the surface, so that transient invertebrates such as Dipterans may have been more common. This idea is supported by the overall lower numbers of insects found at Grasrug (Table 1), and it serves to highlight the fact that sampling was strongly influenced by seasonal variables. Additionally, the abundance of Dipterans may have been partly a result of the proximity of livestock (sheep) pasture.

The lack of Collembolans at Grasrug is also interesting, especially considering their abundance at De Grendel and Hooggelegen. Research on Collembolans has found them to be sensitive to soil acidity and especially organic content but highly tolerant of herbicides and other toxics (Bandyopadhyaya Choudhuri & Ponge, 2002; Gillet & Ponge, 2003; Eaton et al., 2004). Thus, it seems likely that their distribution among sites is related to soil characteristics rather than to agricultural chemical usage. It is noteworthy in this context that the topsoil at Grasrug was found to be of a different type than that at the other three sites (see section V of this report).

Agricultural soil disturbances related have been found to cause severe decreases in Collembolan populations (Bandyopadhyaya Choudhuri & Ponge, 2002). Thus, another important influence on the samples is the fact that Grasrug was sampled soon after the land had been ploughed. High temporal heterogeneity in general has a negative impact on Collembolan and other soil invertebrate populations, and ploughing specifically has been found to have a detrimental effect (Bandyopadhyaya Choudhuri & Ponge, 2002; Ponge et al., 2003). Crop rotation at Grasrug is also likely to lower Collembolan populations (Bandyopadhyaya Choudhuri & Ponge, 2002).

Collembolans are at the base of many macrofaunal soil food chains (Ferguson, 2001; Ferguson & Joly, 2002). Thus, the importance of Collembolans as bioindicators for the invertebrate community is significant, and differences in Collembolan abundance among sites must be seriously considered. However, it is also notable that Collembolan populations tend to respond strongly to certain endogenous pressures and can vary dramatically from month to month and from week to week (Ferguson & Joly, 2002). In addition, different species of Collembolans have different optimum environmental parameters (e.g. Gillet & Ponge, 2003). Thus, a longer-term study with higher taxonomic resolution is necessary to determine the true significance of differences among Collembolan populations at the study sites and to identify the variables which explain these differences.

De Grendel & Hooggelegen. At De Grendel, a large majority of the specimens collected are Collembolans (Figure 9). As noted above, this is likely related to the acidity and organic content of the soil, as well as to the relatively constant, perennial vegetation and soil structure. Of the positively identified specimens, the rest are mostly Hymenopterans. Araneae, Acari and Trichoptera are also represented, but in small numbers. Coleopterans and Dipterans are notably missing. The lack of Dipterans could be partly explained by the observation that the distance between the vineyards and any livestock pasture may have been greater here than at either of the other two farms. In addition, the nearby livestock were mostly cows, rather than the sheep found at the other two sites.

At Hooggelegen, the majority of the specimens are either Dipterans or Collembolans (Figure 9). In this respect, it seems to resemble both De Grendel and Grasrug. The presence of Dipterans may again be partly explained by the presence of livestock near the vineyards. The Collembolans are again reflective of soil characteristics and could also function as the basis for a healthy soil macrofauna. Supporting this idea is the fact that Hooggelegen is the only farm to score higher than Tygerberg with any of the indices used, with a higher Shannon-Wiener index for the whole sample (Table 3). Another point of interest is the single small Orthopteran, which represents a population poorly sampled due to its size and habits. Given these unique results from Hooggelegen, it may be appropriate to note that the fertiliser, pesticide and irrigation regimes at Hooggelegen are distinctly different from those at either of the other two farms (see section VI.1 of this report).

The differences between the two vineyards are intriguing. Hooggelegen had higher Shannon-Wiener index and morphospecies richness values both for average trap values (Table 1) and for whole-site values (Table 3). However, De Grendel had a greater average number of specimens per trap, although that among-trap variability was very large (Table 1). The average taxon richness for both farms was the same (Table 4). As suggested above, some of these differences may be explained by the different soil characteristics at the two vineyards. There are, indeed, notable differences in soil acidity and organic content between Hooggelegen and De Grendel (see section V of this report). As noted above, Hooggelegen also uses a distinctly different fertiliser and pesticide regime than does De Grendel. However, without more detailed data, it is impossible to link these factors conclusively to differences in invertebrate communities. Further investigation of these relationships may be merited.

Tygerberg. Tygerberg showed a relatively high level of invertebrate diversity and abundance, as expected. Interesting characteristics include relatively high proportions of Coleopterans and Acari, both of which are less well represented in samples from the three farms (Figure 9). The presence of Acari could be partly explained by Ferguson's (2001) finding that Acari increase in abundance with increasing productivity of the environment. In contrast, Collembolan populations did not change with productivity, resulting in an increasing ratio of Acari to Collembolans, such as that observed from the vineyards to Tygerberg (Figure 9). As many Acari are predators of Collembolans (Ferguson, 2001), this may have important consequences for the rest of the invertebrate community. Such a trophic relationship, although undetected here, is a possible explanation for the increased numbers of Coleopterans as well.

There was very high variability observed among traps (Table 1; Figure 4) at Tygerberg. This variability likely reflects an environment which is very "patchy," allowing extensive subdivision into microhabitats and providing the opportunity for a greater diversity of invertebrates (e.g. Vinson & Hawkins, 1998; Hughes Daily & Ehrlich, 2000). If Tygerberg is relatively more structurally heterogeneous than any of the farms, as seems likely, its invertebrate diversity may be under-represented here due to the problem of sample size.

Conclusions

It is important that the results presented here be received in the proper context. This study is intended as an overview, providing more breadth than depth. Additionally, it was impossible to control for a number of significant variables, including seasonality and high spatial variability.

As noted above, the season in which the study was conducted (late autumn) is one of the most significant variables influencing results. Season strongly affects invertebrate populations in all temperate environments. In agroecosystems, the importance of seasonality is significantly heightened. The relation of the time of sampling to times of ploughing, planting and harvesting, as well as of application of pesticides and fertilisers, are all crucial variables. It should be noted once more that at the time of sampling for this study, the wheat at Grasrug had not yet been planted, while the grapes at De Grendel and Hooggelegen had already mostly been harvested.

It is very likely that a much greater abundance and diversity of invertebrates would have been found at Grasrug at another time of year, such as the spring near harvest. It is also possible that significantly different results would have been obtained at De Grendel and Hooggelegen at other times of year. However, the perennial vines may in fact be one advantage which viticulture has over the annual wheat from the viewpoint of the invertebrate community.

As noted above, great variability in the measured indices was observed among traps, especially at the Tygerberg (Table 1). The problem of spatial heterogeneity could be significant for a study such as this in which sampling covers a relatively small area. Local invertebrate populations of many types are known to be highly sensitive to physical heterogeneity in the environment (e.g. Vinson & Hawkins, 1998; Hughes Daily & Ehrlich, 2000), and it is unlikely that sampling in this study covered all of the microenvironments which influence invertebrate distribution.

Another factor likely to affect distribution of invertebrates is weather (McCall & Primack, 1992). Inevitably, weather varied both among sites and during the times during which the traps were left out. Traps experienced conditions ranging from overcast to clear skies to rain on at least one occasion (at Hooggelegen).

As noted initially, the results of this study indicate that vineyards generally support more diverse and abundant invertebrate communities than do wheat-fields. This may in large part be due to the perennial nature of vines and the lack of significant soil disturbance which allow the development of complex and stable trophic relationships. However, these results are tentative and conditional and call for further study.

In particular, the invertebrate communities at these sites and others in the Swartland need better taxonomic description by specialists. Case studies of Dipterans and Collembolans should be conducted. Hymenopterans should be studied at a higher taxonomic resolution in order to identify invasive ant species, which are a common concern for ecologists in the Cape Floristic Region. Finally, agricultural practices such as chemical usage and tillage in the Swartland region need to be studied in much greater detail in order to clarify how much of the variation in invertebrate communities can be ascribed to variability in these practices. The lack of data in the latter area highlights the fact that, while this study and others show the impact of crop choice on an invertebrate community, the importance of decisions made about agricultural practices after a crop is chosen should not be forgotten.

Acknowledgements

We would like to thank Mike Picker, Sayed Hess, John Donaldson and Ingrid Nänni for their invaluable guidance and support for this portion of our study.

References

Andersen, A. N., B. D. Hoffmann, W. J. Müller & A. D. Griffiths. (2002) Using ants as bioindicators in land management: simplifying assessment of ant community responses. Journal of Applied Ecology, 39, pp.8-17.

Bandyopadhyaya, I., D. K. Choudhuri & J.-F. Ponge. (2002) Effects of some physical factors and agricultural practices on Collembola in a multiple cropping programme in West Bengal (India). European Journal of Soil Biology, 38(1) February, pp.111-117.

Benton, T. G., D. M. Bryant, L. Cole & H. Q. P.Crick. (2002) Linking agricultural practice to insect and bird populations: a historical study over three decades. Journal of Applied Ecology, 39, pp.673-687.

Büchs, W. (2003) Biodiversity and agri-environmental indicators—general scopes and skills with special reference to the habitat level. Agriculture, Ecosystems & Environment, 98(1-3) September, pp.35-78.

Büchs, W., A. Harenberg, J. Zimmermann & B. Weiß. (2003) Biodiversity, the ultimate agri-environmental indicator? Potential and limits for the application of faunistic elements as gradual indicators in agroecosystems. Agriculture, Ecosystems and Environment, 98(1-3) September, pp.99-123.

DiGiulio, M., P.J. Edwards & E. Meister. (2001) Enhancing insect diversity in agricultural grasslands: the roles of management and landscape structure. Journal of Applied Ecology, 38, pp.310-319.

Donaldson, J., I. Nänni, C. Zachariades & J. Kemper. (2002) Effects of habitat fragmentation on pollinator diversity and plant reproductive success in renosterveld shrublands of South Africa. Conservation Biology, 16(5) October, pp.1267-1276.

Eaton, R. J., M. Barbercheck, M. Buford & W. Smith. (2004) Effects of organic matter removal, soil compaction and vegetation control on Collembolan populations. Pedobiologia, 48, pp.121-128

Ferguson, S. H. (2001) Changes in trophic abundance of soil arthropods along a grass-shrub-forest gradient. Canadian Journal of Zoology, 79, pp.457-464.

Ferguson, S. H. & D. O. Joly. (2002) Dynamics of springtail and mite populations: the role of density dependence, predation, and weather. Ecological Entomology, 27, pp.565-573.

Gibson, C. W. D., C. Hambler & V. K. Brown. (1992) Changes in spider (Araneae) assemblages in relation to succession and grazing management. Journal of Applied Ecology, 29, pp.132-142.

Giliomee, J. H. (2003) Insect diversity in the Cape Floristic Region. African Journal of Ecology, 41(3) September, pp.237-244.

Gillet, S. & J.-F. Ponge. (2003) Changes in species assemblages and diet of Collembola along a gradient of metal pollution. Applied Soil Ecology, 22(2) February, pp.127-138.

Heino, J., T. Muotka, R. Paavola & L. Paasivirta. (2003) Among-taxon congruence in biodiversity patterns: can stream insect diversity be predicted using single taxonomic groups? Canadian Journal of Fisheries and Aquatic Sciences, 60: 1039-1049.

Hughes, J. B., G. C. Daily & P.R. Ehrlich. (2000) Conservation of insect diversity: a habitat approach. Conservation Biology, 14(6) December, pp.1788-1797.

Kruess, A. & T. Tscharntke. (2002) Grazing intensity and diversity of grasshoppers, butterflies, and trap-nesting bees and wasps. Conservation Biology, 16(6) December, pp.1570-1580.

MacArthur, R. H. & E. O. Wilson. (1967) The Theory of Island Biogeography. Princeton, Princeton University Press.

McCall, C. & R. B. Primack. (1992) Influence of flower characteristics, weather, time of day, and season on insect visitation rates in 3 plant communities. American Journal of Botany, 79(4) April, pp.434-442.

Pik, A. J., I. Oliver & A. J. Beattie. (1999) Taxonomic sufficiency in ecological studies of terrestrial invertebrates. Australian Journal of Ecology, 24, pp.555-562.

Ponge, J.-F., S. Gillet, F. Dubs, E. Fedoroff, L. Haese, J. P.Sousa & P.Lavelle. (2003) Collembolan communities as bioindicators of land use intensification. Soil Biology and Biochemistry, 35(6) June, pp.813-826.

Tucker, G. M. (1992) Effects of agricultural practices on field use by invertebrate-feeding birds in winter. Journal of Applied Ecology, 29, pp.779-790

Vinson, M. R. & C. P.Hawkins. (1998) Biodiversity of stream insects: variation at local, basin and regional scales. Annual Review of Entomology: 1998, 43, pp.271-293.

Webb, N. R. & P.J. Hopkins. (1984) Invertebrate diversity on fragmented *Calluna* heathland. Journal of Applied Ecology, 21, pp.921-933.

Wright, M. G. & M. J. Samways. (2000) Biogeography and species richness of endophagous insects associated with Proteaceae in South Africa. African Journal of Ecology, 38, pp.16-22.

3.
THE IMPLICATIONS OF A TREND FROM GRAIN TO GRAPE FOR AVIAN COMMUNITIES OF THE SWARTLAND
~K. McAlister~

Introduction

Agricultural landscapes differ in a myriad of ways from more natural habitats, including species composition and structure of vegetation, application of chemicals such as fertilizers and pest control, nutrient availability, timing of food availability, cover, mechanical impacts of farming practices such as plowing, and more. These changes have a profound impact on the biotic community of an area. Within agroecosystems, important differences in community exist based on the crop type (Boutin, Freemark, and Kirk, 1999) and agricultural practices (Benton *et al.*, 2002). Birds are commonly used as indicators of the diversity of agricultural ecosystems. They are fairly conspicuous and thus easy to count using noninvasive methods. Many studies about birds and agriculture have been published, especially for European farmlands (Omerod and Watkinson, 2000). Studies in Africa and other developing areas are much scarcer. The literature indicates that the avian community composition and species abundance change in measurable ways with agricultural variables. Birds are popular and charismatic to the public, so information about their populations is sometimes used in policy decisions. Birds' high mobility means that they are often influenced by the composition of an entire landscape (Atkinson, Fuller, and Vickery, 2002), therefore they are useful indicators when considering larger spatial scales.

Conventional wisdom holds that conversion of natural habitat into agricultural fields reduces bird communities' diversity and abundance. Efforts at conservation tend to concentrate on developing reserve systems (e.g. Frazee *et al.*, 2003). Much evidence exists to justify this focus on preservation of habitat not modified by humans. For instance, in fragments of renosterveld surrounded by agricultural land in the Western Cape, bird species richness drops with decreasing fragment size (Randrianasolo, 2003). However, a substantial amount of avian biodiversity can persist within agricultural lands. Agriculture can benefit some species and even increase a landscape's biodiversity when present alongside less modified ecosystems. On the Western Cape's Agulhas Plain, bird diversity was greater at sites with a mix of crops and natural fynbos than in fynbos alone (Mangnall and Crowe, 2003). (However, this study found that fynbos had a greater diversity than any crop grown alone, and some species rely exclusively on the fynbos). Continuously cultivated fields in Burkina Faso were found to contain more species than fields long left fallow (Soderstrom, Kiema, and Reid, 2003). . Clearing of land for agriculture tends to increase the abundance of a few species and decrease many others (Mangnall and Crow, 2003). The manner in which agriculture effects bird communities depends heavily on the specific agricultural practices followed.

Not all agricultural regimes are equally valuable for birds Pastureland and various types of crops present different types of habitat, disturbance regimes, and food sources and thus appeal to different types of birds. Species that eat a substantial amount of seed often prefer grain crops, while insectivores often show a preference for pastures (Atkinson, Fuller, and Vickery, 2002). English insectivores in winter were most densely concentrated in pastures, followed by cereal stubble and ley fields, with few birds on winter wheat or bare till (Tucker, 1992). Both crop types investigated in this study have been found to support relatively low diversity. In the Cape, wheat fields were found to have less diversity than fynbos or barley/canola areas and similarly low diversity to barley, although there were substantial differences between sites (Mangnall and Crowe, 2003). Vineyards were found to support fewer species than corn, soybeans, or apple orchards in Quebec, Canada (Boutin, Freemark, and Kirk, 1999). For the greatest abundance and diversity of the whole community, mixed landscapes tend to be better than single-use landscapes of any sort (Atkinson, Fuller, and Vickery, 2002).

Within a single crop type, agricultural practices can make substantial differences in bird abundance and diversity. Timing of disturbances and food availability is important to birds and other organisms. For instance, winter- and spring-sewn cereals differ in their attractiveness to insects and thus to birds (Benton *et al*., 2002). Uncultivated bits of land between fields, particularly natural hedgerows, are critical to many birds (Jobin, Choiniere, and Belanger, 2001). Hedgerows provide corridors of land that plants and arthropods, which many bird species rely on for food, use to survive and disperse between suitable patches (Burel and Baudry, 1995). Applications of pesticides and fertilizers also impact birds. These impacts may be direct if the chemicals are toxic to birds that accumulate from their food. Often pesticides impact birds indirectly by eliminating the invertebrates and weeds that provide important food sources (Boutin, Freemark, and Kirk, 1999; Benton *et al*., 2002). Corn buntings have been demonstrated to forage more in fields that had received fewer applications of herbicides, fungicides, and insecticides (Brickle *et al.*, 2000). Overall, trends toward agricultural intensification, including elimination of non-crop land, simplification of crop rotations with reduced fallow periods, and increased application of herbicides and pesticides, has had a detrimental effect on birds, causing steep declines in the populations of a number of British farmbirds (Fuller *et al.*, 1995; Benton *et al.*, 2002). Agricultural intensification has also been occurring in South Africa, to the detriment of avian diversity (Mangnall and Crow, 2003).

Of South African vegetation types, renosterveld is one of the most transformed by human use. Rouget *et al.* (2003) report that 82.56% of coastal renosterveld has been transformed for human use, and of the Swartland renosterveld subhabitat, a mammoth 89.20% is transformed.

Although renosterveld seems to possess a fairly species-poor avian community with no endemic species (Randrianasolo, 2003), the rarity of this ecosystem makes it a worthy subject of study. Birds are potentially important in the renosterveld for their roles in pollination and fruit dispersal for a variety of plants (Randrianasolo, 2003). Because renosterveld mainly persists as fragments interspersed with agricultural lands, the capacity of former renosterveld species to utilize farms as habitat may be important in their chances at long-term survival. Conservation measures for renosterveld species need to take into account the matrix of farmlands within which most remaining renosterveld is embedded.

This study aimed to examine the effects upon the bird community of the increasing transformation of grain farms to vineyards on former renosterveld in the Swartland through a case study of three agricultural sites (one wheat, one long-established vineyard, and a vineyard recently converted from wheat) and a nature reserve containing renosterveld vegetation in and around the Swartland region of the Western Cape, South Africa. The four sites were compared with respect to bird abundance and diversity (including both species richness and evenness) as well as the degree of dominance by a single species. This section of the report is intended as a case study, and its limited scope means that results may not be generalizable to other situations.

Methods

The study area is described in depth in section II.1 of this report. In short, the study took place on four sites in the Swartland and Tygerberg regions of the Western Cape, South Africa. Three of the sites were agricultural: wheat fields in Grasrug, long-established grape vines at Hooggelegen, and grape vines planted within the past four years on land that formerly grew grain at De Grendel. All three farms also had pasture for sheep and/or cattle and grew other crops. De Grendel possessed natural vegetation fragments adjacent to the grape fields we examined, and

Hooggelegen also had natural vegetation remnants. The remaining site, the Tygerberg Nature Reserve, contained native renosterveld vegetation bordered by suburbs of Cape Town. Sampling took place in early May, which is fall in South Africa.

We counted birds on each site using line transects. Line transects are simple, appropriate for relatively open habitats such as our study sites, and make efficient use of observers' time (Bibby *et al*., 2000: 65-66). We walked five transects at each site. Where possible, transects were parallel, but when the width of the fields or access prevented all five from being walked in parallel then we made as many transects as possible parallel and laid out the remainder approximately end to end with the other transects. The GPS coordinate was noted for one end of each transect. On each transect, observers walked at 2 km/h for 30 minutes in as close to a straight line as possible given terrain, vegetation and structures. Birds were counted if they were sighted within 20 m on either side of the line of travel, for a total width of 40 m. If birds flew high overhead and did not appear to be making use of the habitat, they were not included. When calls could be identified, the species were recorded, but these records were not included in the analyses because it was difficult to determine whether the unseen caller was within the transect area.

Each transect was walked by one or two observers and one recorder. Observers were volunteers from the Tygerberg Bird Club. Binoculars were used. For each sighting we recorded the time, species, number, microhabitat, and, when known, activity, sex, and age of each bird. Although Bibby *et al.* (2000: 69-71) favor estimating the distance of bird from the transect line to compensate for species' differing detectabilities and generate density estimates, we did not attempt to determine distance because the potential for error was deemed unacceptably high, and we were not attempting to quantify density. All sampling was carried out between 09:00 and 13:00 hours, with the bulk of sampling between 09:30 and 11:30.

We used analysis of variance (ANOVA) to compare sites in terms of the number of species seen per transect (species richness), number of individuals per transect (abundance), and the Shannon-Wiener diversity index by transect. Where significant differences were found, we performed unpaired t-tests to discover where the differences lay. The Shannon-Wiener index (denoted by H; $H=-\Sigma p_i \log p_i$ where p_i is the proportion of individuals of the ith species) incorporates both species richness and evenness components. It was chosen for its widespread use in the literature, and is considered meaningful and sensitive when considered in combination with dominance structure. Correlation analyses were performed between each pairing of these variables to assess how independent they were. In addition, we calculated the Berger-Parker dominance index (N_{max} / N_T , where N_{max} is the number of individuals from the most abundant species, and N_T is the total number of individuals of all species). This index indicates the extent to which a community is dominated by a single species and is not overly influenced by the number of species observed (Henderson, 2003: 124). Bird species were categorized based on the principle components of their diets (as reported by Maclean, 1993). All analyses were carried out using Microsoft Excel.

Results

A total of 40 bird species were seen at the sites (Table 1). All species seen in transects are listed in Table 1. In addition, a number of species were heard but not seen or seen on the sites but outside of the transect area. At De Grendel these species were helmeted guinea fowl (*Numida meleagris*), bokmakierie (*Telophorus zeylonus*), grassbird (*Sphenoeacus afer*), blacksmith plover (*Vanellus armatus*), grey-backed cisticola *(Cisticola subruficapilla*), and cape francolin (*Francolinus capensis*). At the Tygerberg bokmakierie was heard, at Hooggelegen there was hadeda ibis (*Bostrychia hagedash*), cape weaver (*Ploceus capensis*), and European starling (*Sturnus vulgaris*), and at Grasrug blue crane (*Anthropoides paradiseus*), and turtledove (*Streptopelia capicola*).

English Name	Scientific name	DG	TYG	HGL	GRA	main food		
African Goshawk	Accipter tachiro		1			meat, mostly birds		
Egyptian geese	Alopochen aegyptiacus	9				grass, grain		grain/seeds
Grassveld Pipit	Anthus cinnamomemus				6	insects		both seeds & insects
bar-throated apalis	Apalis thoracica		2			insects		insects
Cape Batis	Batis capensis		1			insects		fruit and insects
Spotted eagle owl	Bubo africanus				1	arthropods, birds, other meat		fruit/nectar
Spotted Thicknee	Burhinus capensis	1		3		insects, crustaceans, grass seeds		seeds and fruit
Jackal buzzard	Buteo rufofuscus	1	1			meat, mammals and birds		meat
Red Capped Lark	Calandrella cinerea				21	mostly seeds, some insects		omnivorous
Cisticola (fan-tailed)	Cisticola juncidis				3	insects		
greybacked cisticola	Cisticola subruficapilla		1			insects		
whitebacked mousebird	Colius colius		26			fruit, flowers, vegetation, nectar		
rock pigeons	Columba guinea	94		3		seeds, grain, shoots		
Pied Crows	Corvus albus	13		1	1	omnivorous		
cape robin	Cossypha caffra	1	9			insects, small invertebrates		
black-shouldered kite	Elanus caeruleus	1				rodents		
Grey backed finch larks	Eremopterix verticalis				8	seeds, a few insects		
karoo robin	Erythropygia coryphaes		5			insects, worms		
Yellow-rumped Widow	Euplectes capensis		2			seeds, insects		
Red bishop	Euplectes orix				6	seeds, grain, insects for young		
rock kestrel	Falco tinnunculus	1				small mammals		
Thick billed lark	Galerida magnirostris				2	insects, seeds		
fiscal shrike	Lanius collaris	3	1	1		insects, small animals including mammals and birds		
cape wagtail	Motacilla capensis	1		2	2	insects, fish		
lesser double-collared sunbird	Nectarinia chalybea		11			nectar, sometimes fruit and insects		
Capped wheatear	Oenanthe pileata				4	insects		
Tit Babbler	Parisoma subcaeruleum		1			insects, fruit		
Cape Sparrows	Passer melanurus		2		3	seeds, a few insects		
Spur winged goose	Plectropterus gambensis				3	grass, grain		
spotted prinia	Prinia hypoxantha		11			insects		
Cape Bulbul	Pycnonotus capensis		4			fruit, nectar		
cape canary	Serinus canicollis	21		21	3	seeds, buds, fruit		
Yellow canary	Serinus flaviventris				6	seeds, flowers nectar, insects		
Fiscal fly catcher	Sigelus silens		2			insects, fruit		
grassbird	Sphenoeacus afer		6			insects		
turtledove	Streptopelia capicola	2		1		seeds, a few insects		
red eye dove	Streptopelia semitorquata	6				seeds, bulbs, fruit		
Long-billed Crombec	Sylvietta rufescens		1			insects		
sacred ibis	Threskiornis aethiopicus	1				varied: arthropods, small animals, carrion, seeds		
cape white-eye	Zosterops pallidus		21			insects, fruit		

Table 1. Listing of species observed, number of individuals observed in each location, and chief food sources.

The four bird communities differed notably in species composition and diversity. The nature reserve and wheat field had greater proportions of species not seen at other sites (hereafter unique species) than the vineyards. De Grendel had 14 species, 5 of which were unique (35.7%). Hooggelegen had seven species, none of which were unique. The Tygerberg had 19 species, with 15 unique (78.9%). Grasrug had 14 species, of which 10 were unique (71.4%). Three species were shared by the two vineyards. Interestingly, none of these were primarily frugiverous. Considering both these shared species and species unique to either vineyard, the vineyards together contained 38.1% unique species. Three species were found on all three agricultural sites but not the nature reserve.

Significant differences in the Shannon-Wiener diversity index (H) existed between the four sites ($F=5.80$, $p < 0.001$)(Fig.1). The Tygerberg nature reserve had the greatest Shannon-Wiener value, followed by Grasrug (wheat), De Grendel (recent vines), and lastly Hooggelegen (older vines) (Table 2). Post-hoc t-tests revealed that the Tygerberg (mean H=0.819, s.d.=0.090) had a significantly greater Shannon-Wiener value than Hooggelegen (mean H=0.270, s.d.=0.160) ($t=6.70$, $df=8$, $p < 0.001$)), De Grendel (mean H=0.420, df=8, s.d.= 0.251)

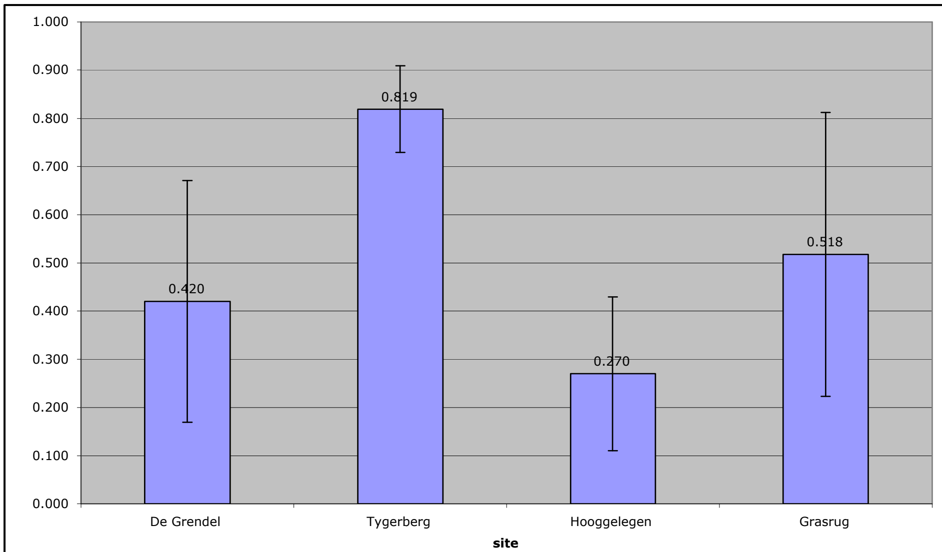


Figure 1. Comparision of mean transect Shannon-Weiner diversity index for bird species at recently two vineyards (De Grendel and Hooggelegen), a nature reserve(Tygerberg), and wheat (Grasrug). Bars represent standard deviation.

(t=3.255, df=8, p=0.005), and Grasrug (mean H=0.518, s.d.=0.295) (t=2.18, df=8, p=0.03). No agricultural sites had significantly differing Shannon-Wiener values.

Location	Transect	#species (no calls)	shannon-weiner	#individuals	Berger-Parker Dominance Index
De Grendel	1	5	0.62	9	0.444
De Grendel	2	2	0.035	63	0.984
De Grendel	3	2	0.301	4	0.500
De Grendel	4	5	0.609	17	0.353
De Grendel	5	6	0.535	62	0.483
De Grendel	site total	14	2.100	155	0.613
De Grendel	mean	4	0.420	29.1	0.553
Tygerberg	1	8	0.814	24	0.292
Tygerberg	2	9	0.804	26	0.423
Tygerberg	3	9	0.879	31	0.226
Tygerberg	4	7	0.681	14	0.500
Tygerberg	5	9	0.915	14	0.214
Tygerberg	site total	19	4.093	109	0.234
Tygerberg	mean	8.4	0.819	21.8	0.331
Hooggelegen	1	2	0.196	6	0.833
Hooggelegen	2	2	0.035	12	0.917
Hooggelegen	3	3	0.413	5	0.600
Hooggelegen	4	3	0.413	5	0.600
Hooggelegen	5	2	0.292	5	0.600
Hooggelegen	site total	7	1.349	33	0.636
Hooggelegen	mean	2.4	0.270	6.6	0.710
Grasrug	1	1	0	7	1.000
Grasrug	2	4	0.555	7	0.429
Grasrug	3	6	0.664	15	0.400
Grasrug	4	6	0.667	14	0.429
Grasrug	5	6	0.703	26	0.308
Grasrug	site total	14	2.589	69	0.304
Grasrug	mean	4.6	0.518	13.8	0.513

Table 2. Measures of bird diversity (including richness and abundance) and abundance for two vineyards (De Grendel and Hooggelegen), wheat (Grasrug), and renosterveld (Tygerberg) in each transect, mean of the transects, and site total.

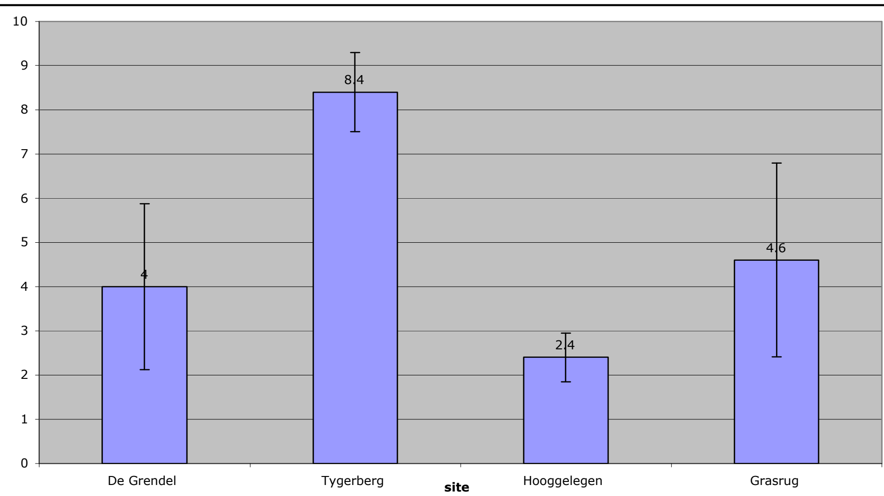


Figure 2. Comparison of mean number of species per transect at two vineyards (De Grendel and Hooggelegen), Tygerberg Nature reserve, and a wheat farm (Grasrug). Differences are significant between Tygerberg and all other sites and between Grasrug and Hooggelegen.

Significant differences between the four sites were found in mean transect species richness (F=13.75, $p < 0.001$) (Fig. 2). The species richness order of the sites was the same as for the Shannon-Wiener index (Tygerberg, Grasrug, De Grendel, and Hooggelegen). (Note that the total number of species seen at De Grendel and Grasrug was the same, but the mean number of species per transect was nonsignificantly greater at Grasrug). T-tests showed that the species richness at the Tygerberg (mean=8.4, s.d.=0.894) was significantly than the species richness at Hooggelegen (mean=2.4, s.d.=0.548) (t=12.79, df=8, p < 0.001), De Grendel (mean=4.0, s.d.=1.871) (t=4.744, df=8, p=0.001), and Grasrug (mean=4.6, s.d.=2.191) (t=3.59, df=8, p=0.003). In addition, species richness was significantly greater at Grasrug than Hooggelegen (t=2.18, p=0.03), and almost significantly greater at De Grendel than Hooggelegen (t=1.84, p=0.052).

No significant differences existed between the sites in mean bird abundance (F=2.26, p=0.12) (Figure 3). De Grendel had the greatest mean number of birds per transect (mean=31.0, s.d.=29.129), followed by the Tygerberg (mean=21.8, s.d.=7.563), Grasrug (mean=13.8, s.d.=7.791), and lastly Hooggelegen (mean=6.6, s.d.=3.050). Large differences between transects at some sites led to large standard deviations, contributing to the lack of statistical significance. When the total numbers of birds observed per site on all

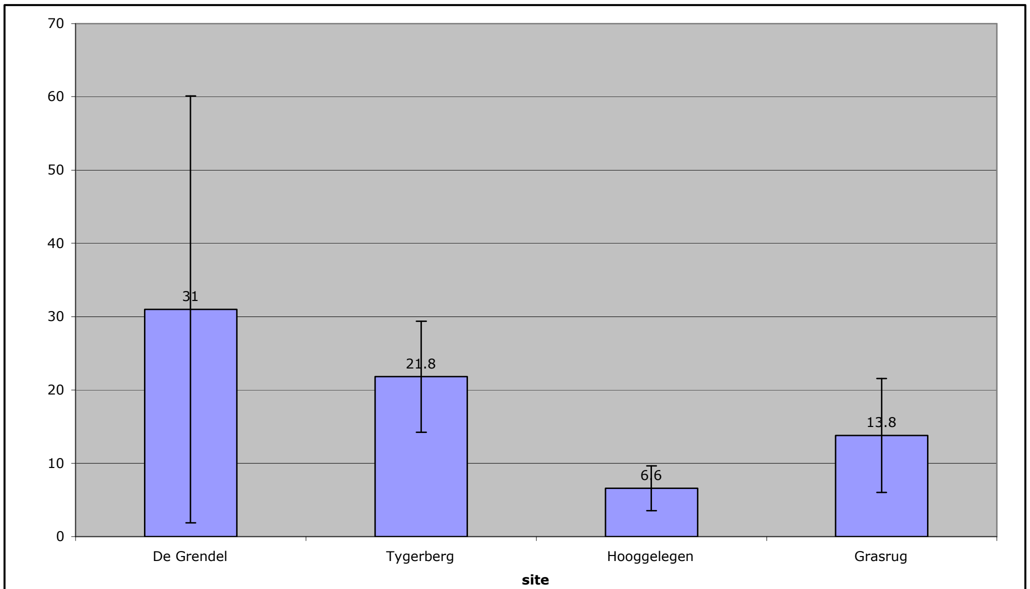
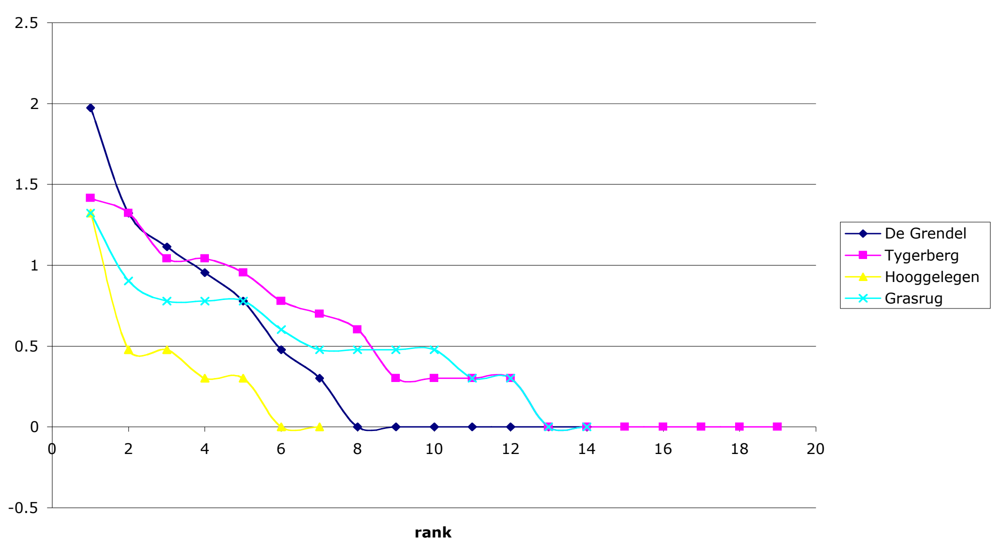


Figure 3. Comparison of mean number of birds per transect seen in two vineyards (De Grendel and Hooggelegen), wheat (Grasrug), and renosterveld (Tygerberg). Bars represent standard deviation. No differences are significant.

transects were compared, the sites did appear to differ, although statistical analyses were not performed. There were 155 individuals observed at De Grendel, 109 at the Tygerberg, 69 at Grasrug, and 33 at Hooggelegen. The high bird abundance at De Grendel was partially a result of large flocks of rock pigeons repeatedly passing overhead and sometimes landing amidst the vines.

When the relative ranks of species were plotted against the log of their abundances (Fig. 4) the vineyards De Grendel and Hooggelegen seemed to have less even distributions than Tygerberg nature reserve or the wheat farm Grasrug.

Figure 4. Rank order-log abundance plot for bird species in wheat (Grasrug), established grape (Hooggelegen), recent grape (De Grendel), and renosterveld (Tygerberg).

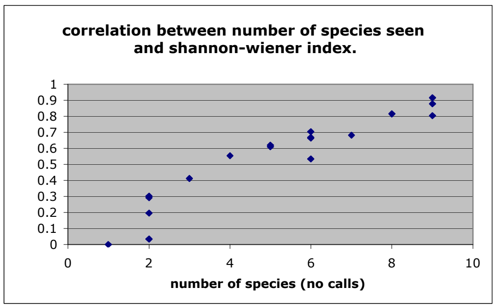


The two vineyards had higher mean Berger-Parker dominance index values (De Grendel: mean=0.553, s.d.=0.248; Hooggelegen mean=0.710, s.d.=0.154) than the wheat farm Grasrug (mean=0.513, s.d.=0.278) or the Tygerberg (mean=0.513, s.d.=0.277), but an ANOVA revealed that there were not quite any significant differences among the sites (F=2.737, p=0.078). However, when the overall Berger-Parker dominance index was calculated for each site, rather than the mean of all the transects' index values, the differences between sites increased.

(Hoogelegen=0.676, De Grendel=0.613, Grasrug=0.304, and Tygerberg=0.234). The vineyards seem to have an increased tendency to be dominated by a single species, which was rock pigeon at De Grendel and cape canary at Hooggelegen.

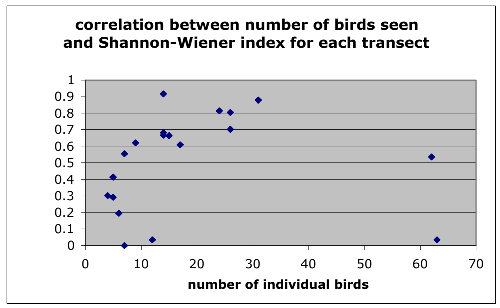
	#species (no calls)	*shannon-weiner*
#species (no c	1	
shannon-weine	0.938447454	1

significant, p<.01



	shannon-weiner	*#individuals*
shannon-weine	1	
#individuals	0.06268147	1

not significant



	#individuals	*#species (no calls)*
#individuals	1	
#species (no c	0.267050347	1

not significant

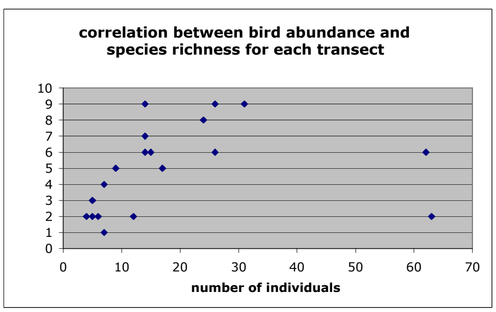


Figure 5. Correlations between Shannon-Wiener diversity index, species richness, and number of birds for each transect.

Correlation analyses were performed between the variables species richness, Shannon-Wiener index, and number of individuals. The only significant correlation was between Shannon-Wiener index and species richness (r=0.94, p<0.01). This result is unsurprising because the Shannon-Wiener index tends to give somewhat more weight to species richness than to evenness (Henderson, 2003: 123).

Feeding patterns differed among the four sites. De Grendel had an unusually high number of meat-eating species (Figure 6). It also had many seed eating species, with 8 of the 14 species including seeds as part of their diet (includes seed, seed and insect, seed and fruit, and omnivorous feeders). The Tygerberg had a wealth of insectivorous species, with 13 of 19

Figure 6. Number of bird species utilizing various food sources at De Grendel vineyard.

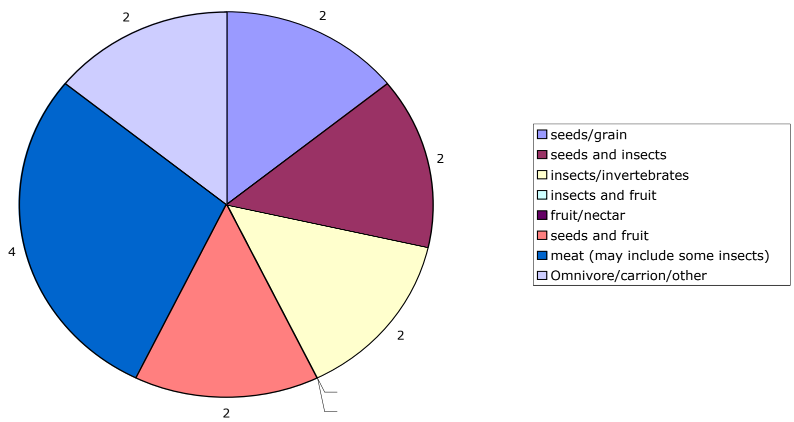
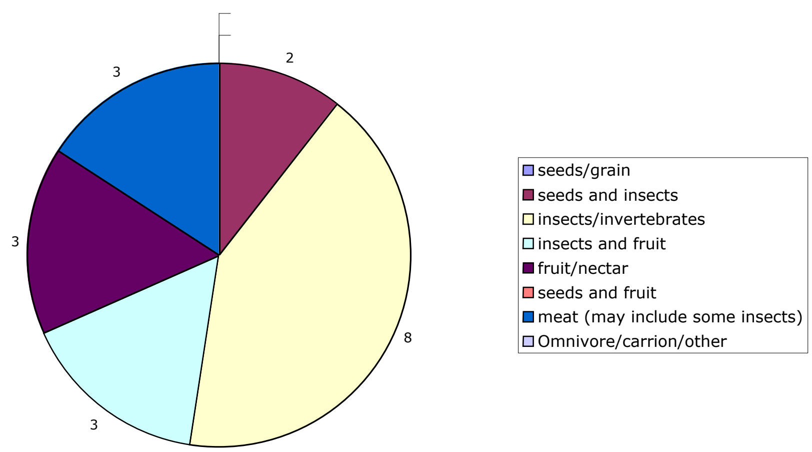


Figure 7. Number of bird species utilizing various food sources at Tygerberg Nature Reserve.



species including insects in their diets (Figure 7). Hooggelegen had a fairly even distribution of feeding guilds (Figure 8). Grasrug had many species feeding on either seeds and insects or exclusively insects and other small invertebrates (9 of 14 species fell into this category (Figure 9). Oddly enough, neither vineyard contained many frugiverous species. Only two species found in these vineyards, the cape canary and red eyed dove, included fruit in their diet, although canaries were quite abundant at both sites. All species that specialized in fruit and/or nectar were confined to the Tygerberg.

Figure 8. Number of bird species utilizing various food sources at Hooggelegen vineyard.

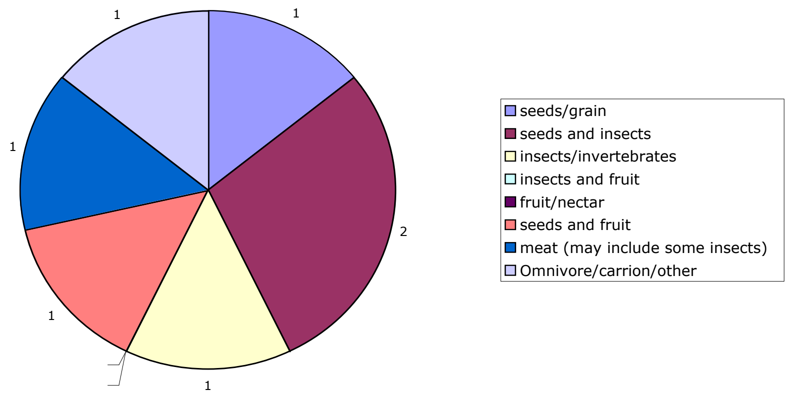
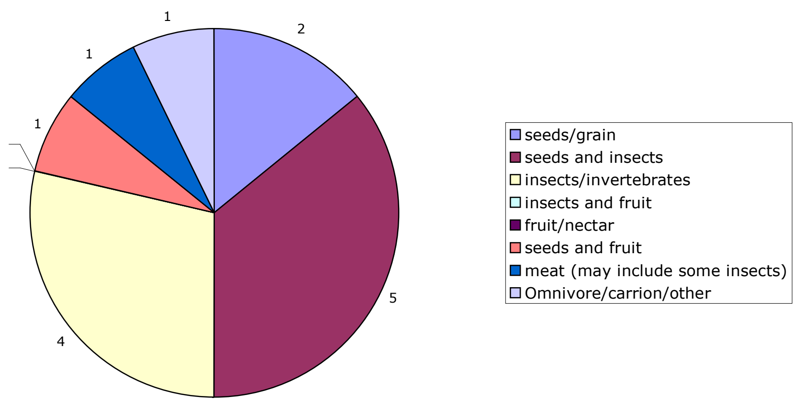


Figure 9. Number of bird species utilizing various food sources at Grasrug wheat farm.



Discussion

Both the Shannon-Wiener diversity index and the number of species shown were significantly different between the Tygerberg nature reserve and all of the agricultural sites, and the number of species differed significantly between Grasrug wheat farm and one of the vineyards, Hooggelegen. There were no significant differences in bird abundance between the sites. The two vineyards were more dominated by a single species and had fewer unique species than the nature reserve or the wheat farm.

The greater species richness and evenness at the Tygerberg nature reserve was predicted. Renosterveld provides a more complex habitat than farmland, with many more plant species. Uncultivated land is free of the major cyclical disturbances of farming, such as plowing, harvest, application of pesticides and other chemicals. Invertebrates were found to be more diverse and abundant in the Tygerberg than in any of the agricultural habitats measured (see section VI.2 of this report). Soil invertebrates are less common in cultivated fields than uncultivated pastures because of the mechanical damage from plowing, loss of insulating vegetation, low organic matter in the soil, and application of toxic pesticides (Tucker, 1992). The renosterveld is the native vegetation type in the study area, and a number of birds in the cape are reliant on the presence of the local natural ecosystem (Mangnall and Crowe, 2003). The Tygerberg's high percentage of unique species observations supports this observation. However, many species were found on agricultural land but not in the Tygerberg.

The differences between the agricultural areas are not so simple to explain. At the time of our field visit, before this year's seeds were sown, the wheat fields do not have an abundance of seed lying around and are bare of vegetation of any size to provide food or cover. The vineyards, in contrast, have large vines with quite a few clusters of grapes remaining after the harvest, and thus would seem to be the more appealing habitat. Insects were found to be more diverse and abundant at the vineyards than Grasrug (see section VI.2 of this report), and bird abundance is linked to arthropod abundance (Benton *et al*., 2002). However, Grasrug had a significantly greater number of avian species per transect than the vineyard Hooggelegen. Grasrug outranked De Grendel nonsignificantly in mean number of species and both of the vineyards in Shannon-Wiener index. Although De Grendel and Grasrug had the same total number of species, the higher mean species richness per transect at Grasrug suggests greater evenness. In addition, Grasrug's low Berger-Parker index suggests that its bird community is more even, and it has a greater percentage of unique species than either vineyard.

Differences in visibility between the sites almost certainly contributed to the differing diversity measures. Although we only recorded birds within 20m of the transect in an effort to minimize the effects of differing cover, within the larger vines it was not always possible to see even 20m clearly due to the leafy vines. Thus, we probably sampled a greater proportion of the actual number of bird species present at Grasrug than at the vineyards. This explanation is supported by the numerous species that were heard but not observed at De Grendel and to a lesser extent Hooggelegen. Furthermore, the gray and chilly weather at De Grendel may have reduced bird activity at that site, masking some species that use the vineyard. Additional sampling incorporating different methods such as point counts would help to reduce the effect of visibility on the data.

Grapevines are perennial, but wheat is an annual crop and hence is planted in rotation. Thus, Grasrug had fallow fields used for sheep grazing. Transects passed through some of these fallow fields, where sheep manure littered the ground. Most bird sightings at Grasrug were in the fallow fields or in unplowed ditches, while the active fields were nearly devoid of bird life. Input of manure onto farmland can increase the use of cultivated fields by a number of bird species because the manure increases the density of earthworms and other decomposers (Tucker, 1992). Tucker (1992) also found that sheep presence can have a positive association with some species and a negative association with others. Fallow fields had not been ploughed this year, which could have increased soil invertebrate density by reducing mechanical damage. The vineyards appeared to have recently ploughed between vine rows. Although at the time of the study there was little difference in the small, sparse vegetation, after the wheat has been planted the fallow and planted fields would become covered with very different vegetation, creating a more mixed landscape on the wheat farm. Mixed landscapes tend to have richer bird communities than single-use landscapes (Atkinson, Fuller, and Vickery, 2002; Mangnall and Crowe, 2003).

Patches of uncultivated land within farms such as hedgerows benefit many species of farmland birds (Jobin, Choiniere, and Belanger, 2001; Abel, 2004; Brickle *et al.*, 2000). All three farms possessed some sort of windbreak, hedgerow, or unplanted margins. Grasrug had a patch of large eucalyptus trees and several ditches and low unplowed grassy patches that may have been seasonal wetlands. Many birds were observed in and around these low areas. Within the field, De Grendel had only strips of small pines. Such planted windbreaks have been shown to have similarly diverse and abundant birdlife as natural hedgerows (Jobin, Choiniere, and Belanger, 2001). In addition, De Grendel had a sizable fragment of renosterveld adjacent to the vineyards, which could have provided shelter for species that forage within the vineyard. Hooggelegen had stands of mature pines. Perches were abundant on all farms, because Grasrug had many barbed wire fences and the vines were grown on trellises. The presence of some sort of non-crop habitat at all three could have contributed to the lack of significant differences in abundance.

The type of food available may influence the diversity of birds present. Cereal crops tend to support granivores (Atkinson, Fuller, and Vickery, 2002). We observed many granivore species at Grasrug, although this site held even more insectivorous species. One would expect frugivores to frequent vineyards. However, we saw few frugivores, in the vineyards or anywhere. Most of the small number of frugiverous species observed during the study were in the Tygerberg, although the most common species at Hooggelegen, the cape canary, does incorporate fruit as part of its diet. Greater numbers of granivore species than frugivore species present in the source community before the advent of agriculture could explain the difference in diversity between Grasrug and Hooggelegen. The greater percentage of unique species at Grasrug than the vineyards suggests that vineyards may be used by more generalist species. Judging by the presence of more fruit-eating species in the Tygerberg than the vineyards, native fruit specialists do not appear to be able to utilize vineyards. This suggestion could have important conservation implications if supported by further data.

Birds tend to be more abundant when more arthropod prey is available (Benton *et al.*, 2002). The Tygerberg, the site with the greatest abundance and diversity of invertebrates in our study, also held the greatest diversity and second greatest abundance of birdlife. However, among agricultural sites opposite trends were observed for birds and arthropods. Possible explanations for this discrepancy are detailed in the preface to the biodiversity sections (section VI.1). In brief, the bird community at the vineyards could have been undersampled due to visibility constraints, or the arthropods potentially providing prey for birds could have been undersampled due to placement of pitfall traps only in an active field, not a fallow field where more insects were likely to be present, and a sampling method that caught many species too small to be likely bird prey and overlooked larger, more active species and soil-dwelling species such as earthworms, which might be more important to birds.

All the farm sites used pesticides. De Grendel and Grasrug used organophosphates, while Hooggelegen used a copper-sulfite pesticide. The use of fields by insectivores has been found to be negatively correlated with the amount of pesticides applied (Brickle *et al*., 2000), but we lack sufficient data about amounts of pesticide applied to determine to what degree pesticide affected the bird community among farms.

Time of year probably influenced our results. Many farmland birds feed in different habitats in the summer and winter (Atkinson *et al.*, 2002). Crop damage caused by birds foraging in vineyards varies with the time of year (Somers and Morris, 2002). Timing is especially important in agricultural landscapes, where the cycle of farming activities such as plowing, pesticide application, and harvest must be considered in addition to the annual cycles of the birds and their food sources. In order to fully assess any differences in the bird communities of vineyards and wheat fields, sampling at other times in the agricultural and bird breeding cycles is imperative.

Differences in bird abundance between the sites were not significant. Nevertheless, the trends in abundance are noteworthy. Birds were most abundant at De Grendel and least abundant at Hooggelegen. This discrepancy between the vineyards suggests that differences in farming practices within a crop type are important in determining a farm's attractiveness to birds. Many of De Grendel's birds were in large flocks that were visible on some transects but not others, leading to large standard deviation that contributed to the lack of statistical significance. The tendency of some types of birds to form large flocks causes patchy distributions in space and time, an important consideration when designing sampling protocols. De Grendel had more individual birds than Tygerberg or Grasrug, but scored below these sites on the diversity indices. When considering measures to conserve farmland birds, one must decide whether the goal is abundance or diversity, because the two do not always go hand in hand.

Wheat and grape vines support different bird communities. The wheat farm had greater species richness than the vineyard Hooggelegen, but not De Grendel, confirming the widespread finding that farming practices and surroundings are very important in determining bird diversity in any given crop type (e.g. Tucker, 1992; Benton *et al.*, 2002). All of the farms had mixed land use, which tends to support a greater diversity of birds than large-scale monoculture.

A conversion from wheat farming to viticulture changes the species present in a bird community, but farming practices can determine whether the overall species richness is adversely impacted by the change. Agricultural intensification has caused the decline of many farmland species in Europe (Benton *et al.*, 2002). To avoid similar declines in South African farmland birds, farmers should maintain mixed land-use practices, allow fields to lie fallow as part of crop rotations, keep or plant hedgerows and other patches of uncultivated land, and minimize pesticide use. Further research is needed to determine which measures are most effective at conserving South African birds and whether different measures are needed in vineyards and wheat fields. Natural renosterveld vegetation has much more diversity than either wheat or grapes, even when that renosterveld is located in a fragment surrounded by suburbs such as the Tygerberg. Thus, in order to conserve the bird diversity of the Cape, it is imperative that future changes in agriculture and other land use retain protected nature areas. Further research should investigate how the bird community of farmlands surrounding renosterveld fragments influences the diversity within than fragments, and management of agricultural areas for greater avian diversity should be incorporated into renosterveld conservation programs

Acknowledgements

We thank M. Delport, K. Drummond-Hay, B. Edgcumbe, B. Anderson, F. Hellmann and especially B. Vanderwalt, all of the Tygerberg Bird Club, for their invaluable assistance with spotting and identifying birds in the field, the farmers who generously allowed us to work on their land, C. Cohen for help finding birders and useful suggestions about our project, P.Ryan for further comments, S. Hess for much help with materials and such, M. Meadows for all he did as

an advisor, and the staff of Butler's Pizza, Debonair's Pizza, and Sunrise Chip 'N Ranch, who really made this project possible.

Works Cited

Abel, C. 2004. Crop patches help skylarks. Farmers Weekly 140(4) January 23.

Benton, T.G., Bryant, D.M., Cole, L., and Crick, H.Q.P. (2002). Linking agricultural practice to insect and bird populations: a historical study over three decades. Journal of Applied Ecology 39, pp.673-687.

Bibby, C.J., Burgess, N.D., Hill, D.A., and Mustoe, S.H. (2000). Bird Census Techniques 2nd ed. London: Academic Press.

Boutin, C., Freemark, K.E., and Kirk, D.A. (1999). Farmland □□□□□birds in southern Ontario: field use, activity patterns, and vulnerability to pesticide use. Agriculture, Ecosystems, and Environment 72, pp.239-254.

Brickle, N.W., Harper, D.G.C., Aebischer, N.J., and Cockayne, S.H. (2000). Effects of agricultural intensification on the breeding success of corn buntings *Milaria calandra*. The Journal of Applied Ecology 37(5): 742-755.

Burel, F. and Baudry, J. (1995). Species biodiversity in changing agricultural landscapes: A case study in the Pays d'Auge, France. Agriculture, Ecosystems, and Environment 55, pp.193-200.

Fuller, R.J., Gregory, R.D., Gibbons, D.W., Marchant, J.H., Wilson, J.D., Baille, S.R., and Carter, N. (1995). Population declines and range contractions among lowland farmland birds in Britain. Conservation Biology 9(6) December, pp.1425-1441.

Henderson, P.A. (2003). Practical Methods in Ecology. Malden, MA: Blackwell.

Jobin, B., Choiniere, L., and Belanger, L. (2001). Bird use of three types of field margins in relation to intensive agriculture in Quebec, Canada. Agriculture, Ecosystems, and Environment 84, pp.131-143.

Maclean, G.L. (1993). Roberts' Birds of Southern Africa 6th ed. Cape Town, John Voelcker Bird Book Fund.

Omerod, S.J., and Watkinson, A.R. (2000). Editors' Introduction: Birds and Agriculture. The Journal of Applied Ecology 37 (5) October, pp.699-705.

Randrianasolo, H. (2003). Birds in west coast renosterveld fragments: implications for a threatened habitat. Master's thesis, University of Cape Town.

Rouget, M., Richardson, D.M., Cowling, R.M., Lloyd, J.W., and Lombard, A.T. (2003). Current patterns of habitat transformation and future threats to biodiversity in terrestrial ecosystems of the Cape Floristic Region, South Africa. Biological Conservation 112, pp.63-85.

Soderstrom, B., Kiema, S., and Reid, R.S. (2003). Intensified agricultural land-use and bird conservation in Burkina Faso. Agriculture, Ecosystem, and Environment 99, pp.113-124.

Somers, C.M, and Morris, R.D. 2002. Birds and wine grapes: foraging activity causes small-scale damage patterns in single vineyards, Journal of Applied Ecology 39, pp.511–523.

VII.
The Cup Runneth Over?:
Do the Benefits of Increased Revenues Trickle Down to Agricultural Workers?

~E. Schobe~

INTRODUCTION

As has been discussed in section III.2 of this report, the advent of the new South African government in 1994 has led to great changes in the agricultural industry for the country. Deregulation of domestic agricultural and integration into international markets informed by increasing globalisation in the agro-food complex have made economic survival for wheat farmers more challenging, while for those in the wine industry, the immediate future prospects appear positive. The question remains, however, as to how these changes have affected the agricultural labourers. Ownership of commercial farms in South Africa remains largely in the hands of whites, following the historical pattern established during colonial and apartheid rule. New labour laws provide a greater deal of security for agricultural employees, but labour has been slow to organise (Ewert & Hamman, 1999).

Despite the increased growth opportunities in viticulture that new markets and globalisation have created for some farm owners, with some exceptions, there has been little translation to an improved financial status or increase of opportunities of advancement for agricultural workers. Although some safeguards now exist for workers, such as protection by law of basic rights, the overall hierarchical and paternalist structure of farm labour has not changed, despite the fact that South Africa has entered the modern and industrialised world of wine production. Finally, this section will compare the economic and labour information from the three case studies and draw out similarities and differences relative to national trends.

FARMING & LABOUR IN AN HISTORICAL CONTEXT

The abolition of slavery in 1833 freed Africans within the country, but further laws created a system of feudal-style relationships between farmers and their employees, forcing farm employees to remain on farms, or face the possibility of imprisonment (Isaacs, 2003: p.28).

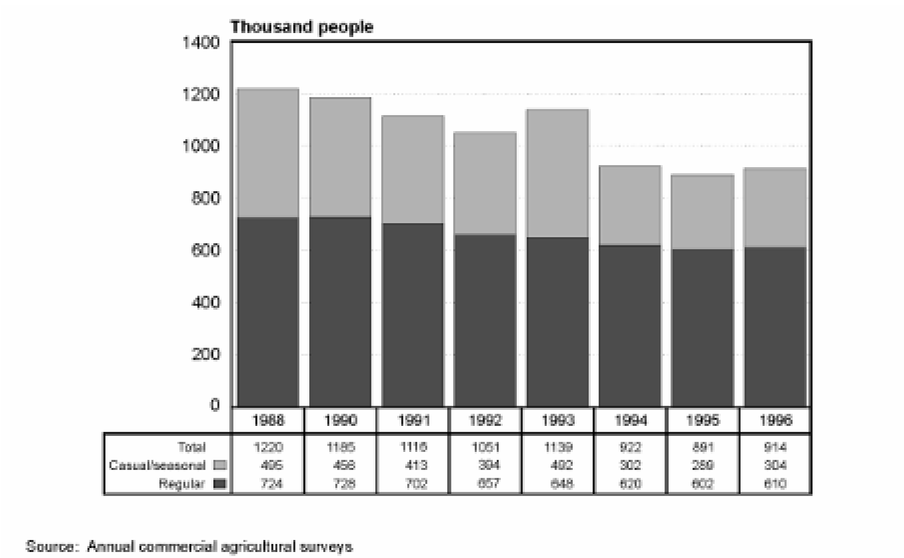
Acquisition of cheap labour became a central motivation for legislation regarding land policies (Kirsten van Zyl & Vink, 1998). In 1913 the Land Act designated 87 percent of land in South Africa for whites only. However, usage of such practices as labour tenancy, on-farm, migrant, and prison labour ensured that there would be an adequate supply of workers for white farm owners (Isaacs, 2003: p.28). Later, during apartheid, farm workers were essentially imprisoned on the farm, as they were not permitted to leave without a pass from the farmer (Isaacs, 2003: p.29).

Additionally, terms of employment meant that women and children were required to provide labour for the farmer, without the farmer being required to pay for their work (Isaacs, 2003: p.29). Workers did not have any rights, and could be fired or evicted without notice. This pattern continued for decades; some argued that conditions on wine and fruit farms in the 1970s and 1980s were similar to those of the late 1800s (du Toit & Ally, 2001: p.5). Overall, the agricultural labour of this time can be characterized as highly paternalistic and hierarchical, establishing the patterns that still affect current practice.

LABOUR STATISTICS IN AGRICULTURE IN THE WESTERN CAPE & SOUTH AFRICA

In South Africa, there has been an overall decline in the number of people who rely on commercial agriculture for their income. In the 1950s, 32.9 percent of economically active South Africans were involved in commercial agriculture, while in 1980 the percentage had dropped to 13 percent (Isaacs, 2003: p.30). This is partly because in the 1970s, the government gave subsidies and incentives to farmers to invest in capital improvements which would decrease their dependence on labour and increase profitability (Issacs, 2003: p.30).

The Centre for Rural Legal Studies in Stellenbosch estimates that currently there are 650 000 people permanently employed in agriculture in the country, with an additional 320 000 classified as seasonal (migrant) or casual (on-farm temporary workers) labour (Centre for Rural and Legal Studies, 2003: p.1). In addition, the livelihoods of 6 million people are dependent on the agricultural industry. However, the number of permanent employees in agriculture has decreased in recent years (Figure 1). For farmers producing field crops, there was a decline of 6.1 percent in the number of permanent employees from 1995/96 to 1998/99, whereas there was



	1988	1990	1991	1992	1993	1994	1995	1996
Total	1220	1185	1116	1051	1139	922	891	914
Casual/seasonal	496	458	413	394	492	302	289	304
Regular	724	728	702	657	648	620	602	610

a

Figure 1: Number of people employed as casual/seasonal or regular labourers in agriculture in South Africa
Source: Statistics South Africa, 2000

slight increase of 1.2 percent for horticultural farms, including vineyards (Statistics South Africa, 2000).

As mentioned above, before the 1990s, most farm workers had very few rights and their livelihoods were subject to the discretion of their employer. However, the new labour laws in effect since the late 1990s afford them more rights and protection. At the most fundamental level, democracy gave them choice of profession as well as the ability to move from farm to farm. In addition, farmers are not allowed to make any form of deduction from a worker's pay without the consent of the employee (Basic Conditions of Employment Act, 1997: p.34). This means that a farmer cannot automatically deduct wages for things such as housing or food.

In terms of increased remuneration, collective bargaining is the main strategy used to attain higher wages. The Wage Act, the state wage fixing mechanism, does not apply to agricultural workers (Kirsten van Zyl & Vink, 1998: p.239). This is due mainly to two reasons: international market competition has led to a decrease in the use of wage regulatory methods, and the South African government has been hesitant to hinder the flexibility of labour markets through the use of wage control (Kirsten van Zyl & Vink, 1998: p.239).

After the end of apartheid, the South African government made the assumption that a deregulation of the agricultural market would weed out "backward" and inefficient farmers, and that only those who were willing to adopt a modern and "market-oriented" approach to their labour practices would survive (du Toit & Ally, 2001: p.6). This supposedly meant that the racist ideas of the past that created the paternalistic structure would be eliminated and more fair policies, including higher wages, would emerge (du Toit & Ally, 2001: p.7).

However, the fact that the South African wine industry has become an important part of the global market of first world countries does not necessarily mean that its labour practices had moulded themselves after those of first world countries. Labour relations between farmers and their employees are for the most part informal, and in some instances, farmers have been known to simply ignore labour laws and hope that they are not punished for it (Ewert & Hamman, 1999). However, Ewert and Hamman go on to say that "With the stringent quality and appearance standards imposed by overseas distributors, farmers could be expected to increasingly focus on the skill, reliability and productivity of ***labour***, amounting to a greater measure of 'scientific management' of the farm. Formalization of the job structure, performance appraisal and productivity measurement - all these could chip away at neo-paternalism and push it over the brink towards adversarialism" (1999: p.210). In the future, Ewert and Hamman (1999) hope that international pressure will force wine makers into creating fairer labour practices.

WAGES & PERMANENT vs. TEMPORARY LABOUR

In 1985, a governmental survey found that the average commercial farm worker's monthly income was R87 (Issacs, 2003: p.32). Another survey found that the average monthly wage went up from R148 in 1988 to R524 in 1996 (Statistics South Africa, 2000: p.54). It should be noted, however, that for the temporary or casual worker, wages went from R49 in 1990 to R180 in 1996 (Statistics South Africa, 2000: p.54). This is significant because the overall trend within agriculture (except for horticulture) is to replace permanent, higher paid workers with casual or temporary workers, whose wages are far lower. Furthermore, temporary workers do not qualify for things such as unemployment insurance, which help offset financial burdens in times of unemployment.

Although there has been a small increase in the number of permanent workers within the viticulture sector, temporary workers are of increasing significance (du Toit & Ally, 2001: p.12). From 1995/96 to 1998/99 there was a 17.3 percent increase in employment numbers for seasonal horticultural workers compared to the 1.2 percent increase in permanent workers (Statistics South Africa, 2000: p.37). Therefore, there are more people who are consistently being paid less. It is also not clear what is causing the increase in permanent workers within the horticultural sector of agriculture when permanent workers' numbers have been declining in all other agricultural sectors. It could be that the increase in permanent workers is due to the fact that there has been an increase in the number of vineyards, or that there has been a trend to hire more of this type of employee within the industry.

Generally speaking, vineyards necessitate a much higher worker to hectare ratio than do wheat farms (de Flamingh, personal communication). In theory, more employees would make it easier for workers at vineyards to organize and assert their rights through union representatives. However, this has not been the trend up to this point. Farmers are not required to bargain with unions, and workers are often unaware of the rights they have (Ewert & Hamman, 1999: p.216). Most general farm labourers have little to no education, and no access to information about the rights afforded to them by law. Thus, there is less likelihood that they will group together to support unions who will bargain for higher wages and increased benefits.

It should be stated that the way most farms are structured at the moment does not allow for employers to increase the wages of their workers substantially (Kirsten van Zyl & Vink, 1998: p.240). This applies directly to farms that have seen profits dwindling, such as South African wheat farms, as price controls have been taken away. As J. Hamman writes, "Increased input costs and market liberalisation have resulted in a cost-price squeeze which has systematically eroded profit levels to the extent that large increases in wage levels will threaten the viability of a substantial number of farming enterprises" (Kirsten van Zyl & Vink, 1998: p.240). As discussed in the first part of this chapter, the decline in the South African price of wheat combined with international competition has meant that wheat farmers do not have the same financial resources as they had under the previous government.

There are some exceptions to the trends stated above. For instance, the Fairview wine estate in Paarl designates the profits of certain wines to be combined with governmental subsidies to help finance housing for its workers (Wines of South Africa website). In general, however, the characteristics of labour of farms in the Western Cape remain similar to the years before democracy. While democracy and globalisation have led to increasing opportunities for vineyard owners, and increasing challenges and declining profits for wheat farmers, the overall structure of the labour and general low wages of both types of farms has not changed dramatically since South Africa's entrance into the global market in the early 1990s. In addition, an increase in the number of temporary or seasonal workers means that, although more jobs are available, they are more likely to be paid less than permanent workers. Although the shift from wheat farms to grape growing would indicate an increased profitability for farmers, it has not been shown that this had led to an overall improvement of condition for workers on these farms.

LABOUR ON WHEAT FARMS AND IN VINEYARDS: A DIRECT COMPARISON USING CASE STUDIES

The three farms used in the case studies provided information regarding economics and labour. This was done through an informal questionnaire and interview facilitated by the authors. All information presented in the following section is derived from the interviews. Questions regarding sales of product, government assistance and employment were asked.

Grasrug

Operational costs at Grasrug are approximately R2000-R2500 per hectare. This number depends on the amount of rain that falls in a given year. When there is less rain, not as much fertilizer is used, lowering costs, but also production. Grasrug is part of a group of about 80 farmers who pool their wheat to be sold to a marketing agent in the area. They can sell their wheat as individual farms as well, and all sales are domestic.

The farm has been greatly affected by the changes in governmental policy in the 1990s. Grasrug had always been assured of a profit when the government set the price for wheat and controlled the import and export market for South Africa. Now, in a free-market economy, the farm must compete with subsidised wheat from abroad, including Europe and the United States (Smuts, personal communication). The government provides some support when the international price drops to a very low level, but the amount of support is too low for the farm to be able meet its financial obligations. This has forced the farm to cut costs wherever possible.

Grasrug employs 6 people at present, but there have been up to 8 employees in previous years. Occassionally an additional employee is required during harvest time. The employees drive tractors or help with the machinery, and they receive about R1600 per month in total compensation. Approximately 10% of expenditures go towards labour costs, whereas fertilizer and other costs are much higher.

Workers range in age from about 20 to 50 years. The employee who has been there longest has lived at the farm for 10 years; the one whose tenure has been shortest has been at the farm for about 6 months. Ten years ago, it was common for a worker to have spent his whole life working at the farm, but now employees are more likely to move off the farm as there is no law requiring them to stay in one place.

Food is bought at local stores and sold to the workers at no profit. This also helps cut down on alcoholism at the farm. Meat is provided from the livestock at the farm, and is sold to employees at below market prices.

De Grendel

De Grendel sells most of its product internationally, specifically in the United Kingdom. They have been selling there for three or four generations, meaning that democratisation did not influence their markets. They do not receive any subsidies from the government.

The farm employs 55 permanent workers. An additional 75 are employed seasonally. There are 3-4 foremen, and most of the others labourers are classified as unskilled.

Approximately 40 percent of expenditures are devoted to labour costs. The foremen earn about R1000 a week and the unskilled labourers earn from R300-R400 a week. Housing is free, and a medical student provides on-site health care to the workers, who live on the farm with their families. All permanent employees receive pension and health care plans.

When the farm added grapes to its produce, labour demands changed. However, the farm retrained its workers so no new labour had to be recruited. The average age of an employee is between 40-50 years. The minimum age for a worker is about 18.

Hooggelegen

Hooggelegen's total operational costs are approximately R1.6 million per year, with an income of R3.3 million from grapes, R 50 000 from sheep and R40 000 from cattle. They spend R200 000 on pesticide, R800 000 on new machinery and R80 000 on seed. The farm is not expanding at this time.

The farm sells its product to Durbanville Hills, a cooperative of grape growers in the Swartland area. Approximately 20 percent of wine made at Durbanville Hills is exported. This has not changed significantly since 1994.

The farm employs 21 permanent workers. At harvest time, employee numbers grow to 40, with the additional workers used to pick fruit. The number of employees is stable from year to year. About 20 percent of expenditures go to labour costs. This percentage reflects both direct pay to workers and any additional benefits they may receive, such as housing.

Most farm workers spend their entire lives working at the farm. The average age of an employee is about 40 years old, and the youngest are 19 years old. All permanent employees are male. Workers live on the farm with their families.

Applications of overall trends to case studies

These three farms tend to fit the overall description of economics and labour in their respective sectors of agriculture. During the interview at Grasrug, Mr. Smuts discussed the challenges that wheat farms in South Africa are now facing. Because other countries subsidise their wheat, South African farmers have a much more difficult time competing (refer to section III.2). As a result, his farm has faced a declining profit margin since the end of apartheid and the beginning of the free-market economy.

The fact that Grasrug employs a much lower number of people in relation to its size than either of the vineyards is consistent with the fact that grape growing is more labour intensive. It is significant that neither of the grape farmers said their numbers of employees had changed in recent years. However, Mr. Smuts said that he has reduced the number of employees, matching the overall trend of the industry. It could be that they are all financially stable and they do not need to replace permanent labour with temporary or casual.

Another interesting fact that came up during the interviews was that Mr. Smuts discussed how it was common ten years ago for workers to have spent their entire lives on the farm, whereas now the workers move around relatively often. At Hooggelegen, however, Mr. de Wit said that his workers had not moved around; those that are there today have been at the farm their whole lives.

The pension and health care plans provided to permanent employees at De Grendel can be viewed as a progressive step towards the modernisation of labour. However, this example also shows that any such steps are at the discretion of an individual farm owner and does not necessarily reflect an overall movement within the agricultural industry.

Limitations

It is difficult to say whether the individual case studies directly support the general information gathered about wheat and grape growing in the Western Cape. This study was not designed to be definitive in its assessments of the status of economics and labour of wheat and viticulture in the Swartland. There are elements in each that reflect what the literature has characterised the current status of economics and employment to be, but none seems to perfectly match the trends. It is also possible that the farmers were hesitant to give out specific information regarding their financial or labour costs, although this did not appear to be the case during the interviews.

References

Basic Conditions of Employment Act 75 of 1997 (2000) Juta's Statutes Editors and Workplace Solutions. Kenwyn: Juta Publishers.

Centre for Rural Legal Studies (2003) Briefing paper: Agricultural trade, globalisation and farm workers. Stellenbosch: Centre for Rural Legal Studies.

Du Toit, Andries & Fadeeda Ally (2001) The Externalization of Agricultural Labour in the Western Cape for the Centre for Rural Legal Studies. Bellville: Programme for Land and Agrarian Reform at the School of Government, University of the Western Cape.

Employment Trends in Agriculture (2000). Pretoria: Statistics South Africa and the National Department of Agriculture.

Ewert, Joachim and Hamman, Johann (1999) Why paternalism survives: Globalization, democratisation and labour on South African wine farms in Sociologia Ruralis, 39, 2, pp.202-222.

Isaacs, Abdoesalaam (2003) Trapped farm labour: obstacles to rights and freedoms. Interfund and the South African NGO Coalition [Internet]. 7th January, 4 (2), pp.27-56 Available from <http://www.interfund.org.za/pub.html>. Accessed 20 May 2004.

Kirsten, Johann, van Zyl, Johan & Nick Vink, eds. (1998). The Agricultural Democratisation of South Africa. Cape Town: Francolin Publishers.

Wines of South Africa [Internet]. Available from <http://www.wosa.co.za/transformation_empowerment.asp. Accessed 21 May 2004>

VIII.
A Discussion of the Recent Trend from Grain to Grape, Its Causes and Implications

~K. Dietrich, C. Fiske, K. McAlister, E. Schobe, I. Silverman & A. Waldron~

THE REALITY OF THE TREND

As noted in sections III.1 and III.2 of this report, statistics from government and agricultural industry groups do suggest that land formerly used for wheat cultivation is being converted to viticulture at a significant rate in the southern Swartland. Additional support for the existence of this emerging trend is provided by the time-series land use analysis of a sample area in section III.1. The land use analysis (section III.1) suggests that this trend began during the 1970s. However, a broader review of available statistics for the Western Cape suggests that the trend may only date to the 1990s (see section III.2). Thus, we suggest that the incidence and importance of the trend may vary with the scale of analysis.

THE CAUSES AND PERMANENCE OF THE TREND

The economic roots of emerging land use trends can be divided into two general categories: agricultural policy and trade policy, both South African and international, and specifically as they vary between wheat and wine. South African agricultural policy has informed land use by imposing governmental priorities on agriculture. As these priorities shifted from food self-sufficiency to economic efficiency after the democratic transition, South African agricultural policy became less supportive of wheat and more conducive to viticulture. Similarly, the agricultural policies of major world economies also favor Swartland wine. In these nations, wheat production enjoys far greater governmental support than it does in the Swartland.

Trade policy reveals similar patterns. While under trade sanctions at the end of apartheid, Swartland wheat enjoyed protection from heavily subsidized northern exports while Swartland wine was banned from international markets. Once sanctions were lifted, the aforementioned subsidies as well as protectionism in northern economies negatively affected wheat producers while wine encountered few trade barriers and soaring international demand. As summarized above, the variations between agricultural and trade policies have created comparative advantages on several scales that favor viticulture over wheat farming in the Swartland.

Land use in the Swartland has vacillated between grain production and viticulture over the past two to three centuries. As discussed above, the history of these trends has been largely influenced by changes in the relative favourability of the two crops related to political and economic variables (see sections II.2 and III.2). A third variable, climate, has also had a very significant impact. These variables will continue to influence agriculture in the region. In particular, general circulation climate models for the Western Cape in combination with projected increases in water demand from the local population and economic pressures from monopolistic international firms provide good reason to suspect that the trend may not be permanent (see section III.2).

THE EXTENT OF THE IMPACTS OF CHANGES IN CROP REGIMES

As this report uses data from only four sites within the study area, it would be irresponsible to attempt to formulate generalisations from the data presented here. However, it may be possible, by combining these data with certain qualitative observations, to build a reasonable framework for future research on the topics discussed.

Wheat and grape are distinctly different crops on a number of levels. From a physical perspective, grape requires larger quantities of water and thus often necessitates irrigation systems, whereas wheat in the Swartland can survive on the water provided by the natural rainfall regime (see section IV for examples). Additionally, grape is a perennial crop, while wheat is an annual. The result is that vineyards provide year-round vegetation cover of the same type, while wheat-fields are usually on a rotation which includes another crop and a fallow period and significant seasonal variation in cover.

From a socioeconomic perspective, viticulture requires a larger and better-trained workforce per unit of land than does wheat cultivation. Also, and perhaps most importantly, the products themselves are dramatically different. Wheat is a staple food crop which commands a relatively low price per volume; grape is a luxury crop which commands a relatively high price per volume.

It might be expected, based on these preliminary observations, that the impacts of wheat and grape on both the physical and the socioeconomic environment would be very different. Some of the results presented in this report can be conceptually tied to the above observations; others remain unexplained by them.

Soils

Analyzed soils from the grape farms were not distinctly similar to each other (see section V of this report). In fact, in terms of organic content and pH, the soil at De Grendel was more like the soil at Grasrug than the soil at Hooggelegen. The soil sampled at the Tygerberg Nature Reserve had more organic content than any of the other sampled soils, which was expected. Overall, pH was similar at all the sites, although the soils from Hooggelegen had the highest values. It is important that all results of the laboratory analyses be taken in context of the limitations of the methodology, the number of sites sampled, and the limited extent of sampling at each site. Sampled soils cannot be taken as representative of the land use types at each site and are beneficial as case studies only. Differences in the soils are as likely due to individual farming practices and pre-existing land characteristics as they are to the crop types. For example, fertilizer application and irrigation use varies at each farm and likely affects the data, as do pre-existing mineralogical differences. The soils section (section V) of this report can be beneficial to future studies by providing a base of qualitative information from which a more comprehensive and representative study can be framed.

Biodiversity

Grain and grape obviously present different habitat structures and food sources for animals (see section VI of this report). Within the limited scope of our study, however, any impacts of the transition from grain to grape on the agroecosystems were unclear and inconsistent across taxonomic groups. Avian communities showed a trend towards greater species richness and evenness in wheat when compared to grape. Invertebrates, however, tended towards greater diversity and abundance in the vineyards than at the wheat farm. Many indices used to compare sites in both invertebrates and birds were not statistically significant.

The opposing trends of birds and insects were probably largely due to sampling methods. However, because crop rotation makes wheat farms a more heterogeneous environment than vineyards, the differing spatial scales at which birds and invertebrates respond to land use may have contributed to our findings. General conclusions about the differences between agroecosystems existing in vineyards and wheat are difficult to draw due to compounding variables and the importance of individual farming practices.

The only trend consistent between birds and insects was towards greater diversity in the Tygerberg than the farmlands. Agricultural landscapes are important habitat for many species, but the presence of natural vegetation is essential for preservation of the full wealth of biodiversity.

Labour

Due to both the qualitative nature of the data of this section and the small sample size of the report as a whole, it is very difficult to determine exactly how the case studies should be classified within the larger picture of farm labour in the region as characterised by the available literature (see section VII of this report). However, generally speaking, each farm fits the overall description of farm labour from the literature. For instance, at all three of our farm study sites, farm labourers live on the farm, as consistent with traditional practices. However, at De Grendel, all permanent employees are given health care packages and pensions, which can be regarded as very progressive in the given context. Thus, differences in labour practices at the three farm sites seem to be more attributable to differences in farm managers and owners than to conditions inherent to the type of farm. This being said, the limitations of this report do not make these conclusions necessarily generalisable. They do suggest, however, that the modernisation of farm labour is an ongoing process, and future studies will have to be conducted in order to continue to monitor its progress.

Crop regimes and other variables

As our results make clear, crop regime is only one variable affecting the impacts of agriculture activities. Agricultural practices—e.g. application of fertilisers and pesticides, tillage, erosion control measures, etc.—may vary as much within crop types as between them. They reflect personal preferences of farmers as well as strong social and economic pressures. They influence a wide variety of environmental and socioeconomic conditions, from environmental health and worker safety to economic relationships among workers, farmers and international markets. Agricultural practices are outside the defined scope of this report, which was aimed at determining differences in environmental and socioeconomic impacts between crop regimes. However, they are not controlled for in the data, and thus present unavoidable difficulties in the process of data interpretation.

THE BROADER VIEW

As this report has demonstrated, both the causes of the trend from grain to grape and its effects are complex and many-layered, including environmental, economic and social dimensions. The trend has been driven largely by national and international economic policies which make viticulture more profitable than wheat cultivation in the Swartland (see section III.2 of this report). Some of the significant effects of these policies include distortions in the prices of inputs through subsidies, such as those applied to irrigation water in the region. Such a subsidy is of dubious appropriateness in a country where guaranteed access to safe drinking water is sometimes restricted to the upper classes due to the failure of government to provide it for free (Stats SA, 2004). However, even this politically expedient arrangement will be impossible in the future if climatic and demographic projections for the region prove correct (Falkenmark, 1990). Thus, environmental variables such as climate and population, by controlling water supply, effectively also exert a strong influence on agricultural economic policy in the region.

Grain and grape are both grown for sale in the Swartland. In 2002, viticulture in South Africa produced average gross returns of R18,952/ha (calculated from SAWIS, 2004), while average gross returns for grain were only R3945/ha (calculated from NDA, 2004). Thus, a change from grain to grape cultivation probably means increasing amounts of economic wealth flowing into the region, at least in the short term. Regardless of the direct environmental impacts of the two types of agriculture, conservationist policy, including unconditional preservation of "natural" areas, generally gains a better reception in wealthier areas (e.g. Shogren et al., 1999;

Bovernberg & Smulders, 1996). The results of this study suggest that natural areas in the Swartland support the healthiest soils and biotic communities (see sections V and VI of this report). Therefore, the amount of economic wealth in the region has important implications for conservation. Similarly, the reception given to ideas of sustainable agriculture and natural land preservation is influenced by social conditions, such as economic inequities, in the region (e.g. Arrow et al., 1995; Tickell, 1996). Agricultural labour practices may thus also exert an indirect influence on the health of the local environment.

Finally, the difference in the agricultural products themselves has important socioeconomic and environmental implications. Wheat grown in the Swartland generally contributes to food production within South Africa; grape is generally converted into wine for both domestic and international consumption (NDA, 2004). The importance of nutrition in a developing nation, especially one plagued by HIV/AIDS and other endemic diseases, hardly needs to be discussed here. In this context, the wisdom of entrusting international markets with the country's food security seems somewhat dubious (refer to section III.2 for a detailed discussion of global agricultural markets).

Socioeconomic changes resulting from nutrition and health variables must have an important effect on the amount of pressure the population applies to the country's natural environment. Once these connections are made, it becomes clear that the health and economic status of South Africa's population as a whole, as well as the fate of the nation's natural environment, are closely tied to the crop regimes in the Swartland.

LIMITATIONS OF THE RESULTS

The limitations of our field studies are of three major and interrelated types: uncontrolled variables, sample size and methodology. All of these limitations have been discussed in detail in various sections of this report. The above discussion of variables other than crop regimes which affect the environmental and socioeconomic impacts of viticulture and grain cultivation and, thus, our results could easily be taken as a summary of uncontrolled variables. The extremely small sample size and methodological difficulties involved only compound the problems of interpreting results in light of these variables. Overall, the limitations involved in the data presented here are such that, as has been noted, they must be used not to draw immediate conclusions but rather as a starting point for future, more detailed research.

ACKNOWLEDGEMENTS

We would like to thank the owners and managers who let us conduct our research on their farms, especially J. de Flamingh and D. Graaf (De Grendel), R. and M. J. de Wit (Hooggelegen) and M. Smuts (Grasrug). We would also like to thank the staff of the Tygerberg Nature Reserve. A special thanks goes to Sayed Hess and Mandy Innes for their gracious assistance to us during the course of conducting this research and their unflagging friendliness. We would also like to thank all of the experts who consulted with us on various sections of this report and all of the researchers who tackled various aspects of this topic before us (see sections for subject-specific acknowledgements). We are also grateful to the staff of the Department of Land Affairs: Surveys and Mapping, Mowbray. Finally, we would like to thank our advisor, Mike Meadows, and his hard-working assistant, Sharon Adams.

REFERENCES

Arrow, K., B. Bolin, R. Costanza, P. Dasgupta, C. Folke, C. S. Holling, B.-O. Jansson, S. Levin, K.-G. Maler, C. Perrings & D. Pimentel. (1995) Economic growth, carrying capacity and the environment. Science, 268 April, pp.520-521.

Bovernberg, A. L. & S. A. Smulders. (1996) Transitional impacts of environmental policy in an endogenous growth model. International Economic Review, 37(4) November, pp.861-893.

Falkenmark, M. (1990) Rapid population growth and water scarcity: the predicament of tomorrow's Africa. Population and Development Review, 16, Supplemental: resources, environment and population: current knowledge, pp.81-94.

National Department of Agriculture (NDA). (2004) Abstract of Agricultural Statistics. Pretoria, National Department of Agriculture.

Shogren, J. F., J. Tschirhart, T. Anderson, A. W. Ando, S. R. Beissinger, D. Brookshire, G. M. Brown, Jr., D. Coursey, R. Innes, S. M. Meyer & S. Polasky. (1999) Why economics matters for endangered species protection. Conservation Biology, 13(6) December, pp.1257-1261.

South African Wine Industry Information and Systems (SAWIS). (2004) South African Wine Industry Statistics No. 28. Paarl, SAWIS.

Statistics South Africa (Stats SA). (2002) Non-financial Census of Municipalities, 2002 (discussion document). Pretoria, Stats SA.

Tickell, C. (1996) Economical with the environment: a question of values. Journal of Applied Ecology, 33, pp.657-661.

IX.
Appendix

An Outline of Questions Asked During Interviews with Farmers

General Information

When was the farm established, by whom, and under what circumstances?
What was the status of these lands before this?
How many hectares is the farm?
How many hectares are devoted to grain? To grape? Under other uses? Are there any remnants of "natural" vegetation on the farm?
How long have current vineyards been used for grape, and current grain lands been in grain?
If applicable, what varieties of grain or grape are present on the farm?
Any details about the history of land use (including crop rotation) on the farm will be appreciated.
Do you ever leave fields fallow or rotate crops?

Economic Information

How much is spend on yearly expenditures such as fertilizer, pesticide, new machinery, water and seed?
Where are your products sold? Are they consumed domestically? Exported? If so, to where (continent, country)?
Have the purchasers of your products changed significantly since 1994?
Do you receive any government subsidies? In times of drought, do you receive government assistance? If you receive subsidies, how have they changed since 1994?
Is your business expanding? In general, is business getting better or worse?

Employment Information

How many people does the farm employ? Does this number fluctuate greatly from year to year?
What is the numeric breakdown of the type of employment?
What specific tasks are employees responsible for?
Has this breakdown changed greatly over time?
What percentage of expenditures is spend on labour?
How long does the average age of a field remain working for you? Is most labour seasonal or year-round?
What is the average age of a field employee?
What percentage of employees is male/female?
Do most workers live on the farm? If so, do they usually live as a family unit?

Science questions
Fertilizers
What are the chemical compositions and amounts of fertilizers applied annually on the farm?

In which season(s) are they applied?
If applicable, what is the break-down of amounts and types applied to grain, grape, and to other lands?
How (if at all) has fertilizer use on the farm changed over its history?

Pesticides
What are the chemical compositions and amounts of pesticides, herbicides or fungicides applied annually on the farm?

In which season(s) are they applied?
If applicable, what is the break-down of amounts and types applied to grain, to grape, and to other lands?
How (if at all) has use of these chemicals on the farm changed over its history?

Other
Are there any other land use, chemical or biological details which you think would help us in our study of biodiversity in the farm's fields?

What (if any) irrigation system do you use?
How much water do you use in each month/season?
Do you take any methods to prevent soil erosion on your land? If so, what are they?