Australian Nuffield Farming Scholars Association

Epsom Road, Ascot Vale VICTORIA 3032.
Telephone (03) 9281 7424

Report of the Study Tour to Poland, North America and South Africa

By Jane Greenslade
1995 South Australian Nuffield Scholar

SUBJECTS:
A Review of Sustainable Agriculture

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An International Scholarship for Australian Farmers

The Nuffield Farming Scholarship Scheme is now firmly established in the United Kingdom, Australia, New Zealand, Canada, Zimbabwe and France and it is probable that other countries will join the scheme in future years.

Each country has its own independent Association responsible for funding, selection and administration.

The United Kingdom remains the focal point of the Scheme, with the United Kingdom Nuffield Farming Scholarship Trust providing an overall secretarial / liaison service.

Since 1950, more than 800 Nuffield Farming Scholars from the participating countries have criss-crossed the world studying a range of agricultural, trade, political and cultural issues.

Each country awards two or more scholarships annually and as a general rule, scholars from all countries assemble in the United Kingdom in February each year for approximately four weeks of group study before pursuing their individual programmes in the United Kingdom and / or other countries.

The interchange of scholars between countries is facilitated, costs are reduced and the standards of study enhanced by the Association and individual scholars in each country accepting an obligation to assist visiting scholars with itineraries, introductions, travel arrangements and accommodation.

This "Nuffield Network" has become a potent force within the overall scholarship scheme and it is constantly reinforced through the holding of a World Conference in one of the participating countries every three years.

These conferences are usually attended by over 150 former scholars at their own expense. They are concerned with the maintenance and improvement of the scholarship scheme and at the same time they provide an opportunity for former scholars to further expand and increase their knowledge of farming and related issues.

The Scholarship

The scholarships are awarded annually by the Australian Nuffield Farming Scholars Association to enable established farmers to travel to the United Kingdom and other countries for the purpose of increasing their knowledge of practical farming and the broader issues of agricultural production.

Obligations

Scholars are required to devote the whole of their time to a programme approved by the Australian Management Council; to resume residence in Australia upon completion of the scholarship; to submit a written report to the Association covering the study programme completed under the award; and to communicate details of their newly-acquired knowledge and experience to other Australian farmers.

Eligibility

The scholarships are open to Australian citizens of either sex who are engaged in farming of any kind in their own right or managing a commercial farming enterprise, and intend in the future, to enagage in farming in Australia. The preferred age is between 25 and 40 years, although outstanding applicants outside of these age limits may be considered.

Tenure and Location

The scholarships are tenable for four months. Initially a minimum of six weeks must be spent in Asia and the United Kingdom; a group orientation study with the Award winners from other countries is undertaken during this period. Scholars are then able to pursue their individual study programmes.

The United Kingdom Farming Scholarship Trust, the national Farmers Union and the Ministry of Agriculture provide generous support and assist in the development and execution of these programmes. Should successful applicants have farming interests which are not practised in the United Kingdom, they are permitted to complete their study programmes in the country or countries best suited to their pursuits.

Application Procedure

The Australian Nuffield Farming Scholars Association allocate a scholarship to each of the States and the Northern Territory once every three years in rotation.

Applications are invited by advertisements in the daily press from February to May; final selection takes place in August and the scholars are expected to arrive in the United Kingdom in February of the following year.

Further information is available from:

The Secretary
The Australian Nuffield Farming Scholars Association
Royal Showgrounds
Epsom Road
Ascot Vale VIC 3032
Telephone (03) 9281 7424 Facsimile (03) 9376 2973
Email rasv@melbourne.net

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Acknowledgements

When I applied for a Nuffield Scholarship in 1995, I had little idea of the opportunities that I was about to experience. Nothing could prepare me for the depth, breadth, and wealth of personal, cultural and professional experience that I, as a scholar, was about to receive.

Becoming a Nuffield Scholar has given me an invaluable look at agriculture internationally. By talking with farmers and scientists, many at the leading edge of their field, I have gained an insight into their diversely multicoloured cultures, concerns and objectives. I have learnt from their successes and failures and been motivated by their passion for the agriculture of today and the future.

Without the support and encouragement of my parents Jack and Lois, none of this would have been possible. They say that those who stay behind are the 'real' scholars. I will be forever grateful that they, by taking on the role of the 'real' scholars afforded me the opportunity to undertake my scholarship.

My thanks to my referees Dr. Peter Sanders and Mr. Alex Brown for their words of support. To the Nuffield selection committees in Adelaide and Melbourne, thankyou for having the faith in me and my potential as a Nuffield Scholar.

I would also like to express my thanks and appreciation to my sponsors QANTAS and HI-FERT for their advice and financial generousity in giving my scholarship wings and wheels and making it a reality.

Thanks to James and Barbara Nelstrop of Roudham Farm, Norfolk, who opened their house and hearts to a most exhausted scholar. Wonderful hosts who refreshed and rejuvenated my travel weary self.

To the network of professional agriculturalists, farmers, academic institutions, scientists and consultants who gave generously of their time and willingly of their knowledge and expertise, my sincere thanks for the opportunity to discuss their operations. Thankyou especially to the many wonderful host families and individuals who with overwhelming goodwill and hospitality shared their lives and homes with me.

Last, but by no means least - to my fellow scholars;

Helen Murphy	NT	Tony Seymour	WA
Russel Reid	NT	Carol Millar	Zimbabwe
Richard Thorneycroft	Zimbabwe	Doug Visser	Canada
Norm Jansen	Canada	Jean Thoby	France
Stuart Wright	New Zealand	Doug Brown	New Zealand
Murray Taggart	New Zealand		

For 6 weeks we shared our lives (and lived to tell the tale !) froze, thawed, laughed and learnt together. It was an unforgettably special experience from which I have many treasured memories. Thankyou for the friendships, the humour, support and ongoing inspiration.

Nuffield opened doors all over the world, giving me opportunities hitherto undreamt of, both associated with agriculture and non-agriculture. I was forced to step out of my comfort zone, consistently meet challenges and fears head on. As a result I am changed and enriched by the experience. My scholarship has imbued me with a sense of optimism and enthusiasm for agriculture and my own future as a farmer.

Objectives

My objective was to study systems of long term sustainable agriculture, that is, responsible farming and its consequent relevance in an Australian context.

To meet this objective I aimed to look at farming systems which took into account the combined characteristics of production, economics, community and environment, all with a long term view to viability.

My topic was broad and diverse. Nuffield gave me the opportunity to travel widely, studying some of the various systems being researched, developed and practised around the world. These included two research sites worthy of mention:

- the Agro-ecological Chlapowski Landscape Park at Turew in Poland
- The Land Institute, Salina, Kansas and their development of perennial crops in conjunction with Kansas State University, and several systems being researched globally including:
- Holistic Resource Management,
- Precision Farming,
- Alley Farming,
- Organic Farming,
- Integrated Crop Management,
- Direct Drilling and Zero-till systems.

Introduction

"Let's quit treating our soil like dirt." *The Land Institute*

Australia's soils are the oldest and most fragile in the world. They are low in soil organic matter and nutrients. Land degradation, primarily erosion and salinity, already affects more than 50% of Australia's rural areas. Hence the maintenance of soil structure and land productivity is vital, underpinning the production viability and sustainability of our farms.

With the advent of Quality Assurance, market globalization, and acute consumer awareness (in particular food safety), regulations and production limitations are increasingly causing producers to assess their farming systems.

There can be no doubt that these environmental and economic concerns are influencing Australia's farming practices more than ever before. The emphasis on sustainability is gaining importance and pace.

My personal concerns about my farming future begged the questions "Is there a way to grow high production crops without such high cost inputs, both environmental and economic?" "Are my farming practices sustainable in the long run or will they adversely affect my human community, my immediate environment - soil, air, water, flora, fauna, and ultimately the 'hip' pocket?"

With these thoughts in mind and my scholarship in hand I somewhat naively set out to find a blue print for farming sustainably. I found myself in a state of confusion until I accepted the broadness of the concept and its applications. Sustainable agriculture has many dimensions, many interpretations and many definitions. It is not, for instance, confined to the system of organic farming as many people tend to assume.

Traditionally, our world has been viewed with scientific crispness, limits and absolutes. This view is no longer adequate to deal with the real complexity of our natural resources.

The concept and application of sustainable agriculture is not finite but dynamic, the following definitions help to illustrate the 'fuzzy' nature and adaptability of 'sustainability';

"The combination of responsible farming practices which balance the economic production of crops with measures to conserve and protect the environment." *The German Plant Protection Act of 1986*

"An holistic pattern of land use, which integrates natural regulation processes into farming activities to achieve a maximum replacement of off-farm inputs and to sustain farm income." *Dr. Adel El Titi, Lautenbach Project, Germany*

"Sustainability is a question rather than an answer, sustainability is a direction rather than a destination, like a star that guides the ships at sea but remains forever beyond the horizon." *Robert Rodale, Rodale Institute, Penn. USA*

"Sustainable agriculture is the production of food and fibre of suitable quality in optimal quantities in a manner that is resource efficient, resource conserving, environmentally sound, economically feasible, and socially supportive." *Soil Conservation Service ,USDA USA*

The 'fuzziness' of sustainable agriculture allows for different people to fulfill different objectives for different reasons, and has an aptitude for compromise. It is an umbrella concept which can provide the rational for overlapping consensus.

Basically the fundamental criteria for agricultural sustainability are;

1. Economic viability,
2. Optimum production ,
3. Ecological soundness,
4. Social responsibility.

Agroecosystems and Landscape Ecology

"Intensification of agriculture in many parts of Europe has triggered many secondary effects, including increasing vulnerability to flooding, ground water pollution and impoverishment of biota." *Professor Lech Ryszkowski, Director Polish Academy of Science , Poznan.*

Poland , in particular the West Poland Lowland , became the first destination of my study, to look at Agroecosystems and Landscape Ecology.

In Poland, environmental considerations with respect to agriculture have gained momentum due to increasing evidence of soil, water and air pollution. 60% of Poland's total landmass is comprised of rural areas where 35% of Poland's population of 40 million are based. Thus, as in many areas in the world, it has been suggested that when formulating programs for agriculture, social and environmental as well as productive outcomes must be recognized.

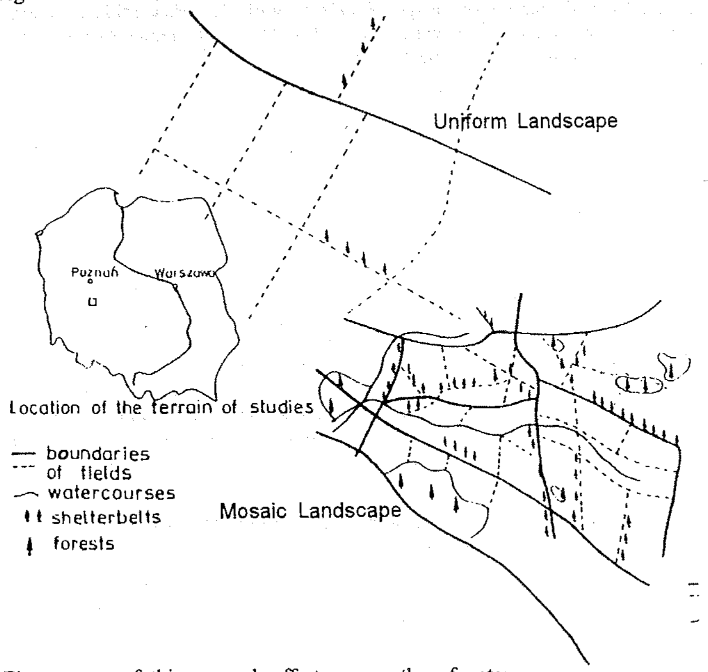
The Chaplowski Landscape park is the model for the long term research being undertaken by the Research Centre for Agricultural and Forest Environment at Turew, SW of Posnan.

Originally established to research improvements in crop production, the Field Station at Turew changed its emphasis to that of Agroecosystems and Landscape Ecology, in 1975. This change in research direction focussed on the landscape as a whole, encompassing the historical agricultural culture as an intrinsic part of a greater ecological system, that is constantly evolving. Thus the health of agriculture became measurable not only by standards of production but by the health of the entire ecosystem, hence agroecosystems.

The research in Landscape Ecology deals with the influence of spatial patterns in the rural landscape, including the influence of landscape boundaries on water cycling, nutrient cycling, modifying the movement of organisms (including pests and pathogens) as well as microclimatic conditions.

The research at Turew focuses on the study of 2 landscapes in parallel; a uniform landscape and a mosaic landscape. [see figure 1]

Figure 1: ***Area of Studies***



Five aspects of this research effort are worthy of note:

1. This research has its roots in basic science. Agricultural systems research is usually done by agronomists and other agricultural scientists, not as part of an ecological whole.
2. The research is long term in nature.
3. The principal focus of research has been at the landscape level and its spatial influences.
4. There are a diversity of disciplines involved in the research ie. 75 staff working in the areas of hydrology, biochemistry, biophysics, limnology, botany, entomology, ornithology and soil science. This provides the basis for extremely fruitful cross-disciplinary work.
5. Collaborative research at a regional and international level, eg. International Association of Ecology, UNESCO-MAB Comparative study on land use change in Europe.

The results of the combined studies suggest that a mosaic landscape structure of small cultivated fields, shelterbelts, meadows, and small ponds enhances water storage, controls groundwater chemistry, reduces soil erosion and structural degradation and helps maintain biological diversity.

The following aspects of this research benefit the mosaic landscapes as explained.

(i) **Water cycling** is greatly influenced by the structure of plant cover by:

- affecting the balance between soil runoff and soil percolation by as much as 65mm between forests and cultivated fields.
- reducing ground water movement.
- improving water storage capacity by up to 60mm.
- improving water savings during hot, windy weather in a shelter-rich region compared to a uniform plain field being up to 40mm.

(ii) **Groundwater pollution** has been significantly reduced using shelterbelts, meadows and small ponds to intercept the groundwater flow from cultivated fields. These 'biogeochemical' barriers can:

- filter chemical compounds from the water flow before it enters the water basin by up to 80% in the case of nitrates.
- accumulate the nutrient rich sediment which is deposited on the bottom of ponds leached from surrounding fields to be used to refertilize those fields.

Thus facilitating in the recovery of mineral nutrients 'lost' from the field.

(iii) Biodiversity is greatly influenced by the landscape structure. Studies indicate that during the period 1965-85 an increase in tillage activity and the unregulated application of pesticides and fertilizers drastically reduced overall biota. In a mosaic landscape arable fields, interspersed with shelterbelts, hedgerows, meadows, swamps, ponds and ditches, provide a refuge and overwintering site for many species. Biodiversity has been found to be considerably richer in these areas. Bird communities, predatory and parasitic insects, and soil organisms are all higher in density and diversity.

(iv) The importance of **shelterbelts** within this landscape cannot be overstated. Shelterbelts;

- act as powerful 'natural water pumps' to influence groundwater chemistry,
- ameliorate microclimatic conditions in adjoining fields,
- strongly influence wind velocity. The air turbulence on the leeward side slows down wind speed. The cumulative effect of consecutive shelterbelts on windspeed can reduce the mean wind rate over the area covered by up to 50%. The change in wind velocity also influences atmospheric evaporative demand.
- can influence the distribution of rainfall and snow cover by eddy currents around the shelterbelts.
- can collect 20-80mm more water than open landscape due to less surface runoff.
- consisting of more than one species have more effective nitrogen uptake due to the species different preferences for different nutrients. [see fig. 2]

The recognition of mosaic landscape structures on the maintenance of biological resources in Poland has provided a basis for a national strategy on the protection of natural resources, while optimizing agricultural yield. As a result of their research findings, these strategies will be used to alleviate and combat future environmental threats on a holistic scale. The work I saw in Turew, both in the field and in the laboratory, gave me a working knowledge of these realistic strategies being developed.

Natural Systems Agriculture and Perennial Polycultures

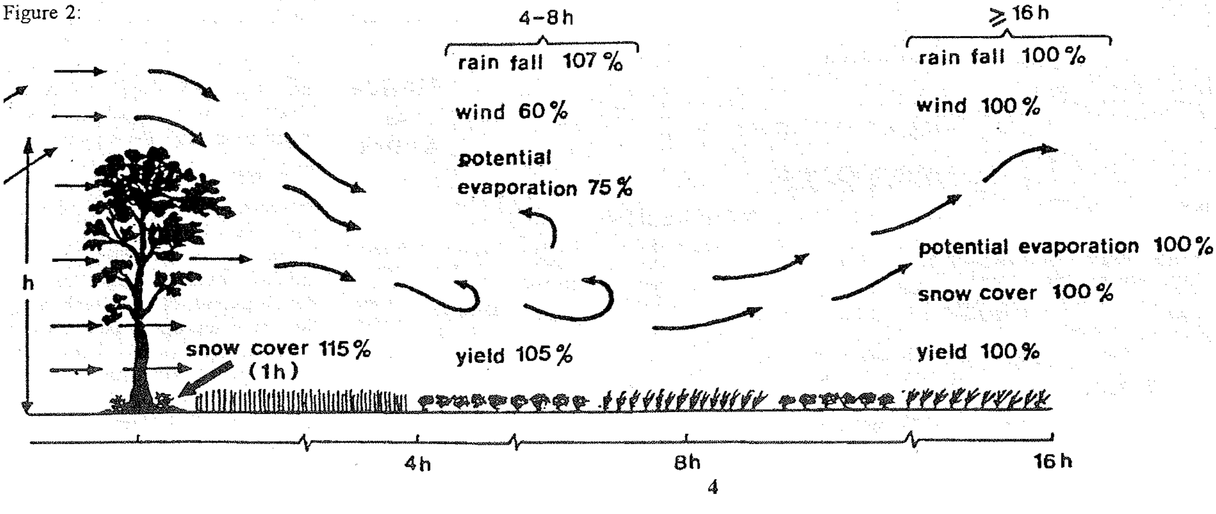
"The more we have come to understand the processes that drive agriculture and all other ecosystems in this environment, the more we have become aware that agriculture as presently practiced has caused disruption to these processes to the point where the resource base of agriculture is being undermined. This then is the dilemma: agriculture is slowly undermining its own existence." *Ted Lefroy WA department of Agriculture*

In my quest to find systems of sustainable agriculture, I did not expect to find research with a long term time frame to achievement set at 50-100 years. This is exactly the goal of the Land Institute at Salina, Kansas which is in pursuit of viable perennial grain crop alternatives to conventional farming. One requires a huge amount of perseverance and vision with this kind of goal in mind. Wes Jackson, who established the Land Institute in 1976 is just such a patient visionary. Considered by many to be pursuing an obscure esoteric lifestyle somewhere ' way out in left field', Wes Jackson's ideals and philosophy have gradually gathered credibility and respectability amongst some of his most ardent critics. So much so, that in 1996, the 20th anniversary of the Land Institute, a joint venture with the Kansas State University and Konza Prairie, has guaranteed the persistence of the initial research of the Land Institute and brought it into the world of mainstream science. However, the long term outlook until the 'release' of the perennial system as a viable agricultural option is still 50-100 years! While for many this is too long to wait, it often takes extremes of this nature to bring balance and change within our own 'known' worlds.

As for the impetus for this research Wes explains "While soil erodes in the rolling wheat fields , it stays put in pastures and in native prairie grassland. Soils have stayed put for a long time on the prairies, independent of human action. With the wheat field comes pesticides, fertilizer, fossil energy and soil erosion. The prairie counts on species diversity and genetic diversity within species to avoid epidemics of insects and pathogens. The prairie sponsors its own fertility, runs on sunlight and actually accumulates ecological capital, accumulates soil." Observing this, Wes formulated the question: "Is it possible to build an agriculture based on the prairie as its standard or model?"

Such a system would feature perennial grain crops grown in mixtures ie. perennial polycultures. Like the prairie a perennial polyculture would hold soil, cope with insects and disease, and conserve water. Unlike the prairie this system

Figure 2:



would produce significant yields of grain.

At the Land Institue, four questions are asked to understand how perennials work in a productive polyculture:

1. Can perennialism and high yield go together?
2. Can a polyculture of such perennials out yield a monoculture?
3. Can we get such an ecosystem to sponsor its own nitrogen fertility?
4. Can this polyculture control insect pathogens and weeds?

In answer to these questions the Land Institute's research has focussed on:

- studying the prairie system itself in an effort to understand the resilient and regenerative processes of the prairie,
- developing perennial crops,
- investigating perennial mixtures in a polyculture system mimicking prairie plant ratios.

Selection criteria for useful plants are their potential for high seed yields, winter hardiness, and the ecological role they may play (eg. legume/cereal).

The results of crop species researched to date include:
Eastern Gamma Grass: a warm season relative of corn: contains 27% protein, 7% fat: fixes small amounts of nitrogen: rhizosphere of the plant leaks sugar which feeds soil bacteria: yields up to 1.3-1.4t/ha (comparable to non-irrigated soybeans).
Illinois Bundleflower: a nitrogen fixing legume: produces seed equivalent to soybean: 38% protein, 34% carbohydrate: yields up to 2.4t/ha.
Perennial Sorghum: a hybrid of wild perennial sorghum and a domestic annual variety: yields up to 11.76t/ha..
Maximillian Sunflower: 21% oil: useful allelopathic characteristics which inhibit weed growth.

As a comparison , the Mid-West produces 12.5t/ha of corn and 5t/ha wheat.

The benefits of perennial grain crops include:

- the use on marginal lands that cannot and should not support annual crops.
- the reduction of soil erosion.
- the reduction of inputs necessary to produce grain crops.

The development of such a system however has significant obstacles. Research to breed palatable species which produce high seed yields is extremely long term. Management techniques which encourage seed production, maintain the longevity of high seed yields and accommodate the production of annual and perennial crops need to be refined.

While this research is truly in an embryonic stage, it is totally different to anything else I saw mainly by virtue of its emphasis on the perennial rather than annual herbaceous crops. But, also by its seriousness in learning from nature rather than attempting to dominate or control nature. It involves an objective on a different plateau to traditional research. It does not seek to put farmers out of business - that would negate its claim to sustainability - but rather to incorporate farming homogeneously within a greater natural system.

Holistic Resource Management

"Control your own destiny, or someone else will."

Now gaining world wide acceptance as a decision-making tool for sustainable farming, Holistic Resource Management (HRM) was developed by Zimbabwean Allan Savory. Facing successive problems with his conventional grazing management techniques, Savory studied his African savannah surroundings for clues to a more sustainable answer.

What he found has developed into a practical decision making process designed to evaluate the farm enterprise in terms of a whole system. It is an old idea with new applications. " 'Holism' is the idea that nature only functions in wholes, rather than 'interconnecting parts' and that nature will never be understood by studying the 'parts'." *Jan Smuts, 1926, South African Statesman.*

HRM is a decision-making process which can be applied to any farm or business. Its philosophical basis is one of wholeness. It has been designed to specifically give the same status to the environment as to economic and social considerations. This automatically involves a less traditional thought process by actually giving a value to natural resources which are an integral part of any farm. For instance, in most farming practices the soil is not actually attributed with a value, it may be valuable, but is not given a quantifiable value. As with family farm labour, it is also valuable, but not economically valued. In many cases this practice contributes to a declining quality of life as farmers and their families become caught in the cost/price/ debt squeeze.

HRM uses a model much like a map to facilitate the decision making process. [see figure 3]

The first step of HRM is to develop a goal, accounting for capital, people and their natural resource base. This recognition of all resources is crucial for the persistence and succession of the farm. The goal must go beyond year to year production planning. It must step beyond the short term and into future planning. Being based on the assumption that diversity is the basis of a healthy system, it involves the quality of life of the people, the forms of production to produce profitability and the future of the resource base.

In the process of achieving a goal it must undergo constant planning, monitoring, controlling, and replanning. An assessment of the raw materials available, tools to hand, and how and when to use them, must be made.

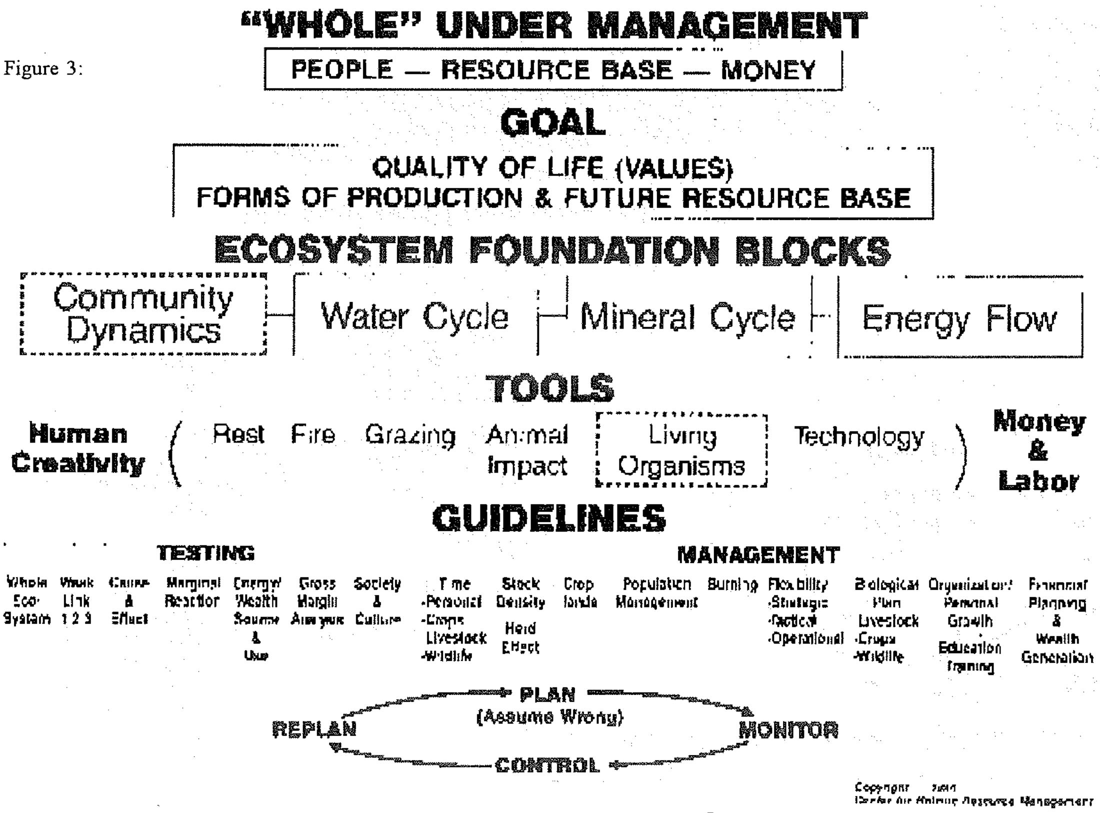
The most difficult part of this model to comprehend are the ecosystem foundation blocks. We are used to implementing guidelines by which we farm. However we are not accustomed to considering self-sustaining levels of our natural resource base. Conventionally, we maximize profits. This process requires an optimization of profits.

HRM has captured the attention of proponents of a more sustainable food and fibre production system in recent years because of its ability to help farmers through the tough decision making required to step out of the mainstream.

To me, HRM appeared to offer a series of steps we can implement objectively to responsibly take control and ownership of ones' own situation. This includes articulating our own social and personal needs, and goals relating to our environment, as well as analysing and assessing our business practices. It is a flexible process applicable to many different circumstances, relying on balance and diversity. It is a planning process which is under continual assessment to maintain its relevance and directions so as not to be vulnerable to 'phases' or 'fads'.

HRM offers a simple diagnostic method, but one which requires persistent commitment, to visualize a future, plan for a future (especially profit) and take steps in the direction of that future. HRM is not for everyone, but I believe that it certainly has a role to play in the pursuit of sustainability. A government initiative in Minnesota U.S.A. called the Land Stewardship Project has adopted the fundamental principles of HRM. This has greatly improved public accessability and generated wide interest in HRM's applicability, and I believe has gone a long way to 'mainstreaming' the concept.

Figure 3:



Precision Farming

Precision farming has the computer and scientific community abuzz. There is more excitement and more money being spent on the development of this technology than in many other 'new' areas of agriculture. Also known as Prescription Farming, Target Farming or Site-specific Farming, this rapidly developing technology is taking hold.

Precision farming is about the exact determination of soil requirements per specific field site, resulting in targeted site specific applications of fertilizer and chemicals in the pursuit of increasing production and decreasing inputs.

Precision farming promotes variable rate management within a field according to site and soil conditions. This is done through the collection of spatial data (using Global Positioning Satellite technology), which when computer generated (using Geographic Information Systems) produces images of variations in field soil types, crop yields, weed sites, nutrient status etc. According to the analysis of this information, variable rate treatment is applied for tillage, seeding rates, fertilizer rates, weed control, etc. The results are then evaluated.

It requires a systems approach with the overlapping of different field maps to generate a whole field picture. This leads to a better understanding of the effect of soil types, technology, topography and climate.

The benefits of precision farming technology are to improve productivity, reduce costs, optimize equipment efficiency and reduce environmental damage through efficient targeted application of inputs. This technology has woken the agricultural industry up to the fact that more precision is required in modern farming.

However, Precision Farming does have its critics:

- generally the concept of Precision Farming and the technologies that go with it are not well understood by farmers.
- it is a system based on historical data and is not predictive.
- this system is generating more questions but with no more answers, ie. the interpretive information is not yet available.
- total commercial availability is 2-3 years away.
- cost of technology hardware and education requirements are daunting for most farmers.
- software engines to interrelate data between layers is lacking.
- its a military based system which is not owned by farmers, but by the US Defence Department and is therefore subject to future increasing costs.
- research has found more correlation between soil type and yield; soil pH and yield, salinity and yield, than variable application of fertilizer and yield.
- 'no cost' precision farming can be implemented by farmers immediately just by intensive crop monitoring ie. crop walking.
- moisture is still the primary limiting factor.

The general consensus amongst scientists and economists is that the technology, as it stands, would not be profitable for most farmers. However, it is being touted as the 'not too distant' futures' more economic method of farming.

Typically it may not be seen as relevant to systems of sustainable agriculture. However, this high-tech. revolution could, I believe, have some very useful practical applications. In theory Precision Farming has the potential, by greatly improved accuracy of seeding rates, fertilizer and chemical applications, to actually reduce their use, and improve their efficiency. This will have environmental implications and benefit the whole farm and its surroundings.

Alley farming and Shelterbelts

Throughout the diversity of countries that formed my study, the use of shelterbelts within farming systems was very evident As the Polish experiment demonstrates, incorporated in a mosaic landscape, shelterbelts reduce erosion and wind speed, create a microclimate effect, provide habitat for flora and fauna, help reduce evaporation and act as a buffer zone.

On the flat prairies of North America and Canada farm houses and sheds not surrounded by trees can suffer winter temperatures 30-50% lower than those with effective shelterbelts (not to mention the wind chill factor). Although historically flat, grassy, treeless plains, the 'Dirty 30's' generated mass plantings of shelterbelts in an attempt to halt any repeat of the drastic soil loss and degradation. These old shelterbelts are very evident, as are new ones, criss-crossing the plains of Northern America.

The benefits of these shelterbelts have been well documented. Not only have they reduced soil loss through erosion, but increases in spring soil water supplies due to snow trapped next to shelterbelts has resulted in increasing yields. However, if shelterbelts have not been strategically placed, this entrapment can also cause ponding and water inundation. Generally crop yield responses to shelterbelts have been documented as higher in dry than in wet years, ranging from 3.5-20% gain. In quantitative studies undertaken, the sheltering and competitive effects of shelterbelts on the adjacent crop are accommodated. Similar research conducted throughout the world is arriving at similar results.

In Australia and South Africa, indigenous and exotic perennial trees and shrubs are being planted in a unique approach known as Alley Farming. This is not a new term, however, it usually refers to highly intensive interrelated cropping in tropical zones. Alley farming, as I studied it, has been designed for temperate zones, dryland cropping and livestock situations.

Australia and South Africa virtually developed their Alley Farming Systems in parallel. They are both systems which employ purpose built shelterbelts to achieve a range of functions, namely fodder production, salinity and erosion control, and sometimes timber production. The shelterbelts are not planted indiscriminantly, but in planned alleys in between which cropping takes place. Therefore the width between alleys is largely determined by multiples of the widths of cropping machinery, eg. 60-250m.

In South Africa the dominant variety of shrub used in the alleys is atriplex nummularia, better known as Old Man Salt Bush. It was first recorded growing on the site of a Boer War Kraal, where horses were fed with hay imported from Australia. Anecdotal evidence from farmers indicates that the use of saltbush alleys in winter rainfall zones of 175-350mm has had a three-fold effect:

1. allowing a significant increase in carrying capacity, from 1dse/6ha up to 1dse/3ha in some cases.
2. allowing the natural Bushveld a rest period over the normally less palatable summer months, while the sheep feed on saltbush and crop stubble residue.
3. wind erosion has been greatly limited.

While I saw many examples of successful Alley farming in South Africa and the use of shelterbelts in Europe and Northern America, I cannot ignore the Australian experience.

By virtue of our ancient vast landscape and climatic differences, Australia has developed a slightly more diversified approach to Alley Farming. Saltbush is gaining widespread popularity as a species choice, largely because of its fodder characteristics. Indigenous vegetation also is selected for incorporation into shelterbelts for its unique fodder, shade, timber, water cycling and more recently, native food and flora characteristics. Exotics, such as Tagastaste (*chamdecytisus palmensis*, from the Canary Islands) and *Pinus radiata*, are also used. Both species have been the subject of extensive research in Australia, specifically Tagastaste for supplementary grazing purposes and *Pinus radiata* shelterbelts for their effect on cropping yields - reporting 18-20% increases. (see Figure 2).

Salinity, erosion and waterlogging due to widespread scrub clearing for crop production is increasing at an alarming rate in Australia. Alley Farming has been widely recognized as a tool to help limit these problems.
I can only see the use and manipulation of such shelterbelt systems as extremely beneficial tools available to the farming community. This will not only help control problems but also enhance our fragile landscape and the diversity of habitats for our unique Australian fauna.

Organic Farming

"By the time Direct Drilling becomes 'conventional' Organic Farming will be the new threshhold." *John Bennet, Direct Drill farmer Canada.*

Organic Farming is considered to be the quintessential example of Sustainable Agriculture. In fact, upon initial contact many people I spoke to thought that by sustainable agriculture I meant organic farming. However, organic farming is in reality merely another system striving towards sustainable agriculture. It suffers from limitations and problems along with all other systems.

Organic Farming practices do not follow a range of well defined management techniques. Rather they are a range of technical and management options used on farms striving to protect health and environmental quality, enhance beneficial biological interactions and natural processes and to reduce costs. Instead of chemicals, organic farmers use legumes, crop rotations, intercropping, livestock manure, composting and integrated pest management practices to run their operations.

Organic farmers are dedicated to soil building and protection. If they lose their soil, they lose everything. They are on the whole far more aware of the health of their soil than conventional farmers. Due to their reliance on chemicals and fertilizers, conventional farmers often ignore the importance of this life sustaining resource.

Organic farming, by definition, uses no synthetic chemicals for pest or fertility control. For this reason alone, the majority of today's farmers cannot contemplate farming with such constraints. They view organic farming with extreme sceptism, mistrust, and disbelief.

Contrary to these views, I found a growing acceptance of organic farming principles by the scientific community, which in some cases spread into the conventional farming community. Several different reasons account for this acceptance and curiosity:

- organic farmers are largely motivated by a deep concern for the health of their environment, which is reflected in their management practices. These techniques are attracting attention as the environment is included on the agricultural agenda.
- organic farming is complex and evolving. It is management-centred and information-driven and does not operate by formula. It is the challenge of these management techniques which are attracting scientists and farmers alike.
- as soil fertility builds and careful, flexible management techniques are implemented, organic yields are increasing. Thus making it very competitive with conventional farming and very attractive by virtue of its clean, healthy image. Even conventional farmers do not like handling dangerous, toxic substances.

Current research conducted in the U.S.A., Canada and Europe indicates that organic yields are lower than conventional yields. However, economic comparisons show that, on average, organic farms compare favourably with conventional farms. This is mainly due to lower input costs to the organic farmer. In many cases, when premiums for organic produce are included, calculations on organic farms show economic superiority. It seemed to me that in densely populated areas, eg. U.K. and the U.S.A., with relative price security the uptake by farmers of organic farming is increasing rapidly. I see

this as a result of improved research and changing farmer attitudes towards their own personal health and their environment.

Organic farming is largely an unknown, untapped, field of knowledge and practice for the majority of Australian farmers. Our shallow, poor soils and small market place pose considerable barriers to organic farming, compared to the deep, rich soils and large population base of Northern America and Europe. However, I believe this method alone presents the greatest future challenge to us as farmers in a changing world of attitudes and practices.

Integated Crop Management

Integrated Crop Management (ICM), as being promoted in Europe and America, is a system which challenges the high input farming which has evolved in these two regions during the 20th Century. I found ICM to be remarkably similar to current traditional mixed farming practices in Australia. This, I have concluded is largely due to the 'comfort zone' afforded by the subsidy system practiced on those two continents, which has resulted in a mentality of maximum output at any cost. Due to this guaranteed price for production, there has been very little motivation to alter production practices.

Farmers in the States and Europe, when adopting ICM practices, are for the first time experimenting with a combination of reduced label rates for chemical inputs, a change in crop rotations, a change in tillage practices and a change in fertilizer usage. They are beginning to use biological pest controls and are conserving semi-natural habitats.

The adoption of these methods of ICM are still largely unrelated to profit, but more so to environmental concern and more particularly to environmental regulations and the consumers' demand for higher quality food.

ICM has developed from the success of integrated pest management in horticulture. Despite having little public recognition outside agriculture, unlike organic farming for example, food retailers in Europe are interested in ICM as a method of adding value and improving consumers' confidence in their products simply by detailed product labelling.

It is claimed that ICM is an environmentally benign system, however there is little research evidence to support this. Indeed, it does not condemn or ban the use of artificial inputs but merely recommends limiting and monitoring their use. However, ICM does give a central place to the environment in on-farm decision-making. This encourages a more diverse, extensive pattern of land use with higher biological diversity and less pollution than conventional intensive European and American styles of farming.

To me, ICM does not seem to be a distinct system, but its techniques to reduce environmental impact and promote sustainable agriculture economically are certainly influencing conventional farming.

ICM as practiced in Australia, deals with some problems not yet seriously affecting agriculture overseas, such as herbicide resistance. It can also promote the use of more, not less inputs, as in the case of nitrogen fertilizer applications on wheat.

Therefore, in the Australian context, it is not easy to define ICM as a sustainable agriculture system, but rather as a collection of tools, which may relate adversarily to production and the environment.

Direct Drilling

The development of Direct Drilling also known as Zero-till or No-till farming has been farmer driven. More recently, scientists have worked with farmers by researching plant agronomy, tillage practices, and chemical applications. This research has provided a better understanding of the results obtained by practicing direct drillers, and has contributed to refining methods adopted by the farmer.

Field experiments by farmers in direct drilling have been ongoing for some 30 years. However, rapid adoption and recognition has happened only in the past decade. It was not until the improvement in chemical efficiency, applicability and, in some cases, a reduction in cost, eg. glyphosate and an improvement in tillage equipment that direct drilling gained credibility with farmers.

Direct drilling or Zero-till is defined as, "an economically viable, erosion proof crop production system in which the crop is planted directly into the stubble with minimum soil disturbance. Cultural controls such as crop competition and rotations as well as responsible use of herbicides are used to replace tillage." *Manitoba-North Dakota Zero Tillage Farmers Association.*

The driving motivations for farmers to adopt direct drilling methods are better soil management and better economics.

The advantages direct drilling brings include:

- Moisture efficiency: direct drill improves soil moisture by improving water infiltration and providing more ground cover which consequently reduces evaporation.
- Improved yields: on average, direct drilled crops yield the same or higher than conventional farming, particularly in a dry year.
- Reduced labour, more timely sowing and less fuel used due to less passes over the paddock.
- Erosion control: more groundcover which is anchored by roots reducing field susceptibility to wind and water erosion.
- Improved soil structure and soil fertility due to less disturbance of the soil.

Once tillage is removed from the conventional farming system it is necessary to learn a new management technique. Direct drilling is a system which relies heavily on the appropriate use of herbicides. This reliance is the main criticism of direct drilling. However, greatly improved knowledge of the applications and actions of herbicides, combined with a greater working knowledge of weeds, make environmentally effective management possible.

Stubble management, crop rotation and weed management play important roles in the operation of direct drill farming:

- Stubble management: uniform straw and chaff distribution contributes to moisture conservation, avoids blockages at seeding and reduces any allelopathic effect on susequent crop growth.
- Crop rotations must be planned with disease, weeds, insects and amount of residue in mind.
- Weed management is probably the most apparent difference between direct drilling and conventional farming. Weeds in an emerged crop are controlled by post-emergent herbicides. Application of a non-selective herbicide at seeding is often a part of the program. **Crop competition** is the most important aspect of weed management. Timing of seeding, variety selection, optimum placement of seed and fertilizer and selection and rotation of crops are all important in improving a crops ability to compete with weeds.

The choice of **seeding equipment** is one of the major equipment decisions faced by a direct drill farmer. It is an extremely important part of direct drilling. It should provide:

- good tilth,
- separation of seed and fertilizer,
- accurate placement of seed and fertilizer preferably deep-banded,
- good seed-soil contact,
- accurate depth control,
- trash clearance.

There are a wide range of makes and models available. Some of the most successful, cost effective machines I have viewed to date have been farmer innovated and often farmer built.

Most indications are that the increase in the cost of herbicides in direct drill are offset by the decrease in cost of tillage. This makes direct drilling an economically viable system. However, its reliance on herbicides is cause for concern as the appearance of herbicide resistance in Australias cropping systems increases and the world wide regulation of pesticide use is tightened. It is hoped that over the long term ongoing innovations in agriculture will combine with methods of direct drilling to further development in sustainable farming practices.

Conclusion

Sustainable agriculture can be viewed from two perspectives, one local and one global.

Sustainable Agriculture in the Local environment.

Australian farmers having faced years of land degradation have developed sustainable farming techniques for dryland farming which easily equate with any of the systems I studied overseas. Landcare programs, TOPCROP, Right Rotations and Property Management Planning are all examples of uniquely Australian systems devised to provide solutions to Australias' agricultural problems.

Many of the systems I studied, such as Direct Drilling, Precision Farming, Organic Farming, and Alley Farming are being adopted in conjunction with the Australian designed systems in an effort to farm more sustainably. These 'overseas' systems are in many cases simultaneously being developed and refined in Australia to suit Australian conditions.

All these systems fall under this 'fuzzy' umbrella of sustainable agriculture. However neither organic farming nor direct drilling necessarily equates to sustainable agriculture. If conditions exist such as soil erosion, increasing salinity, excessive pesticide use, below average yields and lack of profits, then the farm operation is not sustainable. Conversely, if erosion is controlled, nutrients and pesticides applied correctly, production and profit realized, a sustainable system could exist.

More accurately stated sustainable agriculture is a way of thinking. If we are interested in long term farming, the health of our soils, our environment, ourselves and our economic situation, then we are striving towards the goal of sustainable agriculture. The method we choose is simply a tool and a means to a direction.

It is an agriculture that allows for the integration of technologies, procedures and management strategies to produce a more efficient and environmentally responsible agriculture. It is an agriculture which requires diversity, flexibility and a complex balancing of farm resources, enterprises, inputs, methods and whole-farm systems designed to satisfy the criteria of sustainable agriculture.

Systems of sustainable agriculture are continuously in a stage of development and research and so are not finite or a blue print, the end in itself being elusive. Therefore as an ideal, sustainable agriculture presents us with challenges to our more traditional, conventional ways of thinking and farming.

Australian farmers adoption and adaption of sustainable agriculture has been rapid and as such we should continue seeking to fulfill the dual purpose of limiting land degradation and optimizimg production. While agriculture is seen as the basis for economic development and growth, its survival is dependent on the sustainability of the living systems with in which we live, work and farm.

Sustainable Agriculture in the Global environment.

"Picture the annual world cereal grain harvest as a highway circling the earth at the equator. This imaginery highway would be some 17m wide and 2.5m deep and a little over 50,000km long. To provide enough grain to feed the worlds growing population this highway of grain must be entirely reproduced and then increased in length about 1,000km, each year." *Wheat breeder and Nobel laureate Dr. Norman Borlang.*

This image feeds people but does not take into account the impact of urban growth and the consequent pressures on farming and natural resources. The earth's capacity to provide for future human needs sustainably is questionable. Food security (including water scarcity), the environment and the alleviation of poverty are the major issues facing the world as we head into the 21st C.

This may seem remote for Australian farmers farming far away from the immediate source of these problems. However, as price-takers, operating in an ever shrinking more globalized market place, Australian farmers will be directly affected by volatile prices, increasing costs and market insecurity.

On a more optimistic note the Australian agricultural industry is well placed to service the increasing demand for commodities from developing countries. This position in the global arena, needs to be secured by aggressive attention to markets and marketing. Our product carries with it a 'clean, green' image and a guarantee of quality. This we must fiercely defend, protect, promote and capitalize on to ensure our place. Our expertise and farming know-how can already provide exportable solutions to agricultural problems faced in many parts of the world. To continually increase the use of sustainable agricultural methodology in this context we can only enhance our place in the global community.

For me, my Nuffield experience has given me a look at many systems of sustainable agriculture, all equally legitimate in their own way. They will provide the basis for a store of information, techniques and tools to be used in my farming future. The most important concepts that I have learnt on my Nuffield are to be flexible, implement with a balanced approach and maintain as high a degree of diversity as practically possible, whilst always remaining observant. No one system offered me a blueprint for my future, however many have contributed to ongoing questions, and learning.

The following screen saver has stayed with me as a reminder of an enjoyable long term sustainable approach to living and farming!

"Live as if you would die tomorrow, but farm as if you will live forever."

Appendix

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