Visions for agriculture

Department of Agriculture, Western Australia

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VISIONS FOR AGRICULTURE

Proceedings of a workshop held at Tammin by the Merredin Dryland Research Institute’s Research Advisory Committee

22–23 October 1992

Edited by
E.C. Lefroy
CONTENTS

Preface ...................................................................................................................... (ii)
Ted Lefroy

Keynote address
Meeting the expectations of the land ............................................................... 1
Wes Jackson

Invited presentations
Likely developments in cereal growing ....................................................... 17
Wal Anderson

Alley-farming ...................................................................................................... 24
Dean Melvin (videotape transcript)

The Twigg story — intercropping lucerne with cereals .................................. 28
Bill Twigg (videotape transcript)

Tree crops for the wheatbelt ............................................................................ 32
Barrie Oldfield

Ethanol and eucalyptus oil from woody species .............................................. 34
John Bartle

Closing remarks
Living in a fabricated landscape — the look of the land ............................... 39
Barbara Main

Workshop sessions ................................................................................................ 44

Session 1 What would agriculture be like if we had known as much about this landscape in 1829 as we do now?

Session 2 What are the main obstacles to achieving this vision?

Session 3 How do we address these obstacles to make the transition from where we are now to where we want to be?
PREFACE

This workshop grew out of a conversation between Maurice Barnes, a Trayning farmer and member of the Research Advisory Committee of the Dryland Research Institute, and Steve Porritt, the Officer in Charge of the Dryland Research Institute at Merredin. Maurice was interested in the idea of posing the question ‘What would agriculture be like if we had known as much about this landscape in 1829 as we know now?’, to a group of farmers and others interested in the central wheatbelt and its future.

Maurice saw this question as a first step toward achieving some shared vision for the future of agriculture in the region. He was well aware that there was far greater understanding of this region and its suitability for agriculture now than when the first settlers arrived. The question was: how do we incorporate that understanding into the existing agricultural landscape? For example, we appreciate now that the various soil types of the region occur in an irregular mosaic pattern, and yet farming is still largely carried out ‘on the square’ following the north-south, east-west axis laid out by the first surveyors.

The idea of asking the question ‘What would we have done?’ was seen as a way of describing an ideal. The logical next stage was to ask: how do we get there from here? Consequently the workshop sessions on the second day led by John Duff revolved around answering those two questions.

To stimulate that discussion several people were asked to present papers on the first day. These proceedings contain accounts of those talks and a summary of the second day’s discussions. The talks are presented here as direct transcripts of the keynote address and the two videotapes shown and written summaries of the other talks supplied by the speakers.

The timing of this workshop was arranged to coincide with the visit to Western Australia of Wes Jackson, founder of the Land Institute in Kansas, USA and pioneer of the breeding of perennial grain crops. Wes was invited to Western Australia by the Esperance Land Conservation District Committee and his visit was made possible by the assistance of the Soil and Land Conservation Council and the Australian Institute of Agricultural Science.

The six visions presented by the speakers or represented in the videos vary considerably in terms of the timescale anticipated for their implementation. The longest is the research agenda represented by Wes Jackson’s work, where he has set the Land Institute the goal of achieving commercial high seed yielding perennial polycultures within 50–100 years. Although this research agenda based on mimicking the structure and function of the central North American native prairie will not translate directly to the Western Australian wheatbelt, there are valuable lessons for us in the principle of using the native vegetation as a standard or measure in our attempts to restore basic ecosystem functions, particularly water cycling, to the agricultural landscape.

John Bartle emphasises this point in his paper where he sees the future lying in the development of commercial products from woody species. He argues that the scale of replanting of woody species necessary to restore localised balance to a disrupted hydrologic system and protect the soil surface, is so vast as to require the direct commercial value of those species to drive its implementation. The development of new products and their marketing implies a timescale of several decades.

Barrie Oldfield’s vision for the wheatbelt also involves tree crops but emphasises small areas of high value tree crops with products aimed largely at existing markets, resulting in a shorter timescale than John Bartle’s industrial products.

Bill Twigg, a farmer from Horsham in Victoria, presented his vision through a videotape made by the Department of Agriculture and Rural Affairs. Bill Twigg uses lucerne at low densities throughout his farm, including paddocks cropped to cereals. The benefits he cites include
higher water use, increased summer feed, improved soil structure and a reduction in the drenching of sheep due to his rotational grazing system. As with Wes Jackson’s perennial grain crops, while it may not be possible to translate this practice directly to the Western Australian wheatbelt, the concept of finding a perennial legume suited to this region may be worth pursuing but is likely to involve at least a decade’s work.

Dean Melvin has pioneered the concept of alley-farming and the video he presented suggested that this is a practice directly applicable to the sandplain soils of the wheatbelt right now. In discussion, Dean suggested that the same principle should apply to any soil type providing appropriate changes were made to the species used, the width of the alleys and the design and orientation of the planting, especially on sloping land. The wider adoption of this approach to farming depends on evidence from several locations that it offers commercial as well as environmental benefits to farmers. This evidence is probably 5–10 years away.

Wal Anderson suggested that the complex array of decisions facing wheat growers each season would be made easier with the development of decision support systems. Given the continued increase in costs relative to returns, evidence of fertility decline and the fact that yields were still below the potential suggested by the region’s rainfall, it was becoming increasingly important that farmers made decisions concerning variety, sowing time, sowing rate, fertiliser type and rate and legume rotation on the basis of the best available information. The fact that decision support systems could be compiled now based on existing data from across the State means that this vision has the shortest lead time of those presented. Wal also suggested we should specialise our wheat growing to produce types such as noodle wheats, hard and durum wheats that our competitors can not or do not produce.

Two of the speakers, Wes Jackson and John Bartle, both made the point that lack of knowledge is not a limiting factor in developing sustainable agriculture to the same extent as is our failure to come to terms with the nature of our environment. Quoting Wendell Berry, Wes Jackson made the point that in Australia, as in North America, the first settlers ‘came with vision but not with sight’. They came with vision of former places, namely Europe, but not the sight to appreciate where they were. That probably serves as a warning that visions for agriculture to be of value, must be well grounded in an appreciation of place.

In closing the workshop, Barbara Main gave us her view of the region as someone who grew up in the Tammin district and has returned frequently. She pointed out that the small scale mosaic pattern so typical of this landscape prior to agriculture was retained to some extent right up until the second World War. Immediately after that, heavy machinery and trace elements meant that the patchwork of scrub and open paddocks gave way to an almost prairie like sweep of cultivated land. She suggested that to restore basic ecosystem functions and integrity to this landscape would mean reinstating this mosaic principle within our agricultural practice.

It is hoped that the papers presented here and the account of the discussions that followed will serve as a catalyst to others in their attempts to develop a shared vision for the future of this region. With that hope in mind, particularly in view of this region’s current dependence on world markets beyond its influence, it is worth recalling something said by the past chairman of the Commission for the Future, Phillip Adams: ‘...the paths to the future are made, not found’.

This workshop was made possible by the support of Kevin Goss and the Land Management Branch of the Department of Agriculture. Our thanks also to Arthur and Gwen Patten as hosts at the Tammin Alcoa Landcare Education Centre.
‘MEETING THE EXPECTATIONS OF THE LAND’

Wes Jackson

The Land Institute, Kansas, United States of America

The vision:  
*Agriculture based on perennial polycultures designed to mimic the structure and function of native ecosystems.*

I am very happy to be here. I have never been to Australia before although I did manage to get to New Zealand a couple of years ago and wanted to come on to Australia but time would not allow it. So I certainly thank those responsible for me being here, besides Air New Zealand, United States Air and an awful lot of the carboniferous energy stored 400–500 million years ago just so we could be together tonight. So for all of the failures at decomposition in the geological past, I am grateful, even though they are contributing to some other problems.

Now there is a guy in Kansas, which is right smack dab in the middle of the 48 States, who was going to write a book on the Land Institute. He followed me around for a year and a half and I told him I felt like Boswell’s Johnson. He frequently asked me a question that has to do with how I got into this. I would develop a coherent story, a nice story and it held together, and it was persuasive and tidy. I would get to the end and think ..., ‘that isn’t it’. So I would back up and get another run at it, and take off on another tangent that was just as coherent and made just as much sense and I would get to the end and realise that is not it either. I did that many, many times, and so I cannot give you the truth tonight, because the truth of why I got into what I am going to talk about eludes me. I just can’t tell, but I could give you some stories that would be appealing. Instead I am going to try to give you what I would consider to be something of a mysterious coming-to-understand-something.

I was raised on a farm in Kansas. My great grandfather, who was English, came to Kansas in 1854, the day the Kansas-Nebraska Act was ratified. The first day he was allowed to enter the State this act said essentially ‘Indians, here we are, move over’ and he came in and took up 160 acres. He did that on prairie land that was mostly treeless. After fighting in the first battle of the civil war, the battle of Black Jack, which took place on his land, he planted something like 600 trees. His obituary in 1906 said that ‘... because he was English he was a lover of trees ...’. Now, when he and his son went to gather firewood, they had to go 12 miles. That area now is almost 100 per cent trees.

This was tall-grass prairie country, and because they failed to burn the grasslands, which evolved to invite fire, the deciduous forest from the east came in. So now it looks just like New England in the fall with all the beautiful fall colours. That is tall-grass prairie country, and as you move westward and the rainfall drops off, you go from tall-grass prairie to mid-grass prairie to short-grass prairie. His movement onto that continent fits exactly what Wendell Berry had to say about we Americans, but is also true of Australians, that we came with vision but not with sight. We came with visions of former places, but not the sight to see where we are. As we came across our continent, cutting the forests and ploughing the prairies, we have never known what we were doing because we have never known what we were undoing. We are still, we Europeans who are everywhere, still carrying the images of former places. We are still carrying the legacy of the conquerors.

In our continent, we came and found natives and designated them as ‘red skins’ which made them surplus people that we could move over. Because we never really atoned for that sin, now

* Transcript of a talk given at the ‘Visions for Agriculture’ workshop, Tammin, Western Australia, 22 October 1992.*
the great grandsons and great grand-daughters of the settlers are the new ‘redskins’, the surplus people to whom the corporate State says get big or get out. I think that is the same story wherever we have gone. It just so happens you people are in Australia but you came with the same mind set. We came with a humid area mind set and we settled dry places and forced them to conform.

Well that is only by way of introduction, and that is not what I want to talk about. What I want to talk about is what it would mean if we were to get serious about becoming native to our places. That is, native to this place, and put behind us the age of colonisation and begin the age of discovery. I can tell you that this is a paradigm shift as fundamental as the shift from the time before Copernicus when we believed the earth was at the centre, and everything else went around it, and Galileo and Copernicus got us to see that in fact the earth goes around the sun. Galileo tried to get the churchmen of the time to look through the telescope and they refused. For 200 years his writings were forbidden. In a similar manner, it seems to me, we are at the exact instant in history when we have to move from the mind of the conqueror to subdue the earth and force it to our will and move to looking to nature as the standard or the measure against which we judge our agricultural and cultural practices. I can not tell you how I come to this except I can say that it is through a research agenda, and I will talk about that research agenda and how it came about.

The general accounting office in the United States watches over the Congress to see whether its money is being spent well. So they do studies, and in 1977 they looked at soil erosion and the effectiveness of the Soil Conservation Service which had then been in existence about 50 years. Their report essentially said that we were losing at least as much topsoil from our agricultural lands in 1977 as when the Soil Conservation Service had been formed in 1935 or 1936. This was startling to me, because I had seen tens of thousands of miles of contour banks, thousands of miles of grassed waterways, a huge budget (in fact at one time, a sixth of the total federal budget was allocated toward the conservation of soil and water), and here we are with the problem as bad or worse than it was in the 1930s.

So I started looking at the history of earth abuse through agriculture because I wondered whether it was possible that in the past, people were not sufficiently eloquent or enlightened or impassioned about what was happening in terms of destruction of the earth, mostly westward with empire and into the Orient. But you can read the record all the way from the Biblical Job to the present and there were countless people that knew the story and knew what was happening. Job said, ‘... the waters wear away the stones and take away the hope of man ...’. Right up to modern times, I call that the failure of history and prophecy. In the United States, from the first tobacco planted at Jamestown as an export crop, we have just ravaged a continent and so it continues.

As well as the failure of history and prophecy we have the Soil Conservation Service and its problem which has been going for half a century and I call that the failure of organisations. Then even on the farms of people we call the Mennonites and Amish, people who still farm in a traditional manner with horses, good stewards of the land believing that the highest calling of God is to take care of the land, even there I have seen soil erosion beyond replacement levels. So the third failure behind history and prophecy and organisations is stewardship.

However, the worst failure of all is the failure of success. We have gone from 30 bushels per acre of corn in 1930 to 100 bushels in 1980 and everybody says we must be doing something right, otherwise how could we have such great yields. Modern industrial agriculture is seen as a great success. Of course the problem with the failure of success is that you tend not to learn much from it. Nothing fails like success is a kind of a saying.

Looking at these failures, that is, ecological capital running toward the sea, the introduction of chemicals into the environment that our tissues have no evolutionary experience with, the introduction of chemicals into the environment at levels and rates twice that of what happens in
natural processes, such as with nitrogen a kind of ‘hot-wiring’ of the landscape, all associated with the failure of success, lead me to thinking about this experiment that is being run on this planet with an ape that was given a big brain, a 1350 cc. brain. That brain has been around about that size for 150,000–200,000 years. We have had agriculture only 10,000 years. So for only about 5 per cent of our total evolutionary history have we been this species out of context, have we been agriculturalists. So considering the four great failures, what do we do?

I was no longer excited about ‘sound agricultural practices’ that we all know. We all know how to farm well. Well then, why don’t we? One explanation is that we are a fallen creature. That is what it means to live in a fallen world.

Alfred North Whitehead the philosopher said that ‘... the essence of dramatic tragedy lies not in unhappiness but in the remorseless, inevitable working of things. It is however through people that it is experienced as unhappiness ...’.

Think of a Shakespeare play, like ‘Othello’. You go and see that play, and you go out before the last act and you think my gosh, it is piling up in there, there are going to be bodies all over the stage before this is over. You go back in, there are bodies all over the stage, ‘... The essence of dramatic tragedy lies not in unhappiness but in the remorseless inevitable working of things ...’. So is agriculture in the nature of a dramatic tragedy? That is, we have to have food if we are to live, and yet agriculture seems to undercut the basis of its own existence.

Well I am an intellectual pessimist but I am a glandular optimist. Being a glandular optimist you do not want to just cave in to intellect.

Where I live in Kansas I can see a wheat field on sloping ground experiencing soil erosion beyond replacement levels, requiring fossil fuel, requiring chemicals we have not evolved with. On the other hand, next to it is never-ploughed native prairie running on sunlight instead of fossil fuel. Because of species diversity there is chemical diversity so it would take a tremendous enzyme system on the part of an insect or pathogen to mow that diversity down. It is sponsoring its own nitrogen, unlike the wheat field. Furthermore it is not experiencing erosion. In fact nosing roots will suck nutrients from parent rock material or sub-soil and actually build it up. So here is a system that seems to be sustainable that has been that way more or less since the retreat of the ice and the question is: how does it differ from the wheat field?

Well the wheat field features the annual plant grown in a monoculture. Nature’s prairie features perennials grown in a polyculture or mixture. So the question occurs: is it possible to build an agriculture based on the prairie as a model? To what extent would it be possible to mimic this, to have a weak mimic at least? In other words, to use nature as the standard or the measure.

I want to digress here for a moment to talk about a paper that Wendell Berry gave at the dedication of our greenhouse at the Land Institute several years ago. He traced the literary and scientific history of nature as the measure in the British tradition. You can again go all the way back to Job who said, ‘... ask the fishes of the sea, and they shall tell thee ...’. Then Virgil said ‘... before you plough a patch it is well to be informed about the winds ...’. You can bring this literary tradition up to Spenser, Milton and Shakespeare. Shakespeare in ‘As You Like It’ has the forest as judge. Milton said, ‘... let nature never be forgot, she good cater us and attends to our matters ...’, or words to that effect. Finally Alexander Pope says, ‘... consult the genius of the place in awe ...’, meaning nature.

Then it goes underground in the literary tradition, this idea of looking to nature. When it surfaces it surfaces in this century with Liberty Hyde Bailey from Cornell University, Ithaca, New York, who wrote a book called ‘The Holy Earth’ in 1905. There he talked about consulting nature. Sir Albert Howard in ‘An Agricultural Testament’ said we should farm like the forest. Then J. Russell-Smith in ‘Tree Crops’ talked about how the mistake was made when we moved the agriculture of the valleys to the hillside.
At this point Wendell has a very interesting thing to say; that in both the literary and scientific tradition, it comes in the formal culture as a series, not as a succession; that the succession is in the common culture and that it pops up like toast to form a series rather than a succession in the formal culture. Part of my mission right now is to turn that into a succession within the formal culture, and begin to develop a research agenda, worldwide, that will go back to nature as the standard or measure, and that would be the paradigm shift.

I have said that I am an intellectual pessimist and a glandular optimist, so what happened once we decided to embark on this research agenda that would feature perennials grown in a polyculture or mixture? We had to deal with four basic questions:

1. Whether perennialism and high yield can go together.
2. Whether a polyculture or such perennials could outyield a monoculture.
3. Whether we could get such an ecosystem to sponsor its own nitrogen fertility.
4. Whether such an ecosystem has the ability to control insects, pathogens and weeds.

All of our experiments have to address one or more of those questions.

What I want to do now is tell you about the Land Institute, which is a small, private, non-profit outfit. We have had no federal funds to speak of so far, and essentially all the research has been done with money from foundations primarily interested in education and not research. We have had very little funding specifically for research but that may be slowly changing.

At the Land Institute we have ten graduate level students at a time and a research staff of five PhD level scientists. The graduate students are paid US$140 a week to be there and they spend half their time in reading, thinking and discussing and the other half of the time in the physical work of pollinating, weeding, watering, analysing data and writing up the results of their experiments. What is important about this research scene is that it is somewhat community oriented, and that is not typical of your run-of-the-mill research station.

The Institute is just out of Salina in Kansas, 27.5 inches of rainfall. We started off on 28 acres of land and now have about 300. The four main areas of activity are agro-ecological research, an intern program, public education and public policy and conservation efforts.

Why only ten students at a time? I tell everybody Jesus had a twelve-to-one teaching load and gave one F, suggesting he had too many. Another reason is that if you look at the gathering/hunting societies, a fair number of them had around 25-50 people in a group and ten is about the upper limit that you can sit in a circle and have a discussion. The industrial model, as we have here tonight, is everybody sitting in chairs looking up front to one. We did not do that through most of our evolutionary history. When I left the university there were two things I said I would never do; attend another committee meeting and teach students who do not want to be there. So, at the Land Institute there are no grades and no credentials. It is a school of thought, and anybody that wants to come under those conditions is then given a chance to fail. The paradox is you do not really have a chance to fail in the other system. So this involves a philosophy as well as a scientific methodology. Of course we only hire PhDs on the teaching staff which gives the lie to what we think about how to educate the young. That is a level of complexity I can talk about later.

In addition to our small classroom we have a greenhouse for work in winter and a garden that is maintained by staff and students and feeds about 20 people in the summer. We do some farming as well as having an area of never-ploughed native prairie. Now here is where the lecture starts.

[Note: From this point the lecture was illustrated with slides showing the work being carried out at the Land Institute.]

We are surrounded by wheat as far as you can see. Our own 65 acres of wheat can be cut out by two harvesters in an afternoon, which forces us to feel informed on the subject of
agronomics. Of course there are other things that stand behind this wheat field. One is soil erosion which is typically associated with till agriculture.

Something else that stands behind that wheat field are the fossil fuel wellheads. As well we have the Ogala aquifer from which we mine water to grow 200 bushel per acre crops of corn in an area with 17 inches of rainfall, sucking out 20 million acre feet per year. This corn then goes into feedlots which represent the largest cattle and pig welfare program in the world, in order that we may have the combination of cancer of the lower bowel, pollution of groundwater due to nitrates, the problem of what to do with the manure, and people driving 60–70 miles in one direction in order to work at Iowa Beef and contract Carpal-duct Tunnel Syndrome as they dismember the animals. It is just wonderful how it is we are able to do all that.

The Ogala aquifer stretches from Nebraska through Kansas and Oklahoma to Texas at the bottom (where it belongs). This aquifer is running dry in those bottom three States but will probably never run dry in parts of Nebraska only because of the energy cost in getting it out. Then of course we have the fertiliser and pesticide tanks that stand behind our agriculture.

Another cost we pay that never gets acknowledged in our cost for food is the cost of defence. Maintaining the bombing ranges and inter-continental ballistic missiles represent the cost of being sure that the Middle East and other places keep the oil flowing our way. If we were to pay that cost at the tank, our food prices would be much higher. That does not get acknowledged, and so we have had our oil war, not that a single one of our candidates for president mentioned that we have had an oil war already.

So here is this system of agriculture that is unsustainable in almost any way you want to look at it; energy, water, soil or the chemical contamination of the countryside. On the other hand we have never-ploughed native prairie that for thousands and thousands of years supported the large herbivore, the bison. One of the ways it was maintained was by fire. The Indians set fire to the prairies, lightning set fire to the prairies and most of these were cold fires. These are wonderful to see in the spring of each year. Below ground, while all above will burn, are the perennial roots that will hold that soil.

Our agro-ecological program at the Land Institute focuses on using this prairie as our model and involves prairie studies, the development of perennial seed crops and the development of polyculture cropping systems.

Prairie studies

The prairie studies involve asking such questions as: What levels of plant production are sustained by the prairie? When are different types of species active and what are their roles in the grassland community? What are the proportions of legumes, composites and cool and warm season grasses at different sites over time? How does the vegetation change over time? What are the phenological, morphological and physiological factors that allow co-existence?

Now I realise that this is the prairie and it is in the United States, and it is in Kansas, but the principles are the same world-wide. That is what I hope to emphasise this evening. That this is not just a local way to deal with what I call the problems of agriculture. We say we are working on the problems of agriculture rather than problems in agriculture. We are looking at agriculture as a problem in itself.

To get back to our prairie studies, what we do is harvest the above ground portion at different times of the year and sort it into cool-season grasses, warm-season grasses, legumes, members of the sunflower family and others. From that ratio, we say this is what we want to mimic using the perennials that we are domesticking that become the analogs of the original prairie's components. So we sample in different environments on the prairie in half-metre squares and determine the composition. For example, at one site C₃ grasses (cool-season grasses) may be 20 per cent, C₄ grasses (warm-season grasses) 75 per cent, no legumes and sunflower family
5 per cent. At another site, and another season, we get a different mix. We also examine species diversity at different sites. Now if we average the composition at any one time in the four major categories of plants we get a generalised view of what the percentage might be for the mimic that we are going to put together.

**Developing perennial seed crops**

Now let's look at what is involved if we are to domesticate a perennial. The criteria we use when looking at candidate species are; what potential does it have for high seed yields, is it winter hardy (for us a crucial factor), what might be its ecological role in a polyculture and what is the nutritional value of the plant?

We have three alternative strategies for domestication. We can either take a native wild species and simply select for high seed yield, or we can take an introduced wild species and select, or we can take an annual that is already domesticated and convert it into a perennial.

The best candidates right now in our active breeding program are Giant Wild Rye (*Leymus racemosus*) which is introduced, Eastern Gama Grass which is a native relative of corn and may in fact be one of its progenitors, Illinois Bundle Flower (*Desmanthus illinoensis*) which is a native legume, and a perennial sorghum based on a hybrid of annual sorghum (*Sorghum bicolor*) and *Sorghum haliense* or Johnson Grass.

There are several others which we should be working on if we had more help and they are Maximillian Sunflower (*Helianthus maximilliani*), Intermediate Wheat Grass (*Thinopyron intermedium*) and some of the perennial rye hybrids. The first phase is the inventory phase where we put together a collection of native and exotic species that may have promise. The second phase, after the inventory, is a detailed evaluation. We need to survey the genetic variation available for breeding as you can not select if you do not have variation, then some early ecological studies. The third phase involves some preliminary plant breeding to demonstrate that there is potential for selection as all species do not yield to selection to the same degree. Then we assess the promise of that plant for domestication and its role in a sustainable agriculture. Finally we have the fourth phase of further development and testing involving a larger coalition of efforts. By this stage we have to get many more people involved.

In the inventory phase we put together what we called the herbaray. Any plant that was herbaceous, perennial and winter hardy was a candidate for a 5 m long row. Here is where we got a lot of slow knowledge. For example, you walk around in the herbaray at night and see what insects are there. The herbaray reveals itself to you slowly. The most important knowledge does not come very fast. The most important knowledge, as any farmer knows, comes as a result almost at the unconscious level of a lot of subtle information. Most of the plants in the herbaray have no immediate utility but are there to help us piece together the principles of our analog prairie.

At one point we decided to work on six different species within six different grass genera. We wrote to the plant introduction centre at Pullman, Washington and said we wanted the relatives, from all over the world, of these species from all six genera. They wrote back and said: are you sure? We said yes, so they sent us 4300 accessions from all over the world. Our interns of course just loved planting those out in little rows.

One of the grasses we decided to look at was Giant Wild Rye. The Mongols used to eat it, which is probably why they were so mean as it has a lot of ergot in it, which also means there would have to be a lot of breeding to develop resistance to that.

Another was Eastern Gama Grass. My daughter did her PhD thesis on this plant at Cornell University and I will tell you a bit about it. It has 27 per cent protein in the seed, three times that of corn, and twice that of wheat. It has 1.8 times the methionine content of corn. Furthermore, this warm season grass, like virtually every other warm season grass that has
been looked at in North America, fixes small quantities of nitrogen. The way this happens is
that the rhizosphere of the root, that is the gelatinous area that surrounds the root, contains sugar
that leaks out from the plant. Bacteria living in the rhizosphere use that sugar as an energy
source for the fixation of nitrogen. Now here is what I think we have done in the breeding of
our major warm season grasses; we have unwittingly, in our selection for high yield, selected
against sugar leakage and the photosynthate, the sugar, has then been allocated to the seed. We
then substitute a legume like lucerne or clover to provide the nitrogen. So one of the things I am
hoping we will do as we breed for high yielding, warm season grasses is also select for sugar
leakage, because if we are going to pay the bill with sunlight, I think there is the following law;
the internal control of a system is more energy and materials efficient than the external controls
of a system. So if you are going to try to run your agriculture on sunlight, it would be a good
thing if the nitrogen fixation were done internally, rather than to have your nitrogen fixation
done by a legume and then ploughed under in order to get the nitrogen. This is something to
think about; the principle that I would like to see explored is whether in fact the internal control
of a system is more energy and materials efficient than the external controls.

In a normal inflorescence of Eastern Gama Grass the part at the bottom that produces seed is
very small. This plant is so primitive it does not even have a cob. I have suggested that the
United States Department of Agriculture spend $20m and 20 years to build a cob. That would
be only 20 missiles. And of course the gene splicers want to get in on the act and one of the
problems is holding those guys off. They are just salivating to be heroic.

In the meantime we came across one mutant that turned the male part of the flower into female,
and gives us from 12 to 20 times the number of seeds on a head. This is a single locus mutant,
a double recessive. We call this plant 'Pistil' as it is the pistillate part of the plant and refer to
her as our 'Pistil packing momma'. We have crossed Pistil into thousands of offspring
involving many lines, something like 27 different lines. So Pistil’s genes are all over the place,
and we are analysing her offspring relative to the wild individuals.

The advantage of a cob is to give us shatter resistance. In a wild species it is to its advantage to
shatter the seeds. Domestic species we have selected to not shatter. I have suggested to a gene
splicer that maybe we ought to take the gene that is responsible for holding the hair on the hog
and splice that into Eastern Gama Grass in order to keep the seeds from shattering. After all,
they are so full of promises and I thought I would help them out if I could.

So with each species we go through this process and look at its potential as a perennial grain
crop. As an example I will summarise what we have found with Eastern Gamma Grass.

Firstly its nutritional value is excellent, equivalent to corn. The seed has three times the protein,
and 1.5 times the lipid content of maize. The forage is preferred by livestock — it is an ice-
cream grass for cattle. In terms of seed yield we need to increase this through plant breeding in
the order of tenfold. I should say here that our time frame is a 50–100 year time frame. People
begin to yawn when you talk about 50–100 years but I tell my students that if you are working
on something you can finish in your lifetime you are not thinking big enough. You have got to
get onto something you can’t complete in your lifetime. I also tell some of my colleagues that
the value of doing research that will not come to fruition in your lifetime is that by the time the
results are in, you are dead and do not have to take the ridicule. So you see there are positive
aspects to this sort of work too.

Also in terms of seed yield, approximately 25–30 per cent of the fruit case of Eastern Gama
Grass is edible seed. There is genetic variability for seed yield and individual genotypes have
yielded over 10 g m⁻² over two years. In addition, the gynomonoecious sex-form 'Pistil' and
other panicle variants can be used to increase seed number, threshing ability and shatter
resistance after extensive selection in different genetic backgrounds.

In terms of winter hardiness, there is some but there needs to be further testing. This grass
incidentally grows from central North America to central South America. It is susceptible to
several fungal pathogens and to maize dwarf mosaic virus. Genetic resistance or tolerance is present for anthracnose and leaf rust.

I have taken in more detail than you need to know about this species but what I want to emphasise is the kind of procedure that is involved if you are to have a research agenda underway for perennial crops.

Now let us take a look at a native legume, Illinois Bundle Flower. It produces a seed about equivalent to soya bean and is found throughout the central part of the United States. We began by selecting for shatter resistance within this species. The number one way to get an increase in yield is through shatter resistance. Right before I left I said to the guy working on Illinois Bundle Flower, 'I am going to Australia, give me the best news on our research this year'. He told me that our seed yield has nearly doubled from last year's. So right now we are at over 2200 kg ha⁻¹. Why is that crucial? Well, our very first question if you remember was: can perennialism and high seed yield go together?

In a certain sense, I do not care if any of these plants are ever useful to humans or livestock. What I am most interested in is whether it's in the cards for flowering plants, that is crops, for perennialism and high seed yield to go together. In other words it's the biological question that we are after. Now if we can get a definitive answer to that biological question, and we think we do have, then that blows a hole in the wall and causes us to begin to think about the possibility of an agriculture that does not feature tearing the ground up every year and that we can have a vegetative structure that is analogous to what was here before we Europeans came.

Back to Illinois Bundle Flower, we can summarise what we have found so far in terms of its potential as a perennial grain legume. In terms of nutritional grain legume, it is high in protein (38 per cent), it is widely planted for wildlife improvement, its forage is preferred by livestock however the digestibility of the seed as a feed source remains in question.

In terms of seed yield, we have achieved 2200 kg ha⁻¹ with selected accessions which is very high for a wild perennial legume. Germplasm accessions yielding over 1000 kg/ha are common. In terms of winter hardness, some accessions from Texas and Oklahoma have shown poor winter hardiness in central Kansas, while accessions from Minnesota, Nebraska and Iowa may be sources of winter hardiness.

As a nitrogen fixer is has an important contribution to perennial agro-ecosystems and field tests on nitrogen fixation are in progress. In terms of genetic diversity, genetic variability for seed yield, shatter resistance and seed size provide a good base to begin domestication of Illinois Bundle Flower.

We have also been looking at sorghum, and the possibility of crossing the annual grain sorghum (Sorghum bicolor) with the perennial noxious weed Johnson Grass (Sorghum halspense). We did that cross in order to get winter hardiness. We got a race of sorghum that has four sets of chromosomes, because that is what the Johnson Grass has, and we got a tremendous amount of variation in the offspring. Annual sorghum has no rhizomes while Johnson Grass has about 300 per pot. The hybrid has about 8–10 rhizomes per pot and it is the rhizome that is responsible for the perennial condition. The grain yield of the hybrid was lower than annual sorghum but favourable, so we backcrossed it twice with the annual parent. Then came the bad news. None of the backcross offspring survived the winter. So we do not have physiological winter hardiness out of that root.

However, when we crossed Johnson Grass with sorghum to get an F1, and then crossed the F1 times the F1, and in that segregation we got winter hardiness. We do not know why, but we are now optimistic we can take a domesticated plant and turn it into a winter hardy perennial.
Developing polyculture cropping systems

Now let’s move on and look at the second of the questions we started with. Can a perennial polyculture outyield the same crops grown in monoculture? As with most questions, the simple and seemingly obvious question as every farmer knows is not all the questions that attend that question. It is not the only question that attends it.

We need to know what kinds of interactions occur between plant species. We need to know in what ways can crop species complement one another. We need to know how we can promote positive associations while minimising negative interactions between crops in polyculture designs. Also, does overyielding (or outyielding the same crops in monoculture) change from year to year? These are some basic questions that we have to deal with in thinking about trying to farm like the prairie.

We started with a highly simplified polyculture with only three species because it makes it possible for us to do a fairly careful statistical analysis. Every single species is a neighbour unto the other with three species. That is difficult to achieve when you get to four. This way number one is associated with two, two is associated with three, and one can be associated with number three. Also in our polyculture we have the ratio that we got from the prairie. We have taken our species and planted them in such a manner that they mimic that ratio in terms of biomass of plant material. Here I want to relate a story about mimicking the biomass or structure.

Jack Ewell at the University of Florida has, for 20 years now, been working in Costa Rica in a tropical rain forest. There they practise slash and burn agriculture. Jack and his colleagues have studied the succession back to the natural rain forest over time. Knowing what that succession is and watching that succession and seeing what comes in at different stages, Jack has cleared a new area and substituted vine for vine, tree for tree, shrub for shrub to mimic the natural. The rules for this experiment were that no plant in the mimic could have got there on its own. It had to be a species that was different than what was happening in nature, but was a structural analog. Jack’s conclusion was that nearly always, not always, but nearly always, where they mimicked the structure they were granted the functions present in the natural ecosystem. That is part of our rationale at the Land Institute to mimic the structure in order to be granted the function.

So let’s look at overyielding. Say you take species A in monoculture and species B in monoculture and add their yield. Let’s say A plus B equals 100 bushels per acre. Then you take A and B in a biculture, the two together, and if the yield of the two together in the same amount of area is greater than the two separately, you have overyielding. Think of it in terms of a land equivalent ratio. In 1989 we got overyielding with two species, Eastern Gama Grass and Illinois Bundle Flower, and by the way these two grow along roadsides together in Kansas. In 1990 we did not have overyielding. But, if we take the best yields not the mean, we get overyielding in both years.

The fourth question that this research set out to address was: can a perennial polyculture successfully manage harmful insects, diseases and weeds? Again, there are many questions that attend that one, such as: What are the important pest species in our plots and what do we know about their basic biology? What are the differential effects of polycultures on specialist versus generalist herbivores? What methods and designs favour the beneficial organisms? What are the relative roles of resistance, population genetic diversity and species diversity in managing plant diseases?

Let us look at this question of managing disease by way of two examples. In the first the disease is anthracnose, the plant is Eastern Gamma Grass, and in 1989 and 1990 we compared the native population out in nature with plants that were taken from that native population for disease. The native populations back in nature always had less disease than their progeny at the experimental farm. Why? In nature you have got your automatic polyculture. At our
experimental farm we are putting them in plots for disease evaluation. What I hope we will do next year, instead of just taking the progeny, is take exact clones so that they are the same genetic make up, and move then in and see what happens in terms of disease.

For the second example of managing disease in a polyculture I will use Illinois Bundle Flower. There is a splash born bacteria that hits this plant in our monocultures. The rain drops bombard the ground, bounce up on the underneath side of the leaves where the waxy protection is least effective and the bacteria begins to trim the leaves from the bottom of the plant up. The plant breeder in us, being industrial heroes of the modern ilk, says I will build in resistance to that pathogen. I will get a breeding program here and I will get resistance to that pathogen and then I will have my release (now that is an interesting term) in the field. I tell you there is nothing more satisfying than going down the road and seeing your release out there in the field. But the ecologist in us, which also is part of all of us, says let’s walk over to the prairie and see what the story is there. There it is free of the disease. The reason is the grassy mat that absorbs the shock of the bombarding rain. No pathogen present.

The point is, the human cleverness approach will have us breeding for resistance. The nature’s wisdom approach says take the context and solve the problem. You solve for pattern, rather than for some specific problem.

Can a perennial polyculture control weeds? Here I will use the example of Maximillian Sunflower which is allelopathic, which is to say its roots exude a chemical that acts as a herbicide. We have a five-year-old plot on this land which was weeded once in the first year and is now completely free of weeds. Monsanto or Dow Chemical probably have no interest in this plant. Every farmer who comes to our place and is told how old that plot is, gets more excited than they do about a lot of our other work. What we did next was plant Maximillian Sunflower in rows with different densities within the row and measure the weeds between the rows. As the density within the row goes up, the weedy biomass between the row goes down. So now think about a polyculture; one thing we know is that the herbicide effect is most effective at the seedling stage. So you get your other species planted and established within your polyculture, such as your legume, the Illinois Bundle Flower, and your grass, the Giant Wild Rye, and then you put in Maximillian Sunflower which is your herbicide producer and the source of an oil seed crop. There you have your instant granola in a field.

So as a final summing up, take a look at the diagram in Figure 1. We start out with the prairie as our model of a sustainable ecosystem, you start out with something else such as the woodland or heath of the wheatbelt. We bring in native species, non-native species and we do our inventory to select our species. Then we start with germplasm evaluation, we look at the biology of the plant, we think about how it would fit within an agro-ecological setting, we ask what insects are going to be associated with it and what disease to deal with. Then we have a plant breeding program. Following that we look to see how our plants fit in a polyculture or mixture. Eventually we get our domestic prairie (or woodland or heath) and refer that back to our standard.

There are three fundamental questions involved in this process:

- What was here?
- What will nature require of us here?
- What will nature help us do here?

Consider that second question: what will nature require of us here?. Contrast that with: what can we get away with? You see the second is a child’s question: what can I get away with? Or take the third one: what will nature help us do here?, and contrast that to the question: what clever manipulation or invention can I come up with? You can see the psychological differences in the way we approach the research agenda. One set of questions comes out of the mind of the conqueror. The other set of questions comes out of the mind of those that are seeking to become native.
I have spoken all along of using the unploughed native prairie as the model for the future landscape of the central United States. This does not mean our future landscape will look exactly like the native prairie. But it means we use that prairie as our standard in developing our approximation.

Now, seeing it’s a terrible death to be talked to death, I would like to entertain the possibility of a discussion. If you have a question in order to have a discussion we could start with that.

Wal Anderson: In ecosystems where annual native plants are the norm, like a lot of the Mediterranean ecosystems, how do you see those sort of ecosystems working in contrast to your tall grass prairies?

Wes Jackson: That is a question I have thought about. One thing I am doubting about a lot of the Mediterranean ecosystems that are featuring the annual is whether that was the case before disturbance. For instance the hills of California, that everybody goes gaga over every spring, that vegetation is nothing like the vegetation that was there before the coming of the European. That is not to say that there are no annual dominated ecosystems that are what we might call climax communities. Then in that case, that is your standard. You see, there is nothing so sacred about the perennial condition that we have to be eco-fundamentalists about perennialism. What we have to do is battle against the fundamentalist approach.

Some vegetative structures are highly simple, almost monocultures, and they are extremely stable. In May’s book, where he summarised a lot of data and looked at a lot of ecosystems, he argued that diversity does not necessarily mean stability. Some of the most stable ecosystems have just a few species. So again, you come back to the question: what was here?

Let me tell you two stories that illustrate an important point. A man by the name of Knowle in 1931 or 1932, doing a PhD under the Weaver of Weaver and Clements who gave us the book on climax, studied a native prairie that was adjacent to a wheat field. Same soil, same slope, same rainfall. Knowle found that the prairie absorbed the water like a sponge, and then it allocated it over time to stimulate a somewhat even growth. In that wheat field a lot of water ran off, and furthermore, the transpiration rate was so great (it so happened that this study took place during the driest year on record) that the wheat withered and died. Hold that story in your mind. Here is nature and here is human agriculture.

Story number two, back to Jack Ewell in the tropics, looking at that tropical rainforest. There, water is the nemesis of fertility. If water penetrates down it leaches it out. That forest is designed to pump that water back into the atmosphere. So it’s an opposite condition of the prairie. But where they slash and burn, the nutrients are leached downward.

So what is the message that comes from these two systems? Through human agriculture, we tend to invert what nature does well. That is what agriculture is mostly all about, the inversion. So now imagine all the way from Australia, to that wheat field and prairie in Nebraska, to the tropics. From Western Australia to the tropics is an ecological mosaic. Now come back to Alexander Pope. He said, ‘... consult the genius of the place in awe ...’. He did not say do exactly what the genius of the place is doing, but to first of all consult the local genius of the place, meaning nature. Or to use John Todd’s wonderful language about the future: ‘... elegant solutions will be predicated on the uniqueness of place ...’. So it seems to me that is the agenda.

The industrial agriculture is devoted to the homogenisation of the mosaic. This then begins to argue for the need for a lot of people out in the landscape, in a sun-powered world at the end of the fossil fuel epoch. Here is where natural ecosystem ecology begins to have a tremendous effect on the possibilities for human ecology and the process of becoming native.

Even though this is supposed to be discussion, I want to tell you one other story. I realised a few years ago that you do not build satellites of agricultural sustainability and expect them to safely orbit the extractive economy. You have got to think about the culture at large. Almost
wherever we go, in the industrialised world as well as in Third World nations, the tendency is for people to move off the land and into the cities. So what I have done is start buying a town. A community of 50 people called Matfield Green in Kansas, named after a place in England where the people had come from. Matfield Green is an area where 85 per cent of the country is native prairie that has never been ploughed. There are 3000 people in the county. The idea is we do not dare resettle the countryside in the rural areas with the same mid-set that our ancestors had; the idea of infinite soils, infinite forests, infinite resources. My question is this: what is involved in setting up the books in ecological community accounting? It is conceivable that the principles of a natural ecosystem, which inform us on agriculture, might also be applicable for a human community? The human community is predicated upon the extractive economy. A natural ecosystem community features the recycling of materials and runs on sunlight. To think about having an agriculture here and our extractive way of life over there, is to not move beyond the idea of nature as a quarry to be mined. The project then is to see if the paradigm fits for the human community as well as natural ecosystems.

I have bought seven houses for a total of $40,000. We bought the school for $5000, the gymnasium for $4000, the hardware store for $6000, the lumberyard for $1000. My nephew bought the bank for $500. So now I am the Donald Trump of Matfield Green for not very much money, but what I want is for people in the universities and elsewhere to come to terms with why we are losing people, the young, from these small places because they are going to have to keep this paradigm alive on the landscape. So that is my answer to that question.

Tony Liebeck: When you were talking about polycultures, when you thought about it all, did you not think as a stage one, while you were still doing what you were doing with perennials, just to do it with annuals?

Wes Jackson: You mean do the same thing with annuals? Well you see it’s the annuals that cause you to tear the ground up every year.

Tony Liebeck: That is one thing, but if you have got the insect control and the chemical control through polycultures then you are getting people to think about it as a first stage.

Wes Jackson: I do not believe in moving in stages. I want to jump right over. The approach you are talking about would be to work on problems in agriculture rather than to work on the problem of agriculture. Insects, pathogens, soil erosion and chemical contamination are symptoms of the disease of agriculture. I would rather go to work on the disease.

Samuel Johnson said nothing concentrates the mind like waiting to be hanged. So here is the thing; our research agenda is in the 50–100 year time frame. One thing we want to do is increase the imagination about possibilities. As the oil runs out, and the natural gas, and we look at the problems of global warming due to coal burning and we acknowledge that to go nuclear means repealing Murphy’s Law, (Murphy’s Law says that if anything can go wrong, it will). I have talked to some of the people around Chernobyl and I tell you we do not want it. My bet is, that if some of the basic work has been done, then there will be a transition period in which farmers will begin to put in some polycultures and to fit their particular combinations. Right now we do not even have enough for them to begin with. I am not about to release seed that is shattering. I am not about to release seed that is going to produce plants with a lot of pathogen problems and get a bad name for perennial polycultures. The important thing is to get it up to some sort of threshold. I think we will be there before 50 years. I think there will be polycultures experimented with by farmers but they will probably not be compelling till a 60 or 70-year period. Some of that may change. Who knows what the gene splicers are going to want to do with it. I hope we can keep their hands off it. So even though agriculture is a cultural product, there is just an awful lot of basic work that has to be done before farmers get into it. They can not be fooling around with this stuff, they have got to make a living.
Steve Porritt: How do you reconcile trying to achieve non-shattering and high yields, which to me indicates an export from the system, with maintaining the sustainability of that system that you have started with?

Wes Jackson: Well, high yield has to be high enough that people will bother to harvest it. That is what I mean by high yield, it does not necessarily mean export. Do you mean export from a particular piece of land?

Steve Porritt: Yes.

Wes Jackson: All right, let us deal with that. We have done an energy assessment of the cost to replace nitrogen, phosphorus and potassium. Even though these figures may mean nothing to you as Australians they show you the relative problem. On the 316 million acres in the United States devoted to the top ten crops, the energy cost to sponsor the nitrogen in barrels of oil equivalent is about 118 million barrels at the wellhead. The energy cost to sponsor the phosphorus and potassium in the field is under 20 million barrels at the wellhead. The reason is that natural gas is a feed stock for nitrogen fertiliser. So I would hold still for the return of phosphorus and potassium to the fields using that energy subsidy. But if we can get the legume to do the job in the polyculture, seeing as 78 per cent of the atmosphere is nitrogen, then that is a tremendous energy saving. So yes, you do not just pull something from the field as a mine. Thankfully, the most energy intensive nutrient in our fields is atmospheric in origin.

I should tell you a little about our sunshine farm. This is a ten-year project and gets into your question a little bit more. For a 180 acre farm, we are asking what would be involved in getting that farm to sponsor itself. It works out that 25 per cent of the acreage will be necessary to grow the energy for traction. Part of that for draught animals and part of that for oil crops we put into a diesel tractor. Oils that can be squeezed right on the farm. A further 25 per cent of the area is required to sponsor the nitrogen. That is using alfalfa and strip cropping and so on. That shows to what extent agriculture is subsidised out of the wellheads if half the acreage has to go to sponsoring energy and nitrogen.

Malcolm Borgward: This just backs up the figures shown earlier by Wal Anderson where it is costing 30 per cent of our income to achieve that right now.

Dean Melvin: The CSIRO in Canberra claim that for every 1 tonne of wheat we grow in Australia we lose 5 tonnes of topsoil. So is the ultimate in low energy and maximum efficiency to become native, basically as it was before we came and before you guys came to America? Is the ultimate efficiency for mankind to be native like they were?

Wes Jackson: Too much water has gone through the turbines for us to do that. It may be that the answer is yes, but I also doubt if we will stand for it. We are at 5 billion now. We are going to add another billion to this planet in a ten-year period in the 90s alone. Twice the number of people who were in the world 500 years ago will be added in ten years. It seems to be that the problem of becoming native in the modern world is that our standard is a moving target. In other words, what it meant to be native to this place in 1829, is different to what it meant to be native to this place in 1879, and 1890 and 1910 and 1920 and 1950. The problem is, the further we go with the technological imperative, the more compromised we have to become in our standard or our ‘becoming - nativeness’. That is to me the modern human tragedy.

Steve Porritt: Following on from that point, it seems to me as though the energy savings that you are talking about are really on a global scale. You are putting in energy here to get a 3 tonne crop of wheat or gamma grass or whatever, for the sake of the whole system, not just the prairie system. I just wonder, when you say you bought up that town, whether the people from that town really left to go to a desert island where they could be more energy efficient, or whether they moved in to some other ecosystem?
Wes Jackson: It is interesting to me why we have to leave the small towns and rural communities. I did a little historical study a couple of years ago. Francisco Coronado, looking for the third El Dorado, came northward from Mexico with a bunch of Spanish adventurers all the way up to within 18 miles of where I live in Kansas. He was looking for the Kingdom of Ceuvera which was reputed to have gold. It had no gold. The houses were of sticks and mud. But based on archaeological records, and documents in Madrid and Mexico city, one county had 25,000 natives. Today that county has 10,000 people, and the young have to go to the cities. Admittedly they are living better in terms of accommodation. But with such a fossil fuel fly-through, and such a rapid rate of nutrient cycling, why is an economy unable to accommodate as many people in that county today as the native Americans were able to have? They are living in nice houses in cities, but if the people that are in those nice houses in cities had the choice, they would be back in that county where they were raised. In other words, there are 25,000 people who would want to be there, but they can’t be because of some kind of economic arrangement that is not very well understood. So it seems to me that part of our problem is that universities are educating people to leave home. I have been telling universities all over the United States that they have only one major, and its upward mobility. What about a major that will educate people to go back to a place and dig in? Not as a matter of nostalgia but as a matter of necessity to nurture the cultural seed stock, that will see to it that agriculture is sustained. That to me is one of the most serious problems in the modern world.

John Bartle: I can see Wes why you may not have fitted all that well within academe, but if you could have stomached a few more meetings, couldn’t you have stayed there and stayed close to the main stream and done more then you can out there in Kansas?

Wes Jackson: I am more highly visible in Kansas than I ever was in a California university, partly because since Kansas is no place, it’s someplace. You understand what I mean? I was not doing it for that reason, but it has worked out to have made this work more highly visible than a bunch of nattering nabobs of negativism would have made possible.

John Bartle: Do you publish your work in conventional scientific journals?

Wes Jackson: Yes, we publish in refereed journals. We are just now doing it though. We have had all this time in which we have gone through the inventory phase and got our feet under us and because we have had little money we have had to hire young PhDs so it has taken some time but it’s beginning to look like we are legitimate and I am almost ready to go over to the other side.

Barbara Main: Talking about the loss of the population to the cities. I am not sure if you are aware that where we are now there are only 500 people in this district at present, which is considerably less than 25 years ago just like some places you were talking about earlier in the States. But I can not see that it’s just that the universities are doing it in the way they are educating people. If tractors will do the same work now that took a lot of people and horses to do 50 years ago, what is the alternative? Maybe people would like to live in the country, but what are they going to do?

Wes Jackson: Well, E.F. Schumacher talked about how lorries carrying biscuits from London passed lorries bringing biscuits from Edinburgh, going in opposite directions. That is an economic imperative. Somebody is making money out of doing that. If they can do that, why can’t we have tractors doing work and then people just pretending that they have done some work, and be able to stay here and get paid for it? Let me put it another way. You see that sounds absurd, but how absurd are things at present?

Bertrand Russell I think it was, pointed this out; let us say you have a man that is able, with a machine, to make 100 pins in a day. Then a machine is invented that makes it possible for one man to make 1000 pins in a day. Does anybody suppose those other nine people can work one-tenth of the time that they did before? No, because you have an expanding economy, and the expanding economy means that truck drivers from Edinburgh pass truck drivers from London
bringing biscuits. Now when it comes to agriculture, we have an absolutely absurd economic system that says if you can't make it on the farm economically, you just have to leave.

You see I think that gets back to this business of surplus people again. In other words, rather than people being served by an economy, people are serving an economy.

Malcolm Borgward: That is exactly the way they want it to be. The thing to change first is the money system, so that the interest portion which is the usury that causes farmers to have to go is put into circulation at the same time as the debt so that the debt gets paid. That is never done.

Tim Marshall: Schumacher has got some good definitions of what work is and we often think of work as something that has to occupy you for 35 hours of the week, you have to not like being there, and want to be home when you are there. But work is really an essential part of how people define themselves. You are not defined simply by how tall you are and what your name is, you are defined by the work you do. If people defined work as being usefully occupied instead of having a job they go to and get paid for, we could occupy ourselves doing all sorts of useful things. We could occupy a lot of us simply by going out and fixing the countryside up, and helping each other.

Wes Jackson: What we really need is what you might call a mill-around theory for civilisation. In a certain sense all we have to do is figure out a way to stay amused while we live till we die cheap. Isn’t that right? But we can not do that partly because the paradigm under which we work says that it is more important for people to go to work and do things that are unnecessary in order to have the necessities. That has to be a form of sin. That people have to do things that are unnecessary in order to have the necessities.

Now, you won’t get the churches in my country to address that question, partly because there is not really a separation of church and state. What I think we are on the brink of is, just as there was a time when we glibly talked about the divine right of kings, and one day somebody said ‘divine right of kings?’ and then they kind of squinted ... and the world changed. What we have done is moved from a time in which the church organised our thinking and then came the likes of Galileo and Newton and Locke, and the age of the enlightenment which paved the way for the nation state as the thing that organised our thinking. That peaked out with Hitler and World War II, and the nation state as the dominant factor became subordinate to economics. So from religion to the nation state to economics and now we are calling that into question. In other words, economics now decides problems, over-rides nation state considerations. The economic imperative, things like GATT and so forth, are over-riding nation state considerations. That is one reason New Zealand and Australia and some European countries and a hell of a lot of Third World countries are going to be in trouble.

The paradigm we are working on is to move from economics to ecology. The reason ecology, is because ecology has dealt with the intersecting variables that do not lend themselves to the usual linear thinking of the paradigm of Bacon and Descartes and Newton and Locke. Think of the assumption of Descartes in his Discourse on Methods. We wake up every morning and live by this even though we do not know it goes back to Descartes; Descartes said the more he sought to inform himself, the more he realised how ignorant he was, but, rather than regard his ignorance as a statement about the human condition and the very proper result of a good education, he thought his ignorance correctable. So we have as the result of the enlightenment, of which economics is a beneficiary, a knowledge-based world view. A view that our knowledge is adequate to run the world.

Global warming comes out of a knowledge-based world view. Acid rain comes out of a knowledge-based world view. The ozone hole, now that is a good one; 25 years ago chlorofluorocarbons would have been on every chemist’s short list as a non-toxic, non-corrosive, non-polluting chemical that did a lot of wonderful things and now look at it. If we think about it a little bit we recognise that we are billions of times more ignorant than knowledgeable. So what about an ignorance-based world view? Let’s go with our long suit; an
ignorance-based world view, paradoxically, forces us to remember things, to hope for second chances, to study the exits and to keep our scale small. It also says take advantage of the ancient arrangements that have gone through hundreds of millions of years of evolution. If that becomes internalised, then that becomes our organising way of thinking. It does not mean we get rid of economics, even any more than we get rid of the nation state, or any more than we get rid of religion. It is just that they are no longer the dominant paradigm but that they are subordinate to the ecological world view. Of course it is fair to ask: well then, what will come after that? ‘... all good things have the seat of their own destruction ...’ goes the saying.

It seems to me that becomes our mission, so that the economic imperative is a derivative of a larger set of values rather than the thing that determines. I do not know if we have it in us, but it seems to be that as Aldo Leopold, an American naturalist said in 1948, ‘... nothing so important as an ethic is ever written, rather it evolves in the mind of a thinking community ...’. Only the most naive student of history believes that Moses wrote the decalogue. What Moses did was summarise an already existing ethic for a seminar. That is what I think we are involved in now as members of a thinking community in the process of the evolution of an ecological ethic.

That is what sustainability is all about. People say define sustainability, well, define justice, define truth, define love. Any of those value things you can not define, and yet that is what we use to organise society. In a way that is what sustainable agriculture is doing, it is working its way into this arena and providing the wedge point for an ecological ethic. It is fitting that it began in agriculture, because it's through agriculture that we had the break with nature, the split, the fall. It is fitting that farmers have become the ones that have started the revolution. For one thing revolutions do not start with majorities. Revolutions begin with those that are close to, and confront in a very real way, the tension between what is and what ought to be. So it's interesting to me that it comes out of agriculture. So there, if you do not like it, I will take it all back.

![Diagram](image)

Figure 1. Research agenda for developing agriculture in nature's image.
LIKELEY DEVELOPMENTS IN CEREAL GROWING

W.K. Anderson, Department of Agriculture, 2 Baron-Hay Court, South Perth 6151

The vision: Decision support systems to assist wheat growers make the right choice of variety sowing time, rotation, fertiliser and weed control. Specialisation into wheats of a quality our competitors can not or do not grow.

Introduction

This paper discusses the extension of some current trends in cereal production, a few ideas that really constitute a personal ‘wish list’ for the future of the industry and a few genuine predictions of what I feel will happen in the future. Farmers and scientists alike have had three main concerns in the past decade or more that have shaped my thinking in preparing this paper. They are:

• the need to increase yields;
• the cost/price ‘squeeze’;
• soil fertility decline.

Background

Grain yields in Western Australia are often well below the potential that is set by rainfall. This potential for cereals can be estimated by a method that has evolved from about the turn of the century but which was popularised and improved by French and Schultz (1984) in South Australia. It is illustrated below (Figure 1) using data from our local research on wheat in the central wheatbelt.

\[
\begin{align*}
\text{Potential grain yield} & = \left[ \frac{\text{Growing season rainfall} - \text{evaporation}}{\text{Soil efficiency}} \right] \times \text{Water use efficiency} \\
&(\text{kg/ha}) \quad (\text{mm}) \quad (\text{mm}) \quad (\text{kg/ha/mm})
\end{align*}
\]

In the central wheatbelt of Western Australia:

• soil evaporation is approximately 50 mm for well grown crops;
• water use efficiency is 15 kg/ha/mm.

Figure 1

The potential yield formula can be used to estimate yields obtainable with various amounts of growing season rainfall as shown in Table 1.
Table 1. Calculated potential yields

<table>
<thead>
<tr>
<th>Growing season rainfall (mm)</th>
<th>Potential yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg/ha bags/ac</td>
</tr>
<tr>
<td>150</td>
<td>1500 7.5</td>
</tr>
<tr>
<td>200</td>
<td>2250 11.25</td>
</tr>
<tr>
<td>250</td>
<td>3000 15</td>
</tr>
<tr>
<td>300</td>
<td>3750 18.75</td>
</tr>
<tr>
<td>350</td>
<td>4500 22.5</td>
</tr>
<tr>
<td>400</td>
<td>5250 26.25</td>
</tr>
</tbody>
</table>

Table 2. Wheat yields and yield trends in Western Australia. Yield trends, 1960–1990, for selected shires and actual yields in 1990, estimated from the yield trends, as a percentage of the potential yield based on rainfall

<table>
<thead>
<tr>
<th>Shire</th>
<th>Yield trend (kg/ha/yr)</th>
<th>Actual/potential yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low rainfall</td>
<td>(&lt; 325 mm)</td>
<td></td>
</tr>
<tr>
<td>Morawa</td>
<td>0</td>
<td>29</td>
</tr>
<tr>
<td>Nungarin</td>
<td>-6</td>
<td>25</td>
</tr>
<tr>
<td>Kondinin</td>
<td>9</td>
<td>35</td>
</tr>
<tr>
<td>Medium rainfall</td>
<td>(325–450 mm)</td>
<td></td>
</tr>
<tr>
<td>Coorow</td>
<td>28</td>
<td>43</td>
</tr>
<tr>
<td>Goomallling</td>
<td>24</td>
<td>49</td>
</tr>
<tr>
<td>Wickepin</td>
<td>22</td>
<td>42</td>
</tr>
<tr>
<td>High rainfall</td>
<td>(&gt; 450 mm)</td>
<td></td>
</tr>
<tr>
<td>Irwin</td>
<td>12</td>
<td>27</td>
</tr>
<tr>
<td>York</td>
<td>31</td>
<td>42</td>
</tr>
<tr>
<td>Esperance</td>
<td>23</td>
<td>24</td>
</tr>
</tbody>
</table>

If the same formula is applied to average rainfall over the past 30 years in various shires in Western Australia it is apparent that average yields of wheat are at best only 40–50 per cent of the potential calculated as shown in Table 2. The yield trends in our best shires have been about 20–30 kg/ha/year which compares to yield increases in the dryland areas of the USA, for example, of 30–40 kg/ha/year. The worrying trends however, are those in the low rainfall areas which are barely greater than zero (Table 2).

There is a common belief that farmers in the low rainfall areas have not been slow in adopting new technologies such as stubble retention, minimum tillage, herbicides, early sowing and new varieties. If this is so are these new methods masking a fertility decline in the soils of that region? The trends in yield improvement decline as average rainfall declines from west to east, a trend illustrated in Table 3. There may also be fertility declines in the higher rainfall shires that are even more difficult to discern due to the larger responses to ‘improved’ practices.

Table 3. Wheat yield trends, 1960–1990, in selected shires on a west-east transect

<table>
<thead>
<tr>
<th>Shire</th>
<th>Yield trend (kg/ha/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>York</td>
<td>31</td>
</tr>
<tr>
<td>Cunderdin</td>
<td>18</td>
</tr>
<tr>
<td>Tammin</td>
<td>16</td>
</tr>
<tr>
<td>Kellerberrin</td>
<td>10</td>
</tr>
<tr>
<td>Merredin</td>
<td>6</td>
</tr>
<tr>
<td>Yilgarn</td>
<td>0</td>
</tr>
</tbody>
</table>

The pressure to increase yields has resulted from the familiar and continuing trend towards increased costs and lower prices. One example of this is given in Table 4. If costs cannot be reduced, the only ways to stay in business are to increase the yields or the value of the product.
Table 4. Cost of producing wheat as a proportion of its value. Data are for ASW wheat at 10% protein produced on heavy land in the Eastern wheatbelt at a yield of 1.4 t/ha. (A. Peggs, 1991)

<table>
<thead>
<tr>
<th>Year</th>
<th>Cost as per cent of value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981/82</td>
<td>39</td>
</tr>
<tr>
<td>1987/88</td>
<td>49</td>
</tr>
<tr>
<td>1991/92</td>
<td>54</td>
</tr>
</tbody>
</table>

Our research has shown that if agronomic practices are improved, all of the rain that falls during the growing season can be converted at high efficiency into grain. This is illustrated in Figure 2 where the filled circles and the A line represent the optimum management and the open circles and the B line represent the practices common in the wheatbelt 5–10 years ago. Improved management has resulted in halving of the water lost by evaporation from the soil, deep drainage and run-off and has allowed the crop to continue to increase it’s grain yield in response to rainfall over about 250 mm.

![Figure 2](image_url)

Recently our research has been synthesised into a high yield ‘package’ of production practices, the adoption of which has allowed many farmers to double their wheat yields over the last five years or so. These techniques are summarised below:

Table 5. The ‘package’

- Select good cropping land.
- Use a legume rotation.
- Control grass weeds one or two years before the cereal crop.
- Select productive varieties and sow them at the appropriate times.
- Increase N and seed rates if necessary to take advantage of the improved yield potential.
The 'package' technology can contribute in a positive way to the sustainability of our cropping systems. Matching cropping to appropriate soils, the use of legumes, the reduction of run-off and through drainage can be useful in addressing some current problems such as erosion and salinity. It should be recognised that some aspects of the 'package', and modifications of it, are not necessarily so friendly towards the environment, however. For example, the pressure to control grass weeds may sometimes have led to overuse of chemicals that could have aggravated the development of herbicide resistance in grass weeds. We must continue to refine such 'packages' to find the least cost methods, both economic and ecological, of using all the rain that falls in a season.

Challenges for the 90s

I feel that our next challenges can be grouped under two headings as follows:

- improving grain quality;
- sustainability.

About 70 per cent of our wheat, for example, is delivered into the Australian Standard White grade. This is a type that can be produced by most of our main international competitors and is thus susceptible to price undercutting by countries that subsidise their production. One way to avoid this competition is to produce qualities of wheat that our competitors either can't or don't produce. Most of these categories command a high price on international markets. Some examples are Japanese white noodle wheats, soft (biscuit) wheats, hard (high protein) wheats and durum (pasta) wheats. Oats and barley are also being used more for human consumption and these types require improved quality and command higher prices. I believe that the importance of yield as the only goal in production will be reduced and quality will become much more important. A good target for Western Australia wheat growers could be to produce 70 per cent of our crop in high-priced, specialty grades.

Specialised systems will be required to produce specialised grains. These will involve combinations of varieties, selection of soils and locations, crop rotations, sowing times, fertilisers, seed rates and possibly other factors. It should be emphasised that specialisation does not equate to monoculture. Our research must concentrate on whole farm systems that do not provide productivity at the expense of soil fertility.

One other consideration that is already apparent and will, I feel, become more important is the demand that foods should be more nutritious rather than simply tasting good and that they should contain no chemical residues.

Sustainability

There are probably only two points of agreement in all of the definitions of sustainability that I have read. It seems that the definition must contain both economic and biological elements. What is sometimes not clearly understood is that demands outside the farm (or other industry) for clean air, water and food will drive the changes to our production systems as much as the necessity to reduce costs on the farm. These outside influences should not be resented as they are legitimate in most cases and can help us focus on cost-reducing methods.

The symptoms that our past and current systems are not sustainable are familiar to all...... erosion, salinity, herbicide resistance, pH decline, soil compaction, soil crustng and weed invasion. Again we must ask if yield increases are masking a fertility decline that will eventually lead to a breakdown of our systems? Such a fertility decline due to soil erosion, even when yields were increasing, has been measured in an environment similar to ours in Washington state (Krauss and Allmaras 1982).

One recurring theme of the sustainability issue is that diversity is strongly linked to sustainability. This means diversity of crops, pest control strategies, genotypes and farming
systems so that undue pressure is not brought to bear on any one part of the (agro) ecosystem. I feel that animal/crop systems will remain a feature of our agriculture as on balance the advantages outweigh the disadvantages. Some 'pressure points' could be the effect of grazing animals on soil compaction, the overgrazing of crop residues and the sale of residues off the farm.

The use of tried and true conservation farming techniques will increase. Minimum tillage, residue retention, diverse rotations that include pasture, contour cultivation, tree plantings, banks for water control and diverse pest management systems all have a contribution to make. However, the most important tool at our disposal for the improvement of soil fertility is legume-based pastures. The basis of this statement is illustrated by an experiment at Wongan Hills of Ian Rowland and Mel Mason that shows how total soil nitrogen, one index of soil fertility, is increased by clover pasture and decreased by successive wheat crops (Figure 3).

![Soil Nitrogen Increases Under Pasture and Decreases in Crop](image)

What is needed for sustainable management of soil fertility and productivity is a set of fertility benchmarks that will allow farmers to revert from cropping to pasture in each paddock as its fertility drops below pre-determined, critical levels. Measures would be needed of chemical, physical and biological fertility as one measure alone may not give a full picture. Such benchmarks would need to be determined for a range of soils and rainfall zones.

Weed control and nitrogen fertilisers are two of the largest variable costs of producing cereals in Western Australia. Improving the competitiveness of crops with weeds and improving the N use efficiency of crops could thus lead to important savings. Crops that can get access to nutrients preferentially to the weeds, that can emerge faster and grow more quickly will compete better and may require less (or no?) herbicide. Similarly, crops that make better use of the soil
N supply either through more efficient roots, a different uptake pattern or better utilisation within the plant may also reduce costs for N.

Table 6. Example of predicted average wheat yield and grain protein percentage of five wheat cultivars. Estimates made from crop Variety Trial data and agronomy experiments in the eastern wheatbelt during 1986–1990

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Sowing period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Early May</td>
</tr>
<tr>
<td></td>
<td>Yield t/ha</td>
</tr>
<tr>
<td>Spear</td>
<td>1.91</td>
</tr>
<tr>
<td>Kulin</td>
<td>1.86</td>
</tr>
<tr>
<td>Eradu</td>
<td>1.82</td>
</tr>
<tr>
<td>Gutha</td>
<td>1.75</td>
</tr>
<tr>
<td>Wilgoyne</td>
<td>1.72</td>
</tr>
</tbody>
</table>

We cannot afford to ignore recent advances in information technology, particularly in the area of the development of decision aids (expert systems) for farmers. Information support systems that organise and summarise existing knowledge about a problem will be used increasingly for advisers and farmers to assist in making decisions on such issues as weed and disease management, rotations, crop and variety choices. A largely fictitious example of a decision aid for choosing a wheat variety is given in Table 6.

The yields and grain proteins are summarised for a range of varieties at three sowing times. This information can be combined with a set of price assumptions for various grades of wheat to produce gross values of the production (Table 7).

Table 7. Example of gross value of production ($/ha) for wheat cultivars in three sowing periods in the L3 region/zone

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Sowing period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Early May</td>
</tr>
<tr>
<td>Spear</td>
<td>244</td>
</tr>
<tr>
<td>Kulin</td>
<td>242</td>
</tr>
<tr>
<td>Eradu</td>
<td>264</td>
</tr>
<tr>
<td>Gutha</td>
<td>249</td>
</tr>
<tr>
<td>Wilgoyne</td>
<td>252</td>
</tr>
</tbody>
</table>

The effect of season on the choice of variety can also be assessed. This has implications for short term decisions as the sowing period approaches and the type of season becomes clearer,
and for longer term decisions such as the proportions of seed of each variety that should be stored on farm (Table 8).

Table 8. Example of the cultivar with the largest gross value of production for three sowing times in three types of season. Estimated S/ha in parentheses.

<table>
<thead>
<tr>
<th>Type of season</th>
<th>Sowing period</th>
<th>Early May</th>
<th>Late May</th>
<th>Early June</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Good'</td>
<td>Spear</td>
<td>(300)</td>
<td>(316)</td>
<td>Wilgoyne (263)</td>
</tr>
<tr>
<td>'Average'</td>
<td>Endu</td>
<td>(264)</td>
<td>(282)</td>
<td>Wilgoyne (214)</td>
</tr>
<tr>
<td>'Poor'</td>
<td>**</td>
<td>**</td>
<td></td>
<td>Wilgoyne (180)</td>
</tr>
</tbody>
</table>

Finally, I feel that there will be an accelerated trend towards enhancing the productivity of the total farm and catchment. This will be achieved through careful consideration of the optimum management of each part of the landscape, from the marginal areas to the most productive, and their interactions.

References

ALLEY-FARMING

Dean Melvin, PO Box 155, Dowerin 6461

Transcript from ABC TV ‘A question of survival’, broadcast 1 July 1992

The vision:  *Farming in alleys between belts of native trees and shrubs right across the wheatbelt.*

**Voice over**

Less than three hours’ drive east of Perth is one of the nation’s great food bowls, the Western Australian wheatbelt. Producing a third of the annual Australian harvest, these plains have been a gold mine, but the wealth of plump yellow grain has come at a price. Ninety-three per cent of the true-blue bush has gone. Now, soil fertility is declining too. Fresh water is becoming scarce. One in five families is being forced off the land. It is an environment in crisis.

This was the result of the summer wind storms of 1990 (still shot of severe wind erosion). After each summer harvest, the ground is left exposed, and up to 50 per cent of a farm’s topsoil can be lost in a single blow.

In a place like this, the ultimate irony is to inherit a property called ‘Paradise’.

*Dean Melvin*

It is not our fault it is named ‘Paradise’. It’s had five owners in 20 years, and one of the guys just called it out of irony. In early 1986, the farm adviser summed up our position, as he does each year, and said that basically we owe a bit of coin and the way things are shaping up with the amount of dirt that we have got, it would not be able to support three families.

**Voice over**

The Melvin family story could have been one of gaining a paradise already lost. But Dean has added a remarkable new chapter, in fact a whole do-it-yourself manual on resurrecting the wheatbelt.

The environmental problems in this region stem directly from its reliance on crops and pastures which are alive for only half the year. The land is adapted to the perennial native vegetation.

*Ted Lefroy*

A perennial plant like this grass has a root system that is alive and actively growing for 12 months of the year. It is using water for 12 months of the year, it’s providing permanent cover to the soil. Where there is a deep root system like this there is biological activity in the soil 12 months of the year which helps give soil its structure, in contrast to the present farming system which is largely based on annuals.

**Voice over**

The salvation of ‘Paradise’ came in the form of some simple bush logic. Ted Lefroy had been trialing perennials for potential as use as fodder. But Dean was already one step ahead.

*Dean Melvin* (walking down a planted windbreak)

It is looking reasonable Ted, isn’t it? Just like in the bush down the road.
Voice over
Dean had been experimenting with the original perennials, and had tested 100 of them.

Dean Melvin
We have got the wattles and eucalypts together. Bit more of a balanced situation here.

Voice over
Dean’s idea was not just to plant single trees or just perennial grasses. He decided to try to mimic the bush by selecting the right combination of trees, and planting them in rows. Not so unusual perhaps, except that at Paradise, the rows are right in the middle of the paddocks. Spacing the rows widely enough apart for the machinery and animals to move with ease, you can continue with business as usual, growing wheat sheep or whatever you like between.

Dean Melvin
The bush has been around like this for at least 40,000 years. There is very little salinity, there is nearly no wind blow, so that has to be a benchmark to work from.

Voice over
Dean calls it alley-farming and from here you can see why (aerial shot). Rows of native vegetation protect the crops or animals between, and stop the precious topsoil from blowing away. One of Dean’s neighbours was so impressed, he decided to try the system out on one of his worst paddocks.

John Thomas
We started on this particular patch because it was one of my worst areas of drifty sand. There has been no wind erosion whatsoever, even from the first year, and the pasture has picked up a lot in between as well. The amount of grazing we get, this is its fourth year, would be probably equivalent to the best pasture on the farm now.

Ted Lefroy
What Dean has shown is that he can plant back the bush in strips as he has, and it gives permanent cover to the soil, it is using water for twelve months of the year so it is preventing salinity and at the same time it is increasing the yields from his crops and pastures, by protecting them, and that alone can produce increases in yield of up to 20 per cent in crop yield. Now, a plant breeder, working on different varieties of crops and pastures is happy with a 2 per cent increase. The shelter effect of those trees can be in the order of 20 per cent. That is an enormous difference.

Voice over
Up until now, the biggest problem with a scheme like this has been the cost of the trees.

Sherren Melvin
Dean, Dean are you on channel Dean?

Dean Melvin
Yeah, got you Sherren.
Sherren Melvin

Dean, I have just had a phone call. Have you got time to do another 4000 Acacia saligna?

Dean Melvin

Yep. No worries.

Voice over

Dean’s answer was to develop a cheap reliable way to grow native plants from seed. Most of us have been told that doing this (pulling up bare-rooted seedlings) to a native plant is next to impossible. Yet Dean and his co-workers have developed a way to literally rip the seedlings out of the ground, in the same way one might pull up a carrot.

Dean Melvin

The guts to its success is that a bare-rooted plant has a storage of energy and that storage of energy is all that is needed to have a high survival rate. We cut the tops, simulating a roo or an emu coming along and nipping the top out. We cut the bottom, simulating some grub coming along and eating the roots.

Voice over

At six cents each, they are a fraction of the cost of seedlings grown in pots and just as reliable. It means a whole paddock can be planted for the same cost as one application of weed killer a wheat farmer would normally use in one season.

Dean owes much of what he has learnt to the bush. He noticed that nitrogen-rich plants like wattles, always stand side-by-side with their nitrogen-poor mates, the eucalypts.

Dean Melvin

Half the reason we are having problems in our agricultural areas is that things are just simply out of balance. So, we have got nitrogen-making plants and non nitrogen-making plants in our alleys in alley-farming, and they are together so they are complimenting each other.

Voice over

Dean Melvin still farms the traditional way, but is turning as much of his land to alley farming as his finances will allow. At every turn, he is out to break the rules. His hope is that other farmers will follow, so that eventually, the plants and animals that have been introduced to Australia can co-exist with those alienated in their own land.

Dean Melvin

You ask me what is wrong with our present Australian farming systems. Well, apart from our grain quality going down each year, apart from our soil salinity increasing, apart from insecticide and herbicide resistance increasing, apart from the average cocky owing a couple of hundred thousand dollars, I guess there is not a lot wrong with our present farming system.

In answer to questions following the video, Dean made the following points:

- One-third of my farm is non-productive sandplain. This soil type makes up 10 per cent of the wheatbelt, so 10 per cent of the wheatbelt is suited to this alley system I use with the same species, Acacia saligna, tagasaste and eucalypts. On better country, the same principle should apply but with different species, rows wider apart and planting on the contour where there is sloping ground.
• The average cost of spraying in wheat growing in our area is $29 per hectare. The cost of planting alleys 40 m apart with 2 m between trees using bare-rooted seedlings is around $10/ha. Whether you have one plant in 2 m or two plants in 2 m, with our rainfall I believe you will end up with the same biomass.

• The cost of bare-rooted tagasaste seedlings 2 m apart is the same as direct seeding 500 g of tagasaste seed per hectare and far more reliable. Tagasaste is the easiest tree to direct seed in our district, and yet even with it there is a 30–40 per cent failure rate.

• Planting alleys unfenced across a paddock does not mean a loss in grazing. I have grazed paddocks five and six months after planting bare-rooted seedlings. The best way to do this safely is to graze at high stocking rates for short periods. The limiting factor in most cases was the shortage of feed between the trees, not damage to the trees themselves. Bare-rooted trees at that age will tolerate some damage as long as it is not repeated damage.
THE TWIGG STORY

COMPATIBLE SYSTEMS OF LAND USE

Script for video

Produced by AGMEDIA, Department of Agriculture and Rural Affairs, Bendigo, Victoria

The vision:  A deep rooted perennial legume (in this case lucerne) at low densities over the whole farm, including paddocks cropped to cereals.

Bill Twigg

Once farmers only had to keep their families. Now they have to keep so many people in society. The machinery agents, chemical companies, even the banks have got in on the act now. The more inputs you put in the more you have to put in. You get on the merry-go-round and to have to keep going and going. We have farmed in this area for 80 years. Until 1970 we used traditional farming methods just like everyone else, but we found our farm was becoming more and more like a drug addict. The more inputs we put in, the more the land demanded to achieve the same yields.

Voice over

At a time when many farmers are turning to increased inputs and sophisticated management systems, here at Bears Lagoon, 60 km north of Bendigo, the Twigg family are successfully doing just the opposite. Rather than complicating their farming system, the Twiggs have spent the last 20 years simplifying it.

In 1970, fed up with the high cost of inputs, they decided to cut them back. At the same time they wanted to maintain and increase yields. What began as purely economic decision, became a whole new attitude towards farming and some unconventional farming practices. The twist is – the simpler it became, the less others understood it. Perhaps it seemed too simple to work. But this system does indeed work. And it works without high cost fertilisers, dips, drenches, supplementary feed or sheds and sheds of machinery.

In these hard economic times, and with salinity swallowing up our land, the Twiggs believe that farmers and researchers alike must take a hard, long look at their systems. We need systems that will sustain us and our agriculture, not bleed us and our land dry. The over-riding principle behind all farm decisions on the Twigg property is farming in sympathy with nature; looking at how nature does it, then copying it. Say ‘nature’ and people cringe. The word lends itself to all sorts of romantic airy fairy notions, but his system is practical. It works on the principle that things operate in nature’s system for good, sound reasons. We can ignore them or we can study them, work out what they are and turn them to our own use. The objective is not to beat nature into submission but rather to work with it. Some of the Twiggs’ methods are quite unconventional. They try not to eliminate anything in their system. They want their pastures to be as nature intended them. Even the weeds have a role to play.

The basis of the system is lucerne. The lucerne is first sown under a wheat crop at a density of three to four plants per square metre. There is a 50 per cent failure rate, but if it succeeds, it is a very economical way of sowing the lucerne. If successful, it is grazed as soon as the wheat is harvested. If it does not succeed, it is direct drilled into the stubble the next autumn before the rains and grazed three to four weeks after germination to eliminate weed competition. From
then on it is grazed in strict rotation, one week on, seven weeks off. Many people think lucerne is a fragile, fussy plant.

*Bill Twigg*

Complete fallacy! Lucerne is the toughest plant you can get, provided you understand what it needs and it needs space and heavy rotational grazing.

*Voice over*

These plants are the same age. The one on the right has had to compete for space in a traditional planting. The one on the left has not. It is not hard to see which is the stronger plant. Lucerne established at three plants per square metre develops strong, deep root systems that can be grazed heavily without damaging the plant. These roots go down 40 feet so they use the whole soil profile. From here they draw soil moisture and recycle nutrients from deep in the sub soil to the soil surface. Where the roots are active, the whole soil profile is active. The roots assist in water transfer, aeration, and the recycling of nutrients. They also support the soil organisms which break down organic matter into nutrients, so vital to sustained soil fertility and structure.

Annuals grown in between provide winter pasture, clovers for soil fertility, and grasses to build up soil structure. The quickest way to kill a stand of lucerne is to graze it continually. You can kill it in 12 months. A rotation of one week on, seven weeks off is ideal. Lucerne needs time to build up root reserves. After grazing, it draws on these reserves to kick off into vigorous regrowth. The more the top is growing, the more it drives its roots down, the stronger and healthier it, and the whole system, becomes.

But rotational grazing on its own is not enough. Just as important is the number of stock put in to graze. There must be enough mouths to eat it right down in a week, so grazing should be heavy. In spring, when pasture growth is prolific, the Twiggs bring in extra stock. The ideal system would have eight paddocks. The size is not important. What is important is the principle one week on, seven weeks off, and enough mouths to eat the lucerne right down. The same principle operates for 1000 acres as for 10. The Twiggs have discovered that once the lucerne is established the crown can be eaten out, cut off, or subjected to drought without killing it.

In fact, it is so tough that they sow their wheat crops over it and where it is too vigorous, spray to retard it until the crop is taken off. This does not hurt the lucerne at all. Even during the drought in 1983, the Twiggs stuck to this system. The sheep were scratching the soil up to eat out the crown, but the lucerne survived. Three weeks after the ‘break’ the lucerne had bounced right back.

*Green fallow*

*Voice over*

One of the hardest things for other farmers to come to grips with is the Twiggs’ concept of green fallow or conserving soil water for summer growth. In spring, most farmers lock up their best paddocks for hay. The Twiggs’ don’t. Instead, they bring in extra stock.

*Bill Twigg*

In spring the soil profile is fairly full of moisture. The only way for that moisture to get out of the soil profile is to be transpired by the leaves of plants or seep deep down into the soil profile. Lucerne has the ability to trap and utilise this water. So in spring, when growth is prolific we bring in enough stock to eat the grass right down so that there are no leaves to transpire the moisture out of the soil profile, then the water supports the lucerne over the summer. While it is growing vigorously in the late spring, early summer it is getting a tremendous root system.
This produces a very healthy plant at a time when green feed is tremendously valuable. That is why we changed to spring lambing.

**Spring lambing**

**Voice over**

Before the 1970s the Twiggs would lamb early in the autumn and sell when prices are high in July. They would have no stock for the spring flush so they would cut and feed it back in the autumn.

*Bill Twigg*

What a waste of time. We were working like slaves. Then we had some spring lambs and we realised we did not have to feed these spring lambs and we found that our lambing percentage was much higher, and that is what really pushed us into spring lambing, it was just so much more profitable. We had 20 per cent more lambs, and we did not have to do any supplementary feeding.

**Voice over**

1990 is the first year since 1983 that the Twiggs have done any supplementary feeding. Then it was only 300 bags of oats for 10,000 ewes. Since they began farming this way, the Twiggs have found that they no longer need to drench their animals. In fact, they do not have a drench gun on the place. Once again it is a case of letting nature do the work.

*Bill Twigg*

Native animals grazed according to water availability, polluting one area then moving on to another. We pollute our paddocks with dung and worms and we are convinced that is the main reason we do not have to drench. We allow our animals to carry a natural worm burden.

**Voice over**

Behind the idea of compatible systems of land use lies the premise that nature knows what it is doing, that given time, nature will restore the balance. But it is so hard for us to wait. Take weeds for instance.

**Weeds**

**Voice over**

A lot of farmers spend a lot of money trying to get rid of weeds. The Twiggs do not.

*Bill Twigg*

We need a great range of species to grow including what some people would refer to as weeds. These are nature’s healers. They help build up organic matter and soil structure. We then manipulate them by grazing pressure to help the imbalance of the soil or pasture. These species change over the years as the imbalance is corrected and more stable and more productive pasture is established. If a species is sprayed before it has completed its function it will keep re-occurring, and if we eliminate one weed a worse one will take its place.

**Voice over**

Each year, the Twiggs are fine-tuning their system a little more. Their yields compare well with district averages. Protein levels are high yet their overheads are low. They have little
equipment to maintain, no costly fertilisers, drenches, dips, chemicals, and no problems with salinity. Their system is profitable. It has enabled them to increase farm size from 1500 acres in 1970, to its present 8500 acres.

**Conclusion**

**Voice over**

Yet while many farmers have come to look, very few have taken up similar systems. Why? What we do not need in this country is complicated, expensive farming systems. What we do need is simpler, less costly, systems that work for us now and in the future. And this one does.
TREE CROPS FOR THE WHEATBELT

Barrie Oldfield, Men of the Trees, Stirling Crescent, Hazelmere 6055

The vision:  *A small number of high value tree crops on every farm to diversify farm income and improve the environment.*

1. Men of the Trees began 70 years ago as a movement among farmers of the Sahel in Africa to save their land from desertification through tree planting.

2. The first trees they planted were crop trees, capable of diversifying the farm products. That is still our aim today — to address Sahelian conditions with crop trees.

3. Though Men of the Trees are all volunteers they follow professional practice. In fact our aim in recent years has been to improve what we do beyond trade standards. Volunteers have to do their work twice as well as work for which they are paid, otherwise where is the reward?

4. Early experience planting roadsides in North Cunderdin convinced us that our work should be directed more to the farm, to improving the growing climate for tender plants rased by ground-level winds blowing over sandy soils. Hence the start of the Tree Farm Project.

5. We have planted many trial plots on farms to test the feasibility of a range of native and exotic trees, most with multipurpose use.

6. Two trees which are showing promise:

   CAROB — comes from the eastern Mediterranean. Has two products: Carob molasses from the flesh of the pod and Locust Bean Gum from the seed. The bean gum is a widely-used food additive in ice-cream and tinned meats (look for Gum 410 on the label) valued at $2500/tonne, all of which is currently imported into Australia. The pod flesh, used in making carob chocolate is free of the caffeine and theobromine found in ordinary chocolate. Henry Esbenshade, author of 'Growing Carobs in Australia', is managing our work in this area. We can now graft and plant our Carob varieties which match or exceed the quality of overseas imports and have shown growth rates of 2 m in 18 months.

   STONE PINE — grows vigorously under semi-arid conditions and specimens planted at Dowerin seven years ago are now well over 3 m high. We can now improve on those earlier conditions. Stone Pine nuts are currently retailing for $120/kg (so I am advised!!).

   We have also planted oil-bearing eucalypts for Professor Allan Barton's research. We take his seed accessions, propagate them at our nursery at Hazelmere, then plant the seedlings out on surveyed salt-threatened land at Cartmeticup, Woodanilling.

   Many of the Quercus genus oaks are also proving feasible to grow under our highly stressed conditions, including *Q. robur* (English oak) *Q. suber* (cork oak) *Q. frainetoo* (Hungarian oak).

7. To further the work of diversifying farm income and improving the environment through farm trees we made the film 'Wheat Today, What Tomorrow?' with David Bellamy in 1987. That film and the ensuing conversations with Bellamy and others brought us to look more closely at our soils and seek ways to increase the life in them, particularly the soil fauna and micro-organisms.

8. Scatter trials done on the use of igneous rock dust in many parts of the world encouraged us to investigate this locally.
9. Trials began in 1989 and proved so promising that we have now set up field trials at our tree farm, Amery Acres, Dowerin.

10. These trials are in their early establishment phase, the farm only having been officially opened on 3 June this year.

11. The farm is testing a range of trees and shrubs with potential multi-purpose use and in varying configurations.

12. The farm is also seeking ways to improve the soil — not just conserve it. To this end Pioneer Quarry, Herne Hill, have given much material support.

13. David Bellamy was pleased to make a seven-minute promotion for us on the theory behind the use of rock dust as a soil amendment, explaining that it has a parallel in the periodic Ice Ages when the high latitude soils are naturally remineralised through the grinding action of glaciers. Western Agriculture learnt its trade on these high latitude soils. Hence the problems we encounter today when that same agriculture is translated to the poor soils of Australia.
ETHANOL AND EUCALYPTUS OIL FROM WOODY SPECIES

John Bartle, Department of Conservation and Land Management,
PO Box 104, Como 6152

The vision: Twenty per cent perennial plant cover in agriculture, much of it woody species harvested for industrial products.

Introduction

The Mediterranean climate area of the south-west of Western Australia has a quite unusual agricultural environment. Some prominent features include:

- It is an old, flat, deeply-weathered land surface.
- The weathered profile has good permeability, especially in surface horizons, but is sealed at depth by unweathered basement rock.
- Alternation from water excess in winter to drought in summer, winter excess can rapidly infiltrate into the deep profile.
- Native vegetation exploits the deep water storage during the summer drought.
- Poorly developed or absent groundwater systems under native vegetation means poor leaching and massive salt accumulation in the deep profiles.

These basic features of the environment automatically dictate that an annual plant based agriculture will lead to the profile slowly filling up with groundwater, leading eventually to waterlogging and seepage on the valley floors, mobilisation and discharge of salt and enhanced stream flow volume.

The settings also provide considerable potential for a perennial plant component within the agriculture to exploit the surplus water and improve the productivity of the system. This is exactly what is observed (Figure 1).

\[
\text{Production from 10 ha of mixed trees and pasture} = \text{Production from 8 ha pure plantation} + \text{Production from 6 ha pure pasture}
\]

Figure 1. Complementarity in mixtures (after Moore et al. 1991).

This data is for wide-spaced pine trees in pasture in an 800 mm rainfall area. It indicates that some 40 per cent less land is required in the mixed system to get the same total yield that would be expected using pure plantation and pasture.

I believe this result is representative of a general complementarity that is available from skilfully designed and managed mixtures of woody perennial (shrubs and trees) and annual plants in our agricultural environment. The challenge, yet to be addressed by our agriculturalists, is to develop mixtures and farming systems which exploit this complementarity. As indicated in the above example the potential rewards are large.

The phenomenon of complementarity is due to more than just efficient water use. The perennial component in the mixture can exploit water, nutrients and sunlight which is surplus to the requirements of the annual agricultural plants. Perennial shrubs and trees can also create a protected aerial environment which is more productive for the annual plants and animals. Degradation is reduced through protection from erosive wind, through greater water
consumption, drawing down of groundwater systems and reduction in waterlogging and salinity and water erosion. Furthermore, the trees themselves can be productive.

Rationale for development of perennial species

The case for a perennial plant component in our agriculture is compelling. We need to urgently develop a suite of species and to build them into an agricultural system that exploits complementarity. The job is large. To achieve the salinity and wind control benefits of perennials will require some 10–20 per cent of the farming area to be under perennial cover. This is 1.5–3.0 million ha for the whole of the South west of Western Australia. With planning, fencing and establishment it will cost some $1.5–3.0 billion. Clearly the potential to finance such a massive investment will be greatly improved if economic products can also be gained from the perennial plants.

There are two classes of perennials of interest:

- Perennial grasses and fodder shrubs which will mesh into conventional grazing within the existing agriculture.
- Woody plants and trees which will produce wood and other products.

The woody plants and trees are my particular interest. They offer some important advantages over the grazing species:

- They are ‘tough’ and, once well established, are easily managed.
- They include tall species which will be more effective in providing wind protection and water use.
- They provide the opportunity for radical diversification of agriculture into new products.
- They offer substantial nature conservation spin-offs.

Selection of species and products

There is a large number of possible woody species and products which could be developed for agriculture. Some systematic basis for selection of the best prospects is required. Table 1 presents a cursory analysis of potential products. It rates potential products according to criteria which would determine their commercial viability. This approach deals with the obvious constraints and opportunities presented by such factors as scale, rotation length, transport cost, processing cost, value adding potential, compatibility with existing agricultural systems and market factors.

Figure 2 indicates another important concept in the selection and development of products and species, i.e. co-products or multiple products from the same species will improve the viability of the production system.

This analysis has been used to identify two products with potential for development as large scale commodities and capable of providing a commercial incentive for extensive tree planting. They are eucalyptus oil and ethanol.

**Eucalyptus oil:** This oil has traditionally been used as a pharmaceutical and this supports a small international industry. There is good potential to develop new large scale uses for the oil and to develop oil producing eucalypts into a farm crop. The pharmaceutical value of eucalyptus oil derives mainly from its solvent and tissue penetrating properties. These properties also make it an attractive target for development for a range of industrial uses. One of the most prospective uses is as an industrial solvent and degreaser.

Industrial solvent markets are very large and diverse, and predominantly supplied with petrochemical based materials. Many of these materials are subject to increasingly stringent health, safety and disposal regulations. Some common solvents contain chlorine and their loss
to the atmosphere may contribute to ozone depletion. In contrast eucalyptus oil is a natural product, easily recycled and readily biodegradable. In common applications it could provide major economies through recycling and reduced health and safety costs. There is strong market demand, even with some cost penalty, for new environmentally safe materials for industry. Dozens of prospective applications await investigation.

Many eucalyptus species have high oil content. Species suitable for a wide range of rainfall and edaphic conditions could be developed. This would include mallee species amenable to short cycle harvests (2 years) or tree form species which could be harvested on longer cycles while also providing other products and benefits.

Modern harvest and steam distillation techniques would need to be developed. Preliminary work done in Western Australia indicates that some 5000 ha of oil eucalypt crop would be required for efficient utilisation of such infrastructure. This means that only short haulage distances for harvested leaf would be required. Leaf oil contents typically range from 2 to 3 per cent (green weight) and yields of 70 kg/ha of oil can be achieved (on a two-year cycle) even with genetically unimproved stock. With yields at this level, prices of $10–12/kg would make a viable crop.

Ethanol: Wood as an energy source is potentially a very large scale commodity. Close to urban and regional centres firewood is already an economic crop but its low price/tonne means it cannot be transported very far. The rapid technical development of fermentation systems for the conversion of woody feedstocks to ethanol offers real promise for economic energy crops in the medium term (Lynd et al. 1991). Ethanol can be produced competitively in small scale plants thereby overcoming the wood feedstock transport constraint. It can be readily blended with existing liquid fuels in proportions up to 20 per cent without the need for modification of motors. Fermentation would require the feedstock to be reduced to a mash and could therefore provide a dedicated residue use to improve the economy of other products such as eucalyptus oil and sawn timber. Wood is likely to be a cheaper and more reliable feedstock for ethanol production than cereal or sugar crops due to lower harvest cost and the absence of competitive uses. Being a renewable energy source any future control on greenhouse gas emissions would strengthen its competitive position.

Conclusion

Any vision for improvement to the productivity and sustainability of agriculture must include some 20 per cent of perennial plant cover, much of it woody plants and trees, designed to be an integral part of the agricultural system. It is imperative to develop new, large scale woody plant products and markets to add momentum to the rapid establishment of woody plant cover. While the development of such products and markets may appear to be marginal prospects in themselves, they will be very attractive from the viewpoint of aggregate benefit. This prescribes a prominent role for Governments and publicly funded research to help make it happen. Farmers have a good track record as innovators and developers but in the case of large scale, multiple purpose woody plant crop development they should give priority to putting pressure on Governments and the professions to deliver the policies and leadership that is required for this vision to be realised.

References


Table 1. Analysis of the productive potential of woody plants

<table>
<thead>
<tr>
<th>Woody plant part</th>
<th>Product type</th>
<th>Production system</th>
<th>Raw value</th>
<th>Transp</th>
<th>Processing</th>
<th>Market</th>
<th>Other benefits</th>
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<tr>
<td></td>
<td>Cycle years</td>
<td>Capital cost</td>
<td>Labour cost</td>
<td>$/tonne</td>
<td>$/m³</td>
<td>Radius in km</td>
<td>Value added</td>
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<td>5</td>
<td>10³</td>
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<td>1</td>
<td>1</td>
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<tr>
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<tr>
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Notes: 1 Scaling of costs, value, potential etc is 1 = small to 5 = large.
2 Transport radius is distance for which transport cost exceeds value of load.
3 Location symbols are L (local), S (state), N (national), I (international).
4 Market size is gauged in relation to potential area of tree planting required to supply product.
Figure 2. Multiple products improve viability.
LIVING IN A FABRICATED LANDSCAPE — THE LOOK OF THE LAND

By Barbara York Main

Agriculture, very broadly, is about growing things, i.e. the cultivation of plants and animals. Basically, the process involves interaction of people with a landscape, which they use. Inevitably the process (the use of the landscape) involves manipulation, alteration and fabrication of it. However, during these stages of modification people experience and manifest some regard for the landscape.

To view the land as anything other than as a substrate to be used, requires an emotional and philosophical shift of perception from the utilitarian to the aesthetic. While we may lament the fabricated landscapes of today with their wounds and scars of erosion and lost biota, artificial topographies and exotic replacements, nevertheless we have to acknowledge that historically, the behaviour of the first manipulators was in fact imbued with an aesthetic ideal. Those who first altered the indigenous landscape, in many instances, were trying to recreate a forfeited ‘ideal’ landscape from elsewhere while at the same time make a living from it.

Several recent authors have emphasised the synthetic nature of vegetation in Australian rural (and other) landscapes with their mixture of indigenous and exotic elements and argue that such admixtures are acceptable to society (Bridgewater 1990, Mott and Bridgewater 1992). Clearly, so long as people are involved in a landscape and continue to manipulate, alter and fabricate it, then it will remain contrived. Few synthetic vegetation associations are self sustaining. Perhaps abandoned, unrehabilitated but naturally regenerated mine sites with their mixture of indigenous plants and ‘weeds’, regrown gravel pits or old paddocks revegetated without ‘help’ by salt tolerant native and exotic species, fit the concept of a ‘new synthetic wilderness’ rather than a fabricated landscape.

But as long as people are still involved with a landscape then the reality will be a contrived fabrication. Our goal now then, within this concept of fabrication, is to reshape such landscapes so that they both satisfy our physical needs (through the practising of agriculture) and reflect our spiritual visions (which must surely encompass nature conservation and what elsewhere has been termed a ‘biocentric’ rather than ‘anthropocentric’ regard for the landscape). A biocentric attitude accepts that nature, that species of plants and animals exist in their own right but an anthropocentric philosophy sees nature purely as subservient to human needs (see Taylor 1986 and Nash 1990 for explanation of these terms and exposition of the ‘rights’ of nature). The more idealistic, rather than purely utilitarian justification for attempting to maintain the biodiversity of the globe encompasses a moderate biocentric outlook.

Civilised people have an inherent interest in their origins and their historical environment. Now there is no cut-off point in ecological or environmental history. European settlement, Aboriginal history, prehistory, bio-geological history — it is a continuum. Enquiring into and understanding this continuum is to understand our present cultural landscapes. People tend to look elsewhere for ‘culture’ — as though it is something which develops somewhere else and is projected for us in theatre, films, books and through the arts generally. But the fabrication of a landscape, here, as anywhere, is the manifestation of a culture in the making.

Explorers of the last century translated the landscape within a framework of their own history. In 1830 when Dale explored to the east of the Darling Ranges he unconsciously fitted the sweeping views into a known pattern, he spoke of ‘downs’ and ‘wolds’ (our sandplains and heath), of ‘brushwood’ (wodjil), of scenery like a ‘park’ or ‘demesne’ (in reference to banks along the Avon, and probably groves of jam trees). Woodlands and timber were glorified as ‘forest’ even into this century.
In a fabricated agricultural landscape (for example here in the central wheatbelt), each generation will put a different relative value on the particular components and on the total shape of the landscape. This is because people have a natural affinity, an empathy for the landscape into which they are born or grow up in, at least in which their formative years are spent. No doubt to the present generation, the broad almost prairie like sweep of paddocks with crops of wheat or lupins, with maybe a fringe of Banksia and woody pear or straggling York gums, a few clumps of salmon gums and a colourful stretch of cape-weed in flower, strings of river gums along eroded creek-lines, sinuous humps against interceptor ditches and grey mottled tamarisk and salt bush along a gullied flat add up to a comfortable scene, a visual image to hang onto.

But paradoxically if people are relatively sedentary then gradual changes can proceed almost unperceived (how else could anyone tolerate the destructive attrition of some landscapes?). And they may simply forget the former landscape. The present is always just fine. And as each new agricultural practice leaves its legacy (clearing for wheat, sheep grazing out the understorey of timber stands, weeds spreading into bush from introduced fodder plants, salt scalds spreading) it is accepted — such contrivances lock quickly into the landscape.

In contrast it is those who are exiled early on from a landscape who tend to want to keep the landscape of their memory that way — nostalgia is a strong force. Hence the returning prodigals are sometimes aghast at the disruptive changes, lost landmarks and discordant elements in fragmented patterns. It may be hard for them to see in the fabricated landscape anything but a collection of misfits. Similarly the eye of the casual visitor can quickly detect flaws in the composition of a landscape.

A couple of examples: as you approach Tammin from the west along the Great Eastern Highway you pass near Livesey’s siding a patch of derelict bush in a salt flat by the railway line. Amongst the dead mallee and shrubs a Washington palm flaps its green fronds. Closer to Tammin there is a line of sturdy river gums. Somehow to me the accidental palm tree sits more easily amongst the derelict salt waste of native bush than do the planted river gums along the stripped verge. Even exotics can be less incongruous than Australian plants from another region. The palm tree contributes to a new naturalisation, the river gums as yet, still look contrived.

Conscious design, of anything — including landscapes — comes only with a certain sophistication, i.e. with experience and a sense of evaluation.

When the surveyor Terry classified the land which was to become the central Wheatbelt with a view for subdivision into farm blocks, he perhaps unconsciously laid the foundations for an integrated although modified landscape. He was in fact the first ‘rural planner’ for the Wheatbelt. His reports of 1907 and 1908 (Terry 1907, 1908) clearly indicated that the different topographic areas and vegetation types should be exploited in a discriminatory manner. In classifying the land into first, second and third class according to its estimated capacity for grazing stock and growing cereals he recommended that third class land (the granities, stony ridges, sand plains, ‘thickets’ (= wodjil ?) and ‘lake country’), and even some second class land (white gum, salmon gum, mallee on poorer soils), rather than being cleared should simply provide extra ‘rough feeding country’ during ‘certain’ periods.

This policy actually continued into farming practice until after World War II, fortuitously because of poison bush in the whitegum woodlands and rocky ridges and low fertility of the sand plains. Retention of much of this type of land characterised a patchwork landscape, an aesthetically pleasing visual mosaic of scrub and open paddocks (and probably helped maintain the hydrological balance and forestalled some salinisation). Heavy machinery and trace elements were to change the structure and pattern of this fairly cohesive landscape, and give to the present generation, a vastly more open terrain with only scattered indigenous vegetation. Denudation was followed by erosion and salinisation and in turn by honest attempts at reconstruction.
And I must distinguish here between reconstruction (and reclamation) and restoration. Clearly restoration can only be attempted on a small scale for perhaps conservation reasons, I mean nature conservation. The greater part of the landscape has been alienated for agricultural purposes and thus reconstruction is the ideal in this context.

But for anyone who can either remember the interim landscape or who has a strong sense of the ‘rightness’ of composition in a landscape, the reconstruction is flawed. Functionally parts of it are obviously working but aesthetically there are elements that jar. I believe the main error is associated with the scale. Although the substrate is a broad sweeping, undulating configuration, the parts of the landscape were originally small-scale, right from topographic features to discrete vegetation patches to what I recognise as microhabitats favoured by invertebrate fauna.

Now it is well to recall that many of the early settlers came from a background of small-scale countryside, if not as emigrants then at least only one generation removed. Some of them remembered hedgerows, stone walls, copses and pockets of wood. And they slotted into the ‘Terry’ pattern of 500 to 1000 acre blocks. The ‘difficult’ country remained uncultivated. Certainly life was hard, the country improvident; farming didn’t really pay on this scale. The Depression determined abandonment of holdings by many families while others profited by absorbing these farms into their own. But until after the War the structure of the landscape still didn’t alter much. So that the composition was still made up of small-scale units, cohesive and aesthetically comprehensible.

The current ongoing attempts at reconstruction, including soil conservation, revegetation, the efforts by Land Care Groups and implementation of Catchment area units which are all geared to re-establishment of a hydrological balance are all laudable. But the most likely method to effect a combination of function and total integrity of the landscape is the blue print espoused in ‘The Revegetation Guide to the Central Wheatbelt’ (Lefroy, Hobbs and Atkins 1991). In this guide for reconstruction of farms the vision is towards matching key elements of the indigenous (original) vegetation with the inherent structure or skeleton of the landscape so that the two are again spliced together but with areas for profitable farm activities and products intersticed into a kind of topographic latticework. Consciously or otherwise the small-scale ‘fractals’ will thus be replaced in the overall landscape.

I have hinted at some determining historical ‘policies’ and occurrences. There is another human factor which I must mention. Historically, control of rural land in the Wheatbelt has been largely in the hands of men. A former Director of Agriculture, in the early 1950’s (Sutton 1952) commended the role of women and praised their contribution, ‘the splendid part’ they played in the progress of agriculture in Western Australia. He noted that many left ‘refinement and comfort and accompanied their menfolk to endure hardships and to attempt unaccustomed tasks. They did it cheerfully, in order to make homes in the wilderness; in doing so, they encouraged and inspired the men to their best endeavours.’

Powerful assumptions and indirectly an indictment of our grandmothers. Are they indeed to blame for the ravaged, denuded, eroded, salinised landscape of parts of the Wheatbelt, because of their ‘cheerfulness and encouragement’? Or in fact were the mistakes, many of them ‘honest’ mistakes, made by men governed simply by the practicalities of making a living. I would argue that women generally are more sensitive to landscape values and that until recently, because of tradition and lack of educational opportunities, they have not been able to express this sensitivity in a practical way on the ground.

Where women have been able to manifest a practical role in land management in the Wheatbelt they have demonstrated that it is possible to combine viable farming with reconstruction and reclamation (e.g. Jos Chatfield’s tree planting programs here at Tammin). In addition in some cases reconstruction and some restoration combined with fulfilment of an aesthetic ideal which plays true to the inherent structure of the landscape has succeeded. And here I must praise
Alison Doley of ‘Koobabbie’, Coorow. Nevertheless it is probably true to say that men predominantly still have the major influence in shaping this landscape. The gender balance (or imbalance) of the present workshop appears to confirm this statement.

These remarks on relative influences lead to another philosophical question regarding land ownership. Several years ago Bill Thomas gave a challenging address at an Australian Ecological Society meeting at Geraldton, titled ‘Who owns the Environment?’ Because of the various Government and legal constraints he argued that indeed the Government owns the environment (which presumably includes the land). Well of course nobody really owns the land as many altruistic environmentalists are quick to tell us — we are all tenants or stewards. Quite simply, none owns the land, the land belongs to the future. But even if none owns the land, we are all nevertheless in one way or another responsible for its upkeep.

And depending on the scope of our vision the landscape in all its eclecticism will attain some measure of unity. I am going to quote now a member of the farming community. Before the push from CSIRO and CALM for nature conservation in farming areas, Erwin Barrett-Lennard of Konduk pronounced that he believed the landscape was settling into a new ‘harmony’ — he was already accepting then (in 1975) the disappearance of some indigenous elements and expansion of others e.g. extinction of some beautiful insects, spread of salt tolerant native plants and the ‘rightful place’ of exotic plants, long before Peter Bridgewater was acclaiming what he termed ‘anthropochorous’ and ‘synthetic’ vegetation (Bridgewater 1990; Mott and Bridgewater 1992). I was still distressed at the conflicts, the juxtaposition of exotics and indigenous vegetation, weeds and diminishing bushland, despoliation of natural topographies. Erwin and I were talking about a landscape, the integration of all its parts, its functional and visual wholeness. Bridgewater seems more concerned with how plants hang out together, a kind of lose some/gain some game.

But it is increasingly being shown that the functions of agriculture and nature conservation can be integrated. Nearly 30 years ago, a local resident (the late Anne Raston) said to me, ‘The country isn’t as pretty as it used to be’. Some of us now hope and dare to believe that the current process of integration will reflect a new aesthetic idiom; there will always be some contrivances (some examples of the wrong tree in the wrong place) but even a ‘fabricated landscape’ can be beautiful, different, but for a later generation, as beautiful as Anne Raston’s lost landscape, and thus still be a place worth living in.

References


VISIONS FOR AGRICULTURE

Workshop I:

What would agriculture be like if we had known as much about this landscape in 1829 as we do now? What would we do differently?

Brainstorming, Group I

(Letters indicate grouping made once list was complete).

F 1. Determine our purpose - agriculture or hunting and gathering.

G 2. Develop unique products through market analysis, to achieve sustainability by using the natural advantage.


C 4. 15% for nature conservation
   15% productive bush
   70% for agriculture.

F 5. Consider the indigenous population.

C 6. Survey the landscape and plan the infrastructure.

D 7. Every 60 km have a 20 km buffer of native vegetation.

C 8. Determine natural landscape units and have farm scale determined by unit size.

A 9. Conduct a full inventory including mapping vegetation and all natural resources.

A 10. Separate farm areas from areas of natural drainage.


H 12. Development strategy aligned to proposed use.

D 13. Mandatory that some land is not released.


D 15. Have cadastral boundaries based on the nature of the resource.

B 16. Establish maximum unit area.
E 17. Ban private ownership.

H 18. Develop land condition indicators as performance standards.

B 19. Segregate units so there are no externalities, i.e. along catchment boundaries.

I 20. Remove the "shiny bums".

F 21. Subsistence living for all.

J 22. Women more involved in decision-making.

Summary

1. Determination of objectives for production (F).

2. Inventory and assessment of natural resources (A,B).

3. Market analysis for diversification of production (G).

4. Development strategy aligned to land uses (B,C,D,H).

5. Land condition indicators for resource maintenance (H).

6. The ethic of land stewardship (E,J).

Brainstorming, Group II

(Letters indicate grouping made once list was complete).


B 2. Start with a resource inventory.

B 3. Ecologically-based property boundaries.

C 4. Greater integration of native resources.

A 5. A forest net system with belts of vegetation separating smaller paddocks.

A 6. Alley farming network based on a mosaic of selective clearing.

A 7. Greater retention of native vegetation.

C 8. "Go native" through development of native industries, e.g. acacia seed, quandongs.
C 9. Work with nature, including the use of exotic species.

C 10. Selection of plants and animals synergistic with this environment.

A 11. Keep soil covered (much less bare ground).

B 12. Re-think the introduction of exotic species (everything from the fox to wheat).

C 13. Industries based on native herbivores (particularly the kangaroo and emu).

Summary

1. Aim to maintain the physical and hydrologic balance of the native system (A).

2. Exploit native species (C).

3. Look before we leap off the boat (B).

How Group II saw this 'new' landscape:

- More native species.
- More industries based on native species.
- Changes made with caution.
- More thought given to land ownership and social structure.
- Use of the hydrologic, physical and biological characteristics of the native system to monitor environmental balance.

Shared vision statement (both groups)

Community stewardship of the environmental balance.

- Resource inventory.
- Development strategy.
- Monitoring of land condition.
Workshop II

What are the major obstacles to achieving this vision?

Brainstorming, Group I

(Letters indicate grouping made after list was complete).

A 1. Lack of education toward good stewardship.

B 2. Global economic influences on land utilisation, particularly market interference.

C 3. Lack of agreement on what constitutes stewardship.

C 4. The wide variation between different individuals' priorities and goals.

D 5. The time required for planning.

A 6. The lack of education toward a commonality of goals.

G 7. Too many politicians.

G 8. The present centralisation of power.

B 9. Increasing global influences on land use (e.g. International Monetary Fund dictating to national governments).

A 10. The lack of role models of land stewardship.

G 11. Our cultural heritage which puts power, profit and fame ahead of other achievements.

F 12. Usury and greed versus gratitude and humility.

G 13. The lack of perennial plant products and markets.


D 15. The loss of income in transition.

H 16. Climatic change and its effects on agriculture.

F 17. Objective measurement techniques.

E 18. Unknown and unforeseeable obstacles.

E 19. Changing requirements.
Summary

1. Cultural inertia (B,G).
2. Lack of a definition of stewardship (A,C).
3. Lack of research, development and extension on perennial plants (F).
4. The time required to make the transition and the cost involved in making it (D).
5. Unknown and uncertain changes such as climate change (E).

Brainstorming, Group II

(Letters indicate grouping made once list was complete).

A 1. People's attitude to change.
C 3. Present banking practice.
C 4. Economic theory, particularly the practice of discounting the future.
D 5. The cost of vegetation replacement.
C 6. Society's current value system dominated by short term dollar gain.
B 7. Soil fertility decline (physical, chemical and biological).
D 8. Lack of landholder funds to make the change.
G 10. Unstable nature of the political agenda.
C 11. Vulnerability to world markets.
E 12. Lack of holistic knowledge of the environment.
A 13. The social stigma attached to failing or trying something new.
G 14. The taxation system.
H 15. The likely increase in climatic variability.
G 16. Politicians are lawyers and not biologists.
F 17. Few examples of native industries.

G 18. Our present representative democracy (as opposed to participatory democracy).

D 19. The lack of investment in rural industries.

G 20. The loss of cohesion in rural communities.

G 21. The lack of accountability.

B 22. Resistance of pests to present controls.

E 23. Loss of knowledge of the landscape.

E 24. The 'cult of the new' i.e. the rejection of older knowledge or values.

A 25. Personal attitudes to environmental issues (golf versus landcare).

A 26. The unwillingness to acknowledge problems.

Summary

1. People's attitude to change (A).

2. Present environmental imbalance (B).

3. The present economic imperative (C,D).

4. The lack of holistic knowledge (E).

5. The lack of models of native industries (F).

6. Inappropriate political system (G).

7. External factors out of our control (H).
Workshop III

How do we address these obstacles to make the transition from where we are now to where we want to be?

Brainstorming, Group I

(Letters indicate grouping made once list was complete).

A 1. Public forum for ideas.
A 2. Arrest the population drift to the city.
D 3. Define the stewardship ethic.
B 4. Model farms for education.
A 5. Allow expression of individual rights and choice.
A 6. Invigorate the landcare movement as the vehicle for change.
A 7. Ensure the use of grass roots groups as agents for change.
A 8. Community awareness and involvement.
C 9. Revise research programs.
B 10. Identify short term achievable goals.
B 11. Act now.
D 12. Developing monitoring philosophies (biological economic, cultural and spiritual).
C 13. Select and breed suitable perennials.
C 14. Increase R & D in the development of perennial plant products and markets.
C 15. Repeal Plant Variety Rights and other restrictive legislation.
B 17. Promote innovations by individuals and groups.
B 19. Develop sustainable systems according to land type.
B 20. Encourage conservation farming and the integration of agriculture and nature conservation.
E 21. Target this document at:

- advisory committees
- WAFF, PGA, RAM
- LCDCs
- Industry funding committees
- volunteer groups.

B 22. "Farmers up Front" project to support extension on innovative farms.

F 23. Longer term economic horizons to finance change.

E 24. Take concept to the media.

E 25. Market "Visions for Agriculture".


Summary

1. Cultural change through grass roots community involvement (A,D).

2. Development of educational and extension strategy (B).

3. Research and development in sustainable systems (C).

4. Communication and marketing of the concept to widen ownership of the initiative (E).

5. Encourage use of longer term economic horizons (F).

Brainstorming, Group II

(Letters indicate grouping made after list was complete).

A 1. Understand the nature conservation implications of correcting ecological imbalance on farms.

B 2. Establish a participatory democracy.

A 3. Community knowledge bank.

C 4. Demonstrate losses resulting from non-adoption.

D 5. Alley farming - get out and do it.

C 6. Create awareness throughout the community.
D 7. Get out and do it, then publicise.
E 8. Encourage city-based businesses to invest in farms with tax write-off as incentive.
F 9. More pest and feral animal research.
G 10. Create a greater diversity of products to offset external uncontrollables.
D 11. Convince mainstream industries (wheat and wool) of the benefits of alternatives such as alley farming.
A 12. Develop closer linkages between researchers and farmers.
D 13. Do not carry out research on research stations to improve relevance and accessability.
G 14. Avoid external factors by diversifying and/or selling through farmers' markets or directly to consumers.
B 15. Remove red tape and over-regulation holding up change.
B 17. Make catchments the basic political unit.
G 18. Buy only Australian products.
H 19. Support polycultural research.
G 20. Market research for native plant and animal products.
F 21. Initiate research into native plant and animal industries.
A 22. Use decision support systems.
B 23. Set up a real rural bank.
C 24. Initiate a media campaign to discredit destructive farming systems.
D 25. Establish models of alternatives.
G 26. Adapt the cyclical nature of resource use in nature to agricultural production.
B 27. Vote in more sympathetic and understanding politicians.
H 28. Only fund research into multiple issues (i.e. multi-disciplining).
B 29. Encourage community cohesion.
B 30. Ensure continuity of funding to deal with problems.

**Summary** (not ranked in any preferential order)

1. Create accessible information base for decision-making (A).

2. Redefine political boundaries along catchment lines and devolve power to 'bio-regions' (B).

3. Conduct an advertising and educational campaign on the benefits of 1. and 2 and the on-ground dollar benefits of alternative systems (C).

4. Implement models of farming systems (D).

5. Promote financial and social links between metropolitan businesses and alternative farming systems (E).

6. Initiate broad spectrum research into alternative farming systems (F,H).

7. Seek and develop diversified native product markets (G).

**Workshop participants**

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<tr>
<th>Group I</th>
<th>Group II</th>
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