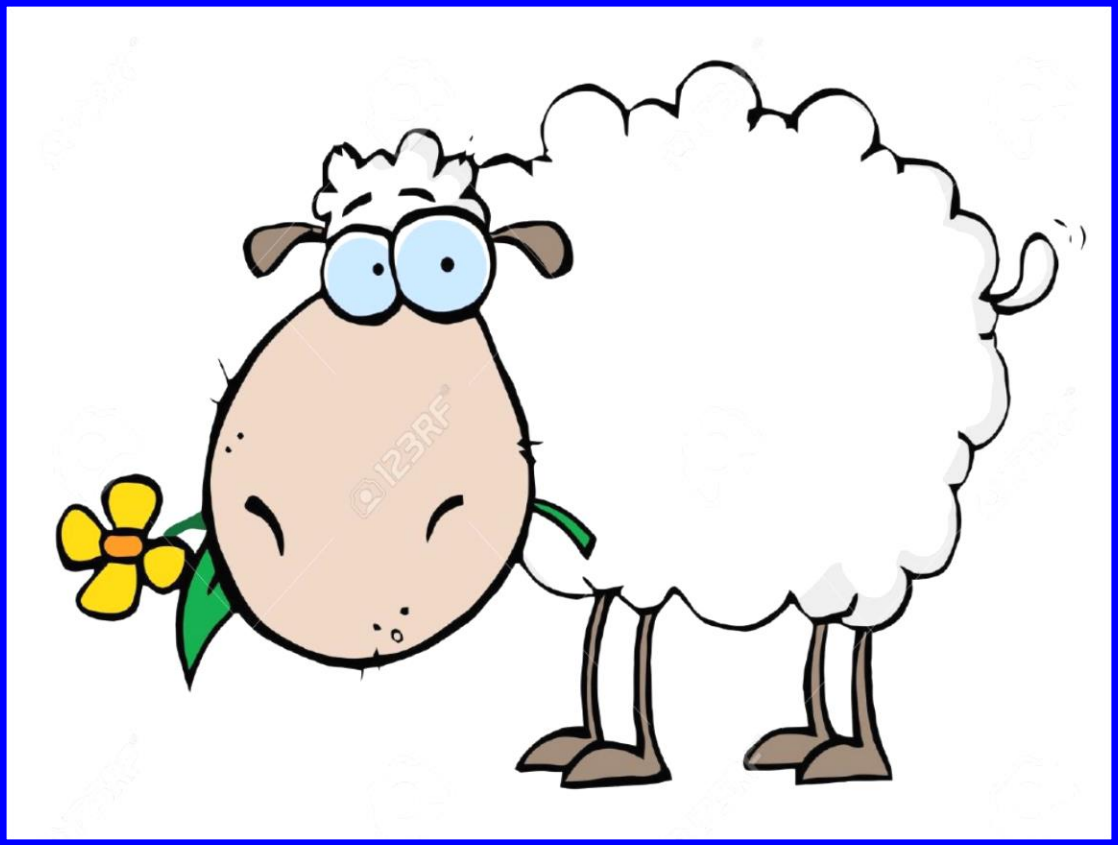
Grasslands

Restoring our farms, soil and profit



Colin Seis

Winona

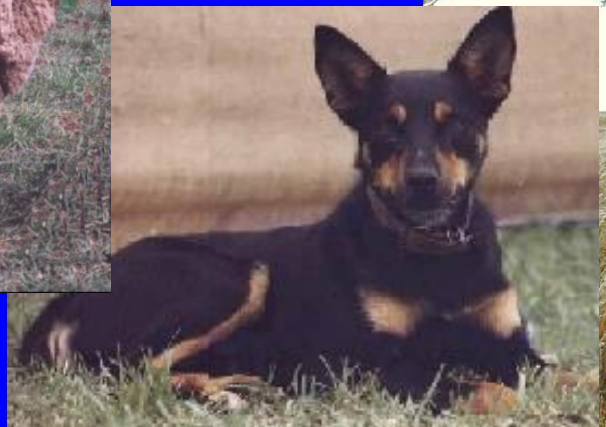
- **2000 acres (840 Ha)**
- **300 km NW of Sydney**
- **Central Tablelands NSW**
- **Granite soil, Ph 5.5-6.0**
- **600 mm annual Rainfall**

Winona Enterprises

4000 Merino Sheep wool & meat production.

500 acres of Crops
Wheat, oats, rye. (pasture cropped)

Merino Stud
ram sales



Kelpie Dogs

Native Grass Seed

How can we be more profitable?

To be more profitable we should look at what has gone wrong

For 10,000 years we have killed grasslands and destroyed soil to grow crops & graze animals

The grassland destruction continued during the 1900s by ploughing the soil to grow crops

After the 2nd world war there were concerns about producing enough food for the increasing world population.

A new “Agricultural revolution’ was developed to solve these problems

Labelled the ‘Green Revolution’, it developed new, high yielding crops, and fertiliser and pesticides to help crops yield to their maximum

The ‘Green Revolution’ was very successful

- Produced huge amounts of food.
- Reduced hunger and poverty.
- Created wealth for farmers.

It sounds like an ideal method of agriculture.

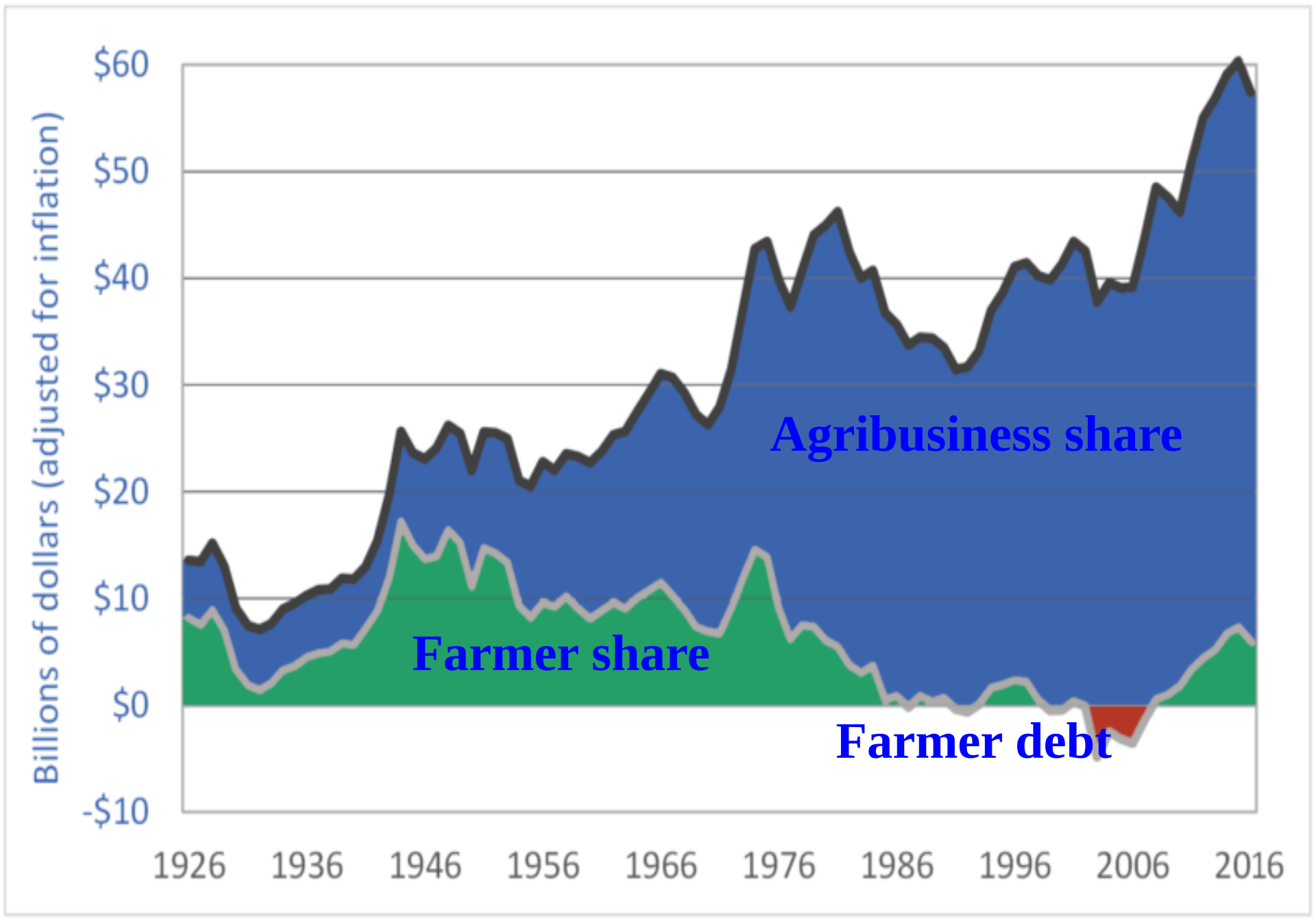
What could possibly go wrong??

It has created many problems

- **Ecological disaster for our farms and the planet**

- Declining soil health
- Dependency on fertiliser
- Dependency on pesticides
- Reduction in food quality
- Human health problems

Wealth is now with multi-national companies



THE GREEN REVOLUTION CAN NO LONGER BE AFFORDED.

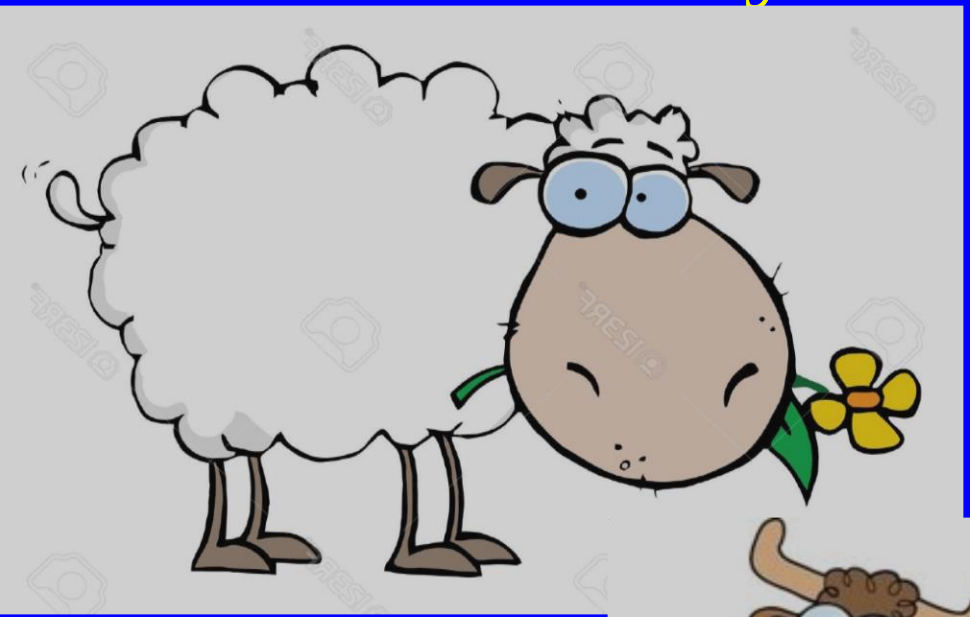
Many of the things we do in agriculture make someone else wealthy, not farmers

Not only is this form of agriculture sending farmers broke, it has also created serious human health problems

Agriculture is supposed to be about FOOD

But there is something wrong

Mineral depletion in vegetables, meat, and dairy from 1940 - 1991



Minerals in food have declined by 60-90 %

This form of intensive agriculture was also the final nail in the coffin for most of our grasslands

Although fertiliser and pesticides can be an aid to agriculture they have created many problems for our farms, soil, farm ecosystem,
and our profit

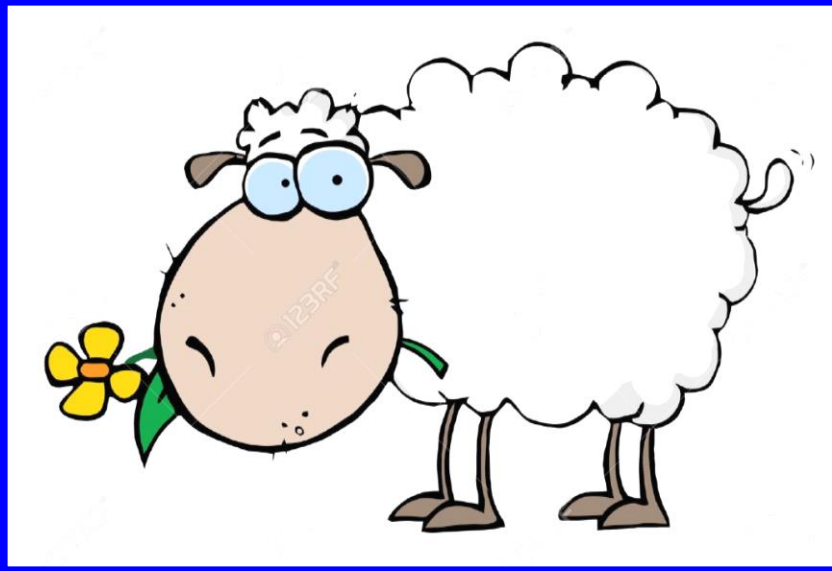
Many paddocks, and whole properties, have become un-productive, covered in weeds, and hard, compacted soil

Why??

The way crops are grown using ploughs or excessive herbicides & pesticides

- **Kill grasslands & pasture**
- **Destroys the soil ecosystem**
- **Destroys the farm ecosystem**

The way we graze animals is not working



- **Kill grasslands & pasture**
- **Destroys the soil ecosystem**
- **Destroys the farm ecosystem**

How can we fix our farms, soil, grassland, soil nutrient decline, weeds, crop disease, as well as being productive and profitable?

How can this be done without spending excessive amounts of money?

We need to start by fixing our soil, but this can only be done by growing more plants

We need to cover our soil and farms with a diverse range of living plants

Not a monoculture of plants

Single plant species in crops and pasture are also a large part of our problems

Plants will restore our farm, and soil and profit

- Perennial grassland /diverse pasture

  (50- 100 plant species)

- Pasture Crop *(Perennial cover crops)*
- *(20 – 50 perennial plant species)*

- Multi- species, cover crops

  (6-10 plant species, or more)

Plants can be grown and grasslands restored by using a few different techniques

- Change grazing management
- Change cropping methods
- Grow multispecies crops and cover crops
- Sow pasture species

Sowing pasture

- Sowing pasture can be a way of restoring the property's pasture if all the pasture/grassland has been lost through overgrazing or cropping.

But!!!!

Sowing pasture is one of the last things to do

We grow plants that want to die
and
Kill plants that want to live

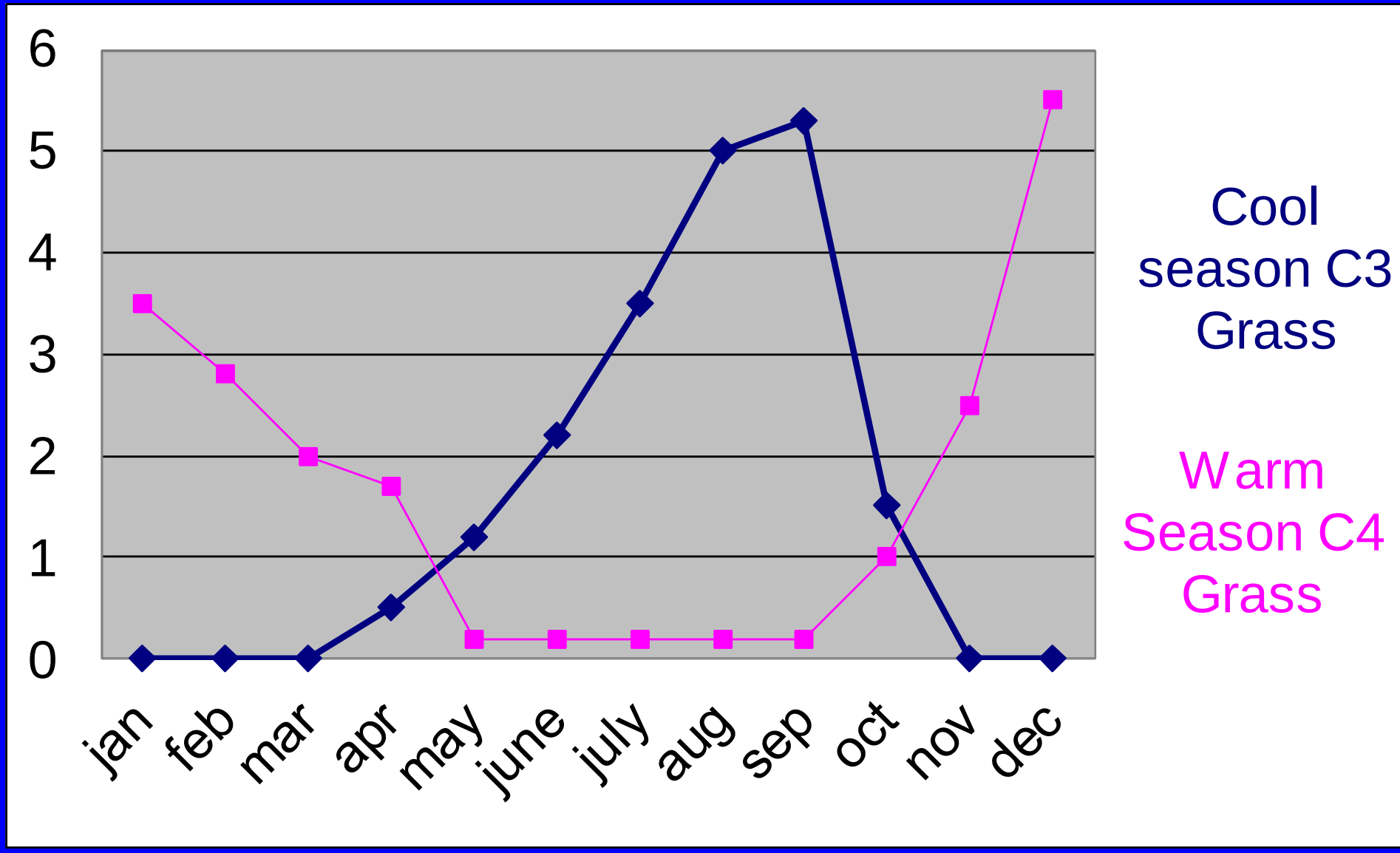
Sowing pasture

Pasture should be dominated by perennial species not simply annual species of clover and ryegrass.

Pasture should contain a mix of grass species, forbs, herbs and legumes.

Pasture should function like grassland with a lot of species diversity, and contain a mix of winter species (C3) and summer species (C4).

The graph illustrates how C3 and C4 plants function



Instead of sowing pasture why not restore the grassland

Winona Grassland 2020

February 2020

August 2020

How do we change, and what do we change to??

What happened to my Property!!!

In 1860 the original grassland was very high quality and contained over 200 plant species.

- My Great Grandparents, Nicholas and Catherine Seis were some of the original pioneer/settlers in the district in 1860.
- Produced merino sheep and wool
- Started growing wheat in 1868

Industrial Agriculture was adopted in the 1930s.

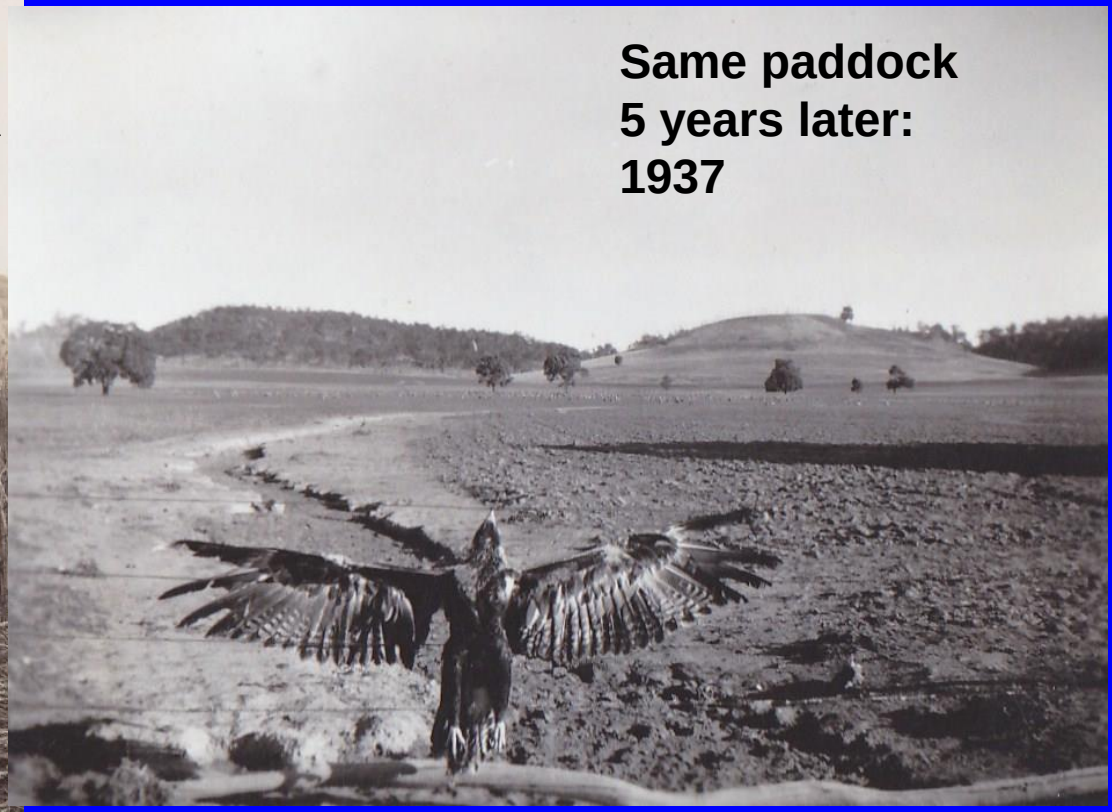
Sowing wheat, 1934

Growing wheat was very profitable in the 1930s

Within 20 years major damage to soil and grasslands had occurred

Ploughing and sowing wheat destroyed Winona's grassland and contributed to soil health decline, erosion and salinity

1932



Same paddock 5 years later: 1937

My father (Harry Seis) fixed many of the erosion and pasture problems.

- Filled erosion gullies
- Began an innovative fertilizer program for pastures and crops.
- Sowed the property with introduced annual species

Industrialized, high input, farming methods

From 1950 to 1978 on 'Winona'

- **All sown to introduced annual pasture**
  (clover ryegrass, etc and regularly re-sown)
- **Pastures annually fertilized.**
- **Ploughing and cultivating soil to sow crops.**
- **High use of fertilizer & pesticides**
- **Set stock grazing (no rotation)**

This high input system was very productive during this era

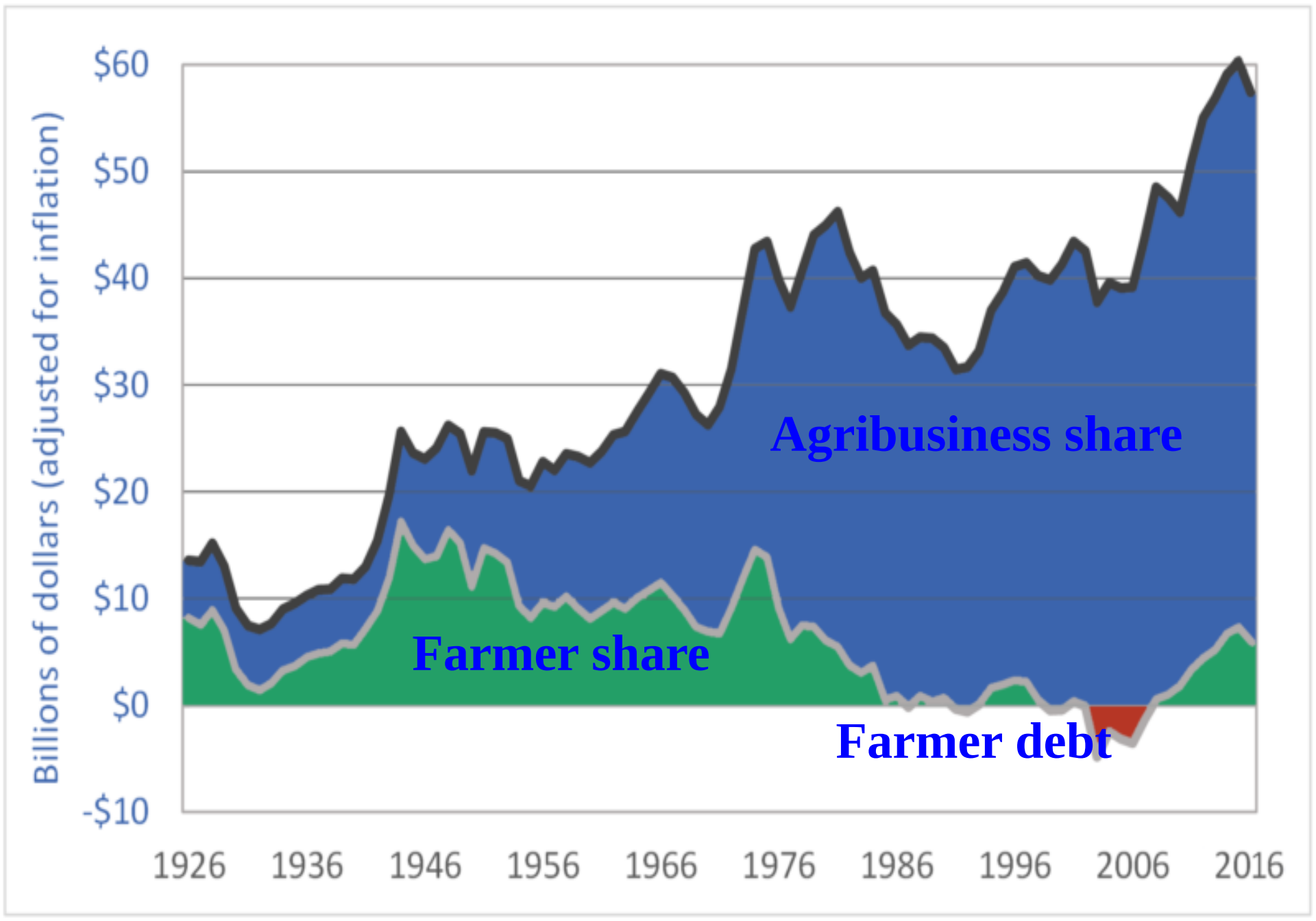
1970s

Over time, industrialized agriculture was doing serious ecological damage to Winona

These high input methods were costing us over $80,000 annually *(2020 values)*

High input, Industrialized Agriculture started to crash on “Winona” during the 1970s

- Fertiliser costs became too high
- Cost of sowing pasture became too high.
- Rainfall no longer infiltrated
- Soil lost structure
- Soil became acid
- Salinity problems
- Trees dying
- We were going broke

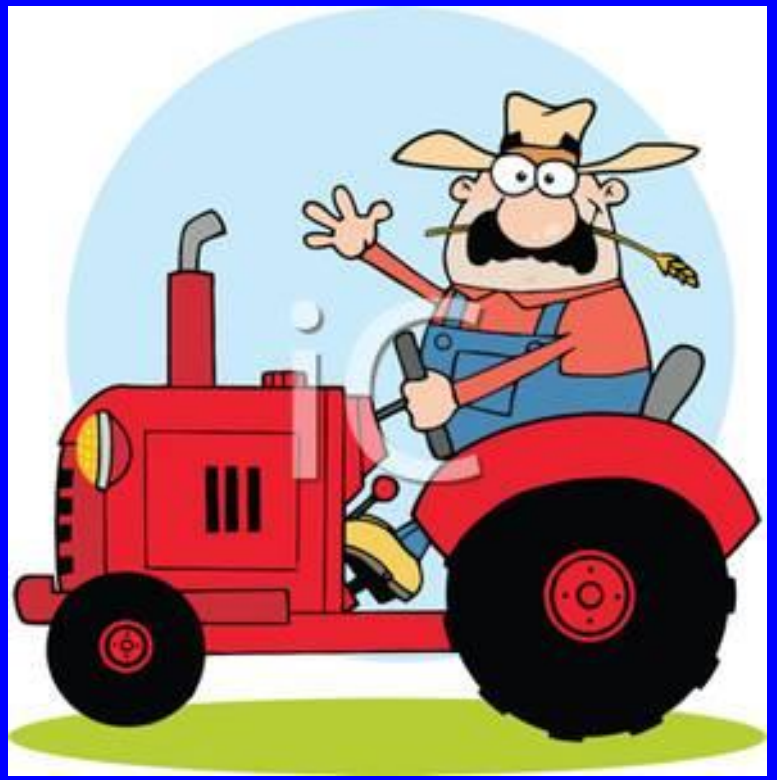


THE GREEN REVOLUTION CAN NO LONGER BE AFFORDED.

By 1970 the ‘Winona’ Grassland was destroyed.

All that was left were a few remnant plants.

How and why did I change??



Major bushfire destroyed Winona 1979

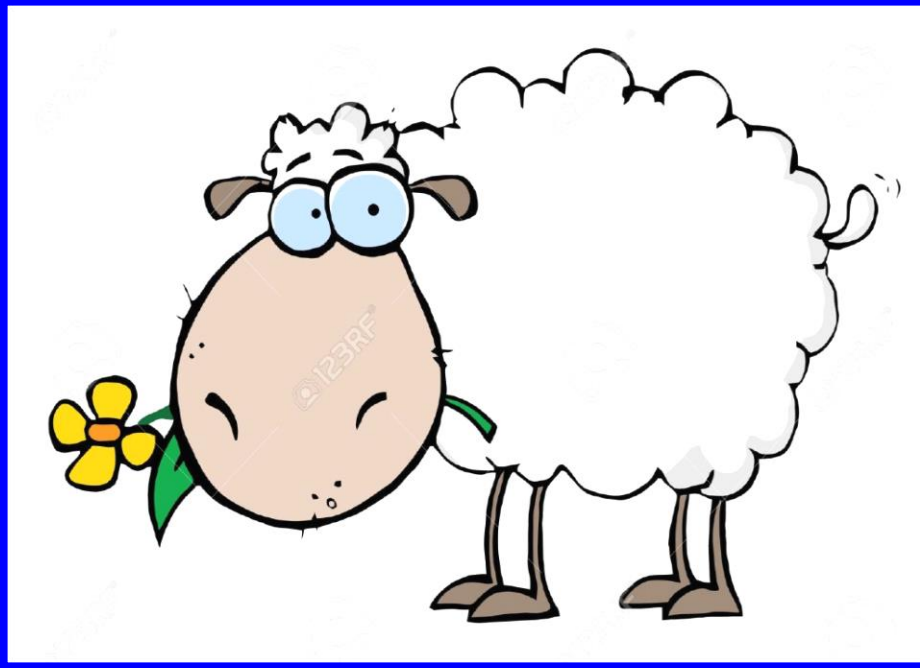
Winona Homestead 1979

Winona sheep shearing Shed 1979

- 3000 sheep killed
- All buildings destroyed
- 50 km of fencing burned
- No money

How did I survive??

- 1000 ewes survived which were used to rebuild sheep numbers



- Grew wheat

- Learned to have a sense of humour

How did I change

- **Focused on restoring Winona to grassland.**
- Looked for low input agriculture methods.(1980s)
- Stopped using pasture fertilizer and pesticides (1980)
- Focused on 100% ground cover. *(crops an*
- Adopted ‘Holistic planned grazing’ 1993
- Developed ‘Pasture Cropping’ in 1993
- Combined ‘Pasture Cropping’ and ‘Holistic planned grazing’ in 1995

Grasslands

Why are we talking about grasslands?

- Grasslands are the best benchmark we have to model our farms on, to function as an ecosystem.
- Grasslands are about species diversity (plants animals , insects, soil microbes.)
- If our farms function more like grassland we will solve most of our soil health,weeds, disease and insect problems , reduce costs and be more profitable.

Grassland function is the template on which agriculture should be modelled

The types of plants in a Native Grassland are:

- Perennial C3 grass *(Winter growing)*
- Annual C3 grass

- Perennial C4 grass *(Summer growing)*
- Annual C4 grass

- Forbs
- Scattered trees and shrubs

C3 and C4 plants

Refer to the different pathways that plants use to capture carbon dioxide during photosynthesis

What is a C3 plant

- Can be perennial or annual
- Mostly Autumn – Spring growing
- Require more water (than C4 plants)
- Are more tolerant of cold (less than 25 degrees)
- Are not tolerant of heat over 30 degrees
- Produce higher quality feed (than C4 plants)
- 95% of the earths plants are C3

Winter growing perennial grass species

Native C3 species

- Wallaby grass (Danthonia)
- Weeping grass (Microlaena)
- Common wheat grass (Elymus)
- Plains Grass (stipa)
- Spear grass (stipa)

Introduced C3 species

- Phalaris
- Rye grass
- Cocksfoot
- Fescue

Annual C3 Crops

- Wheat
- Oats
- Barley

What is a C4 plant

- Can be perennial or annual
- Are Australia's dominant grassland species
- Are mostly summer growers
- Have very high water-use efficiency.
- Are more tolerant of heat 25 - 35degrees
- Generally produces more dry matter/year but lower quality than C3 plants
- Less than 1% of the earth's plants are C4

Summer growing perennial grass species

Native C4

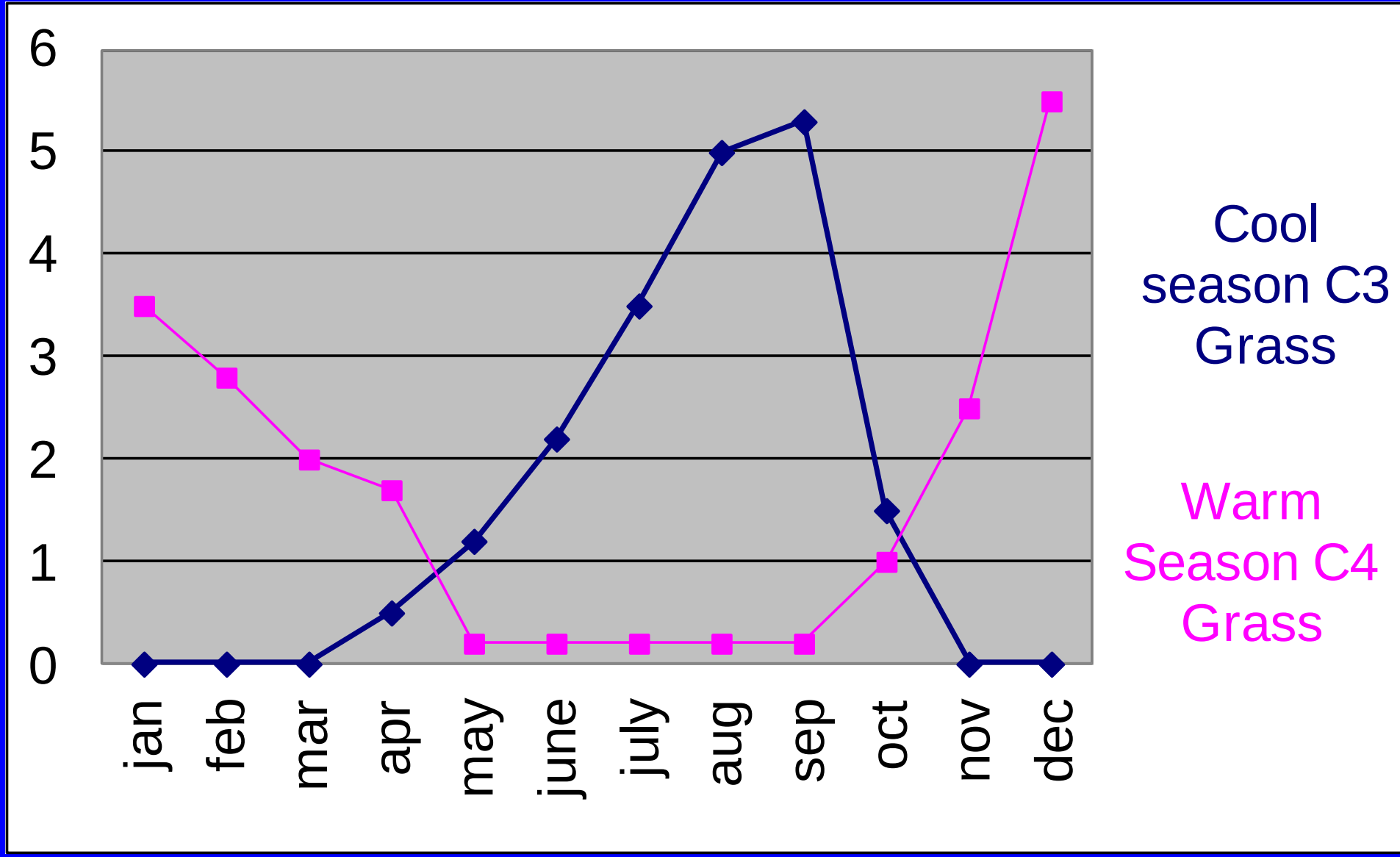
- Windmill grass *(chloris)*
- Kangaroo grass **(***themeda)*
- Warrego summer grass *(Paspalidium Sp.)*
- Red Grass *(bothriocloa)*

Introduced C4

- Premier digit grass
- Green Panic
- Rhodes grass
- Paspalum

- **Annual C4 Crop**
- Corn
- Millet
- Sorghum

The graph illustrates how C3 and C4 plants function



Forbs and Herbs

Forbs are flowering plants with a non woody stem.

Herbs are plants that have no woody tissue and die down at the end of the growing season.

Native forbs and herbs

- Glycine sp.
- Orchids
- Lilies
- Irises

Introduced forbs and herbs.

- Clover
- Lucerne
- Chicory
- Plantain

Many of these species fill the gaps between grass tussocks in grasslands

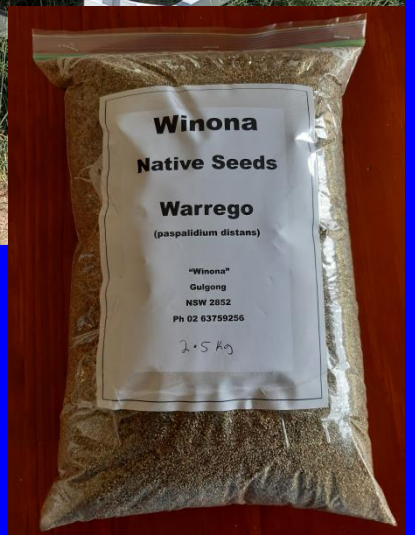
Harvesting, cleaning, and sowing native grassland species

Native Seed Harvesting

Vacuum Harvester

Brush Harvester

Seed Cleaning



Sowing native grass seed

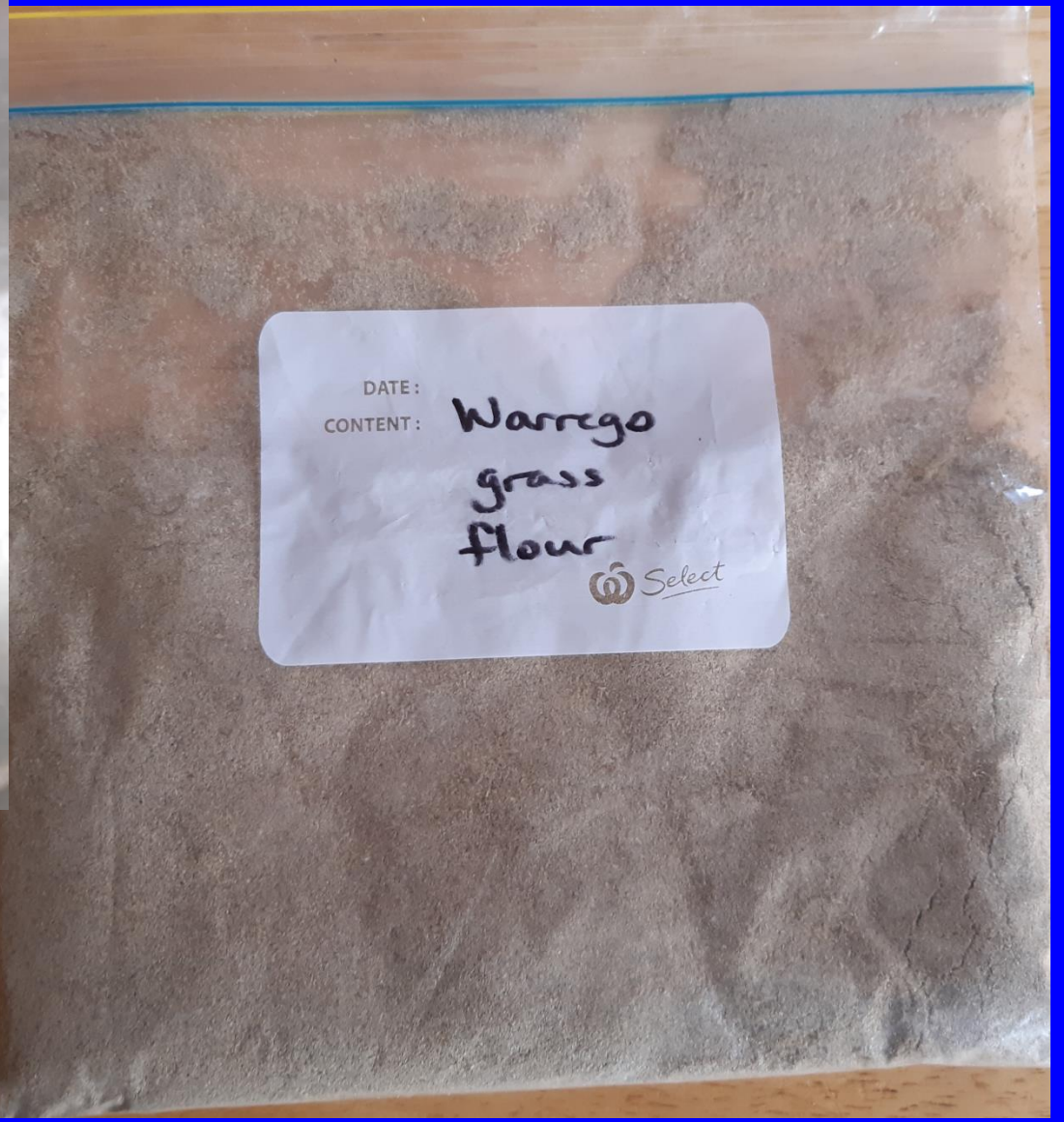
- Seed without awns can be sown through a seed box.
- Seed with awns requires spreading

Food from Native grains

The University of Sydney
Plant Breeding Institute – Narrabri

Gomeroi first nations people

Bread baked from Native Warrego seed


DATE :
CONTENT : Warrego grass flour
Select

Green Summer grass (arm grass) is showing great potential

In Australia, the first nations people nurtured the grassland for many tens of thousands of years

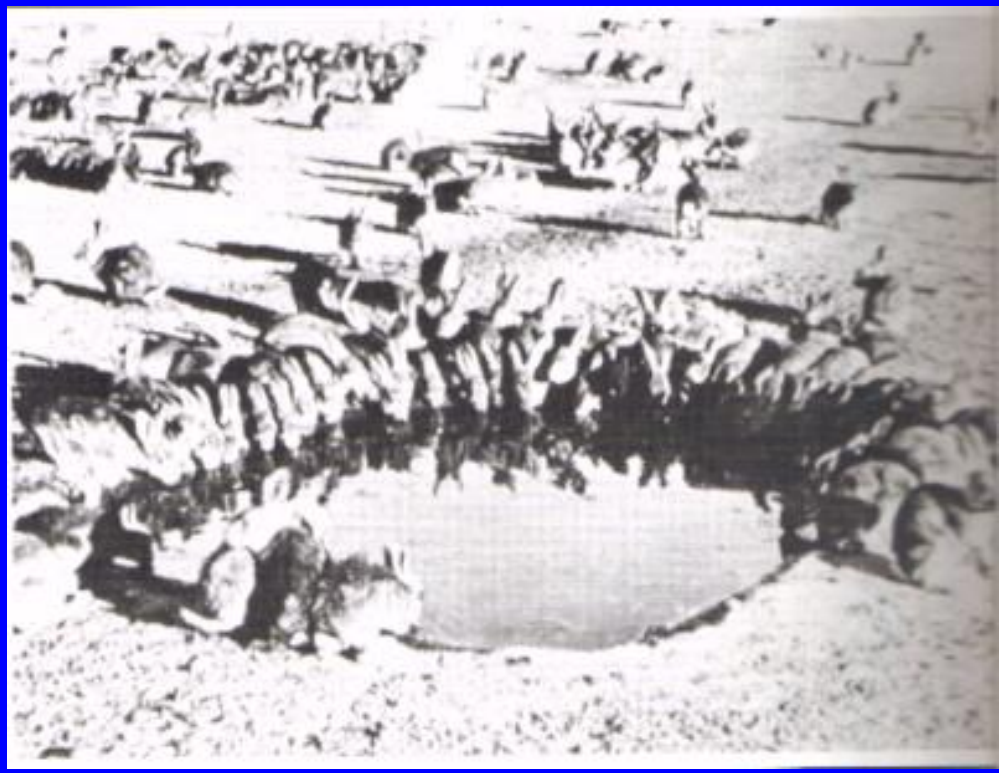
The arrival of Europeans saw the start of the grassland destruction and within 100 years most of the original grassland was in serious decline

Australia's grassland has declined in species diversity and livestock carrying capacity over the last 150 years

What caused the destruction of our grasslands???

Many of the better quality grass species had declined in the first 80 years of settlement by:

- Inappropriate grazing methods. *That were better suited to European grass species and European climate.*



- Ploughing to sow crops
- Diverse grassland
- Rabbits

What were Victoria's Grassland like ?

- George Augustus Robinson – 10th Jan 1840

  (The area described was near Mt Camel, 50km east of Bendigo)

- Described as; *The country through which we travelled today consisted of green hills and valleys with a verdure of transparent green.*

  (verdure --- the fresh green colour of lush vegetation.)

- *The country as far as the eye could scan was truly luxuriant."*

How did I restore ‘Winona’s’ Grassland and soil

Restoring native grassland

On My property I did not sow any native grass seed

- I adopted and developed methods that stimulated seed germination.

(pasture cropping & holistic grazing)

- Seed can be sown if there is no seed in the soil
- Awnless seed can be sown through a seed box.
- Awned seed should be spread.

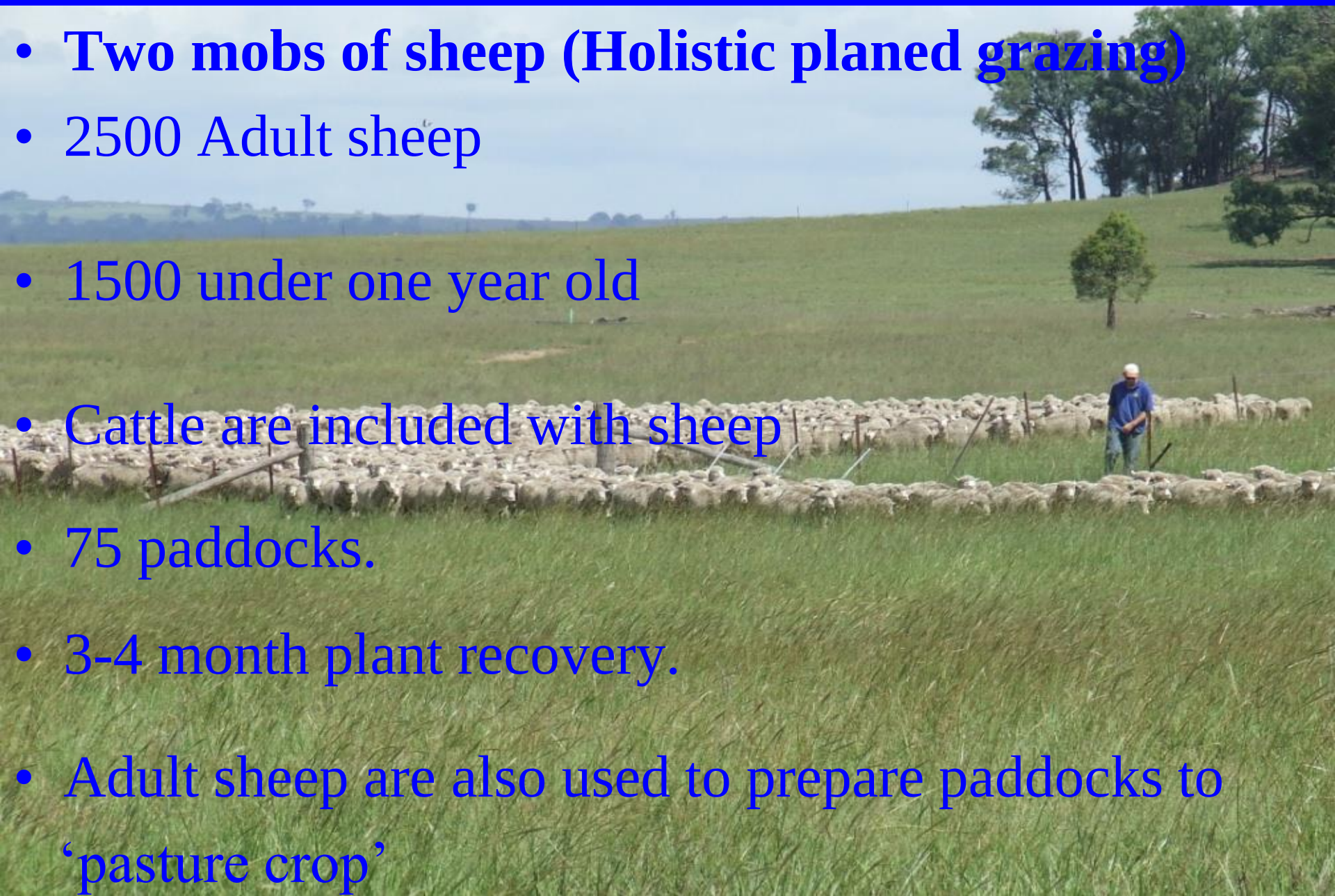
- Establish C4 species first.
- Sow C3 species into dormant C4 plants using ‘pasture cropping’ methods

Winona Grassland April 2020

(After 3 years of severe drought)

Grazing Management

Winona Grazing Management



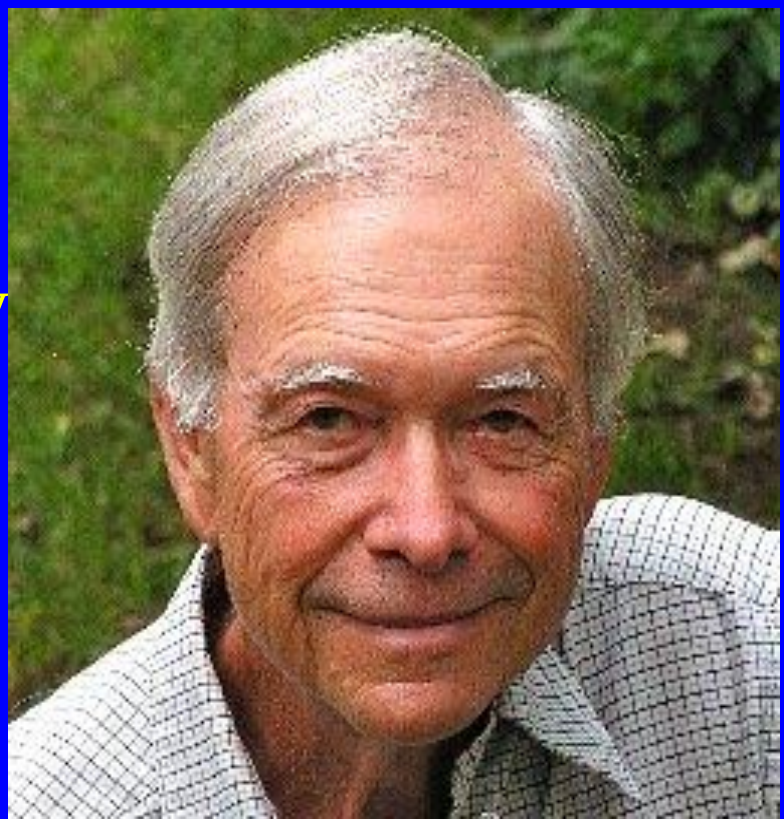
- **Two mobs of sheep (Holistic planed grazing)**
- 2500 Adult sheep
- 1500 under one year old
- Cattle are included with sheep
- 75 paddocks.
- 3-4 month plant recovery.
- Adult sheep are also used to prepare paddocks to ‘pasture crop’

Holistic grazing management, and using a grazing rotation, will encourage the growth of perennial grassland species and discourage the growth of annual weeds

The use of different grazing methods is not new

- One of the very early pioneers of rotational grazing in the 1950s was the French scientist/farmer Andre Voisin.

- The idea of holistic planned grazing began with Alan Savory in the 1960s



Grazing

- Grazing techniques have not changed for hundreds of years.
- Inappropriate grazing techniques have done severe damage to grasslands around the world
- **Animals can be beneficial, if they are grazed well.**

Grazing on Winona 1938

Grazing on Winona 2020

- Poor grazing management creates short root growth, unproductive leaf growth, and unhealthy badly structured, nutrient depleted soil.

Grazing Management

It is not grazing that kills plants

- It is not giving the plants enough time to recover from grazing that kills the plant.
- It is not the animal that is the problem
- It is the human managing the animal that is the problem

I also used ‘Pasture Cropping’ to restore the grassland !!!

Pasture Cropping
What is it??

‘Pasture Cropping’ is perennial cover cropping

"Pasture Cropping was invented and developed in 1993 by Colin Seis and Daryl Cluff.

“Pasture Cropping” is a perennial Cover Cropping technique where annual crops are zero - tilled into dormant perennial grass or grassland.

But it is more than that

Pasture Cropping

Grazing and cropping are combined and managed in a way where each one benefits the other.

Pasture Cropping can:

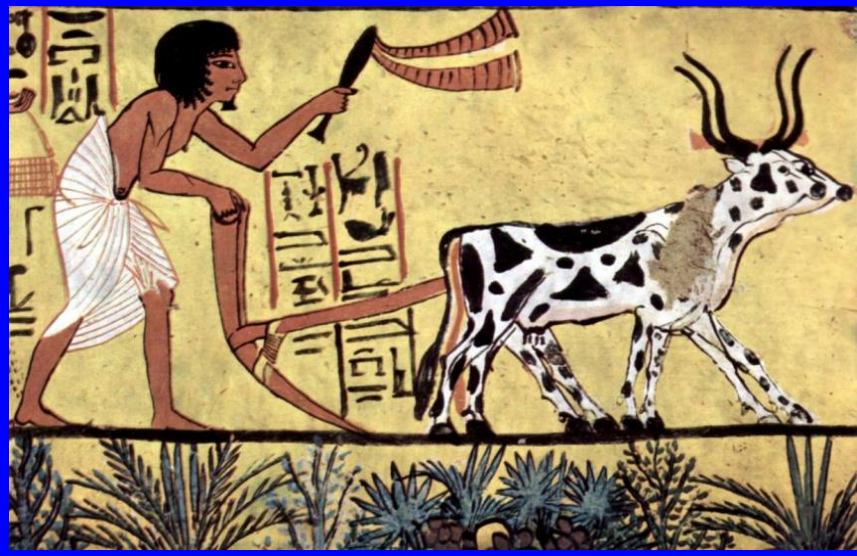
- Produce crops for grain and/or grazing
- Restore grassland by stimulating perennial grass species and species diversity.
- Improve soil health and increase soil organic carbon.
- Improve the farm ecosystem

‘Pasture Cropping’

- **<u>Zero till</u> sowing of crops into perennial pasture.**
- **Never Plough.**
- **Never kill perennial species.**
- **Weeds are managed by creating large quantities of thick litter by using <u>good</u> grazing management of livestock.**
- **Weeds can also be controlled with very careful use of selective herbicides.**

Why haven't crops been planted into perennial grass before?

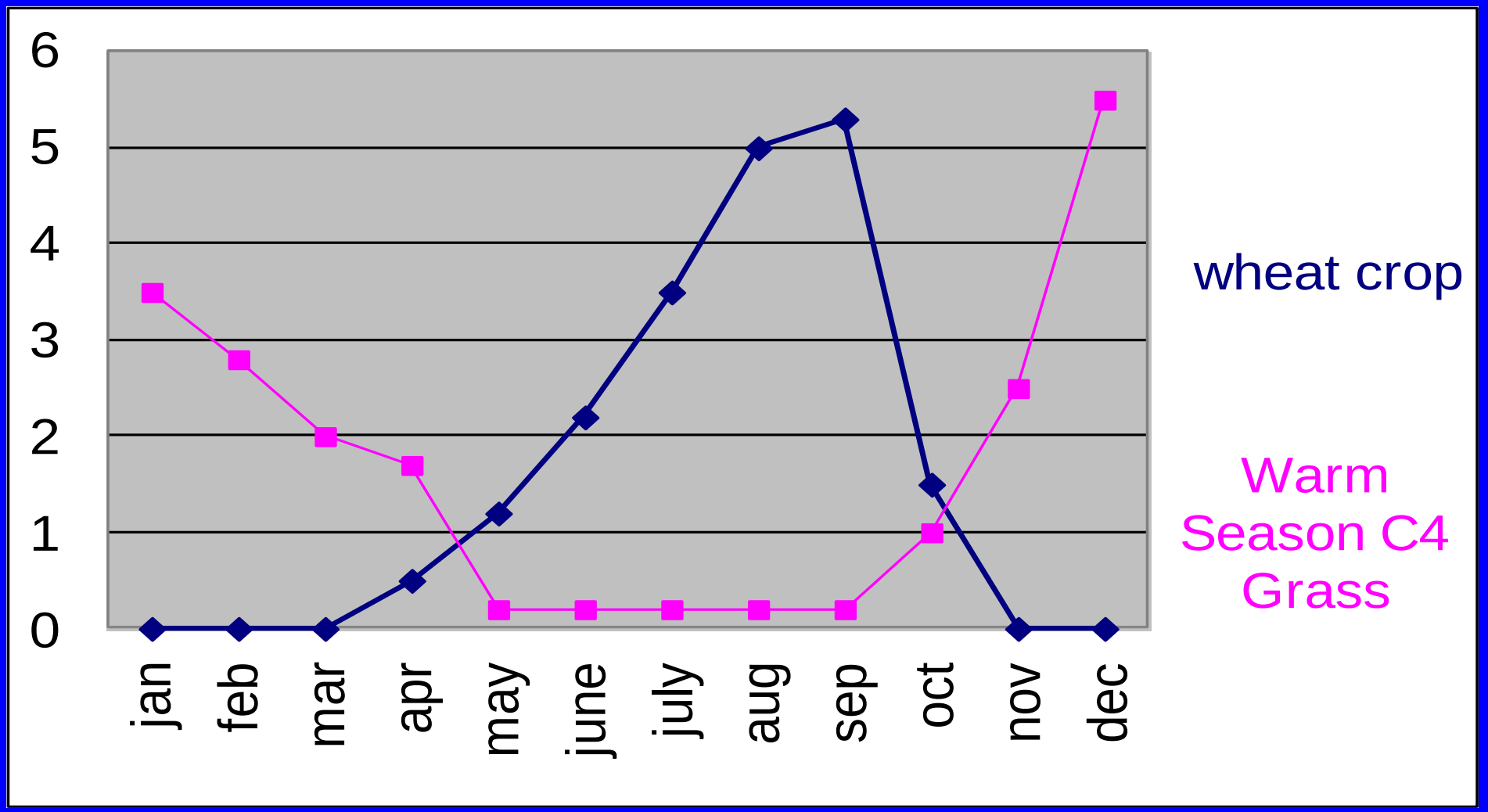
- It was known that annual plants will compete with each other. (wheat & annual grass)
- It was assumed that perennial plants would also be incompatible with cereal crops.
- Crop disease



- No one had looked at how nature worked in a grassland

(Warm season and cool season plants are compatible)

Crops are usually growing during the pastures natural dormant period



Pasture Cropping

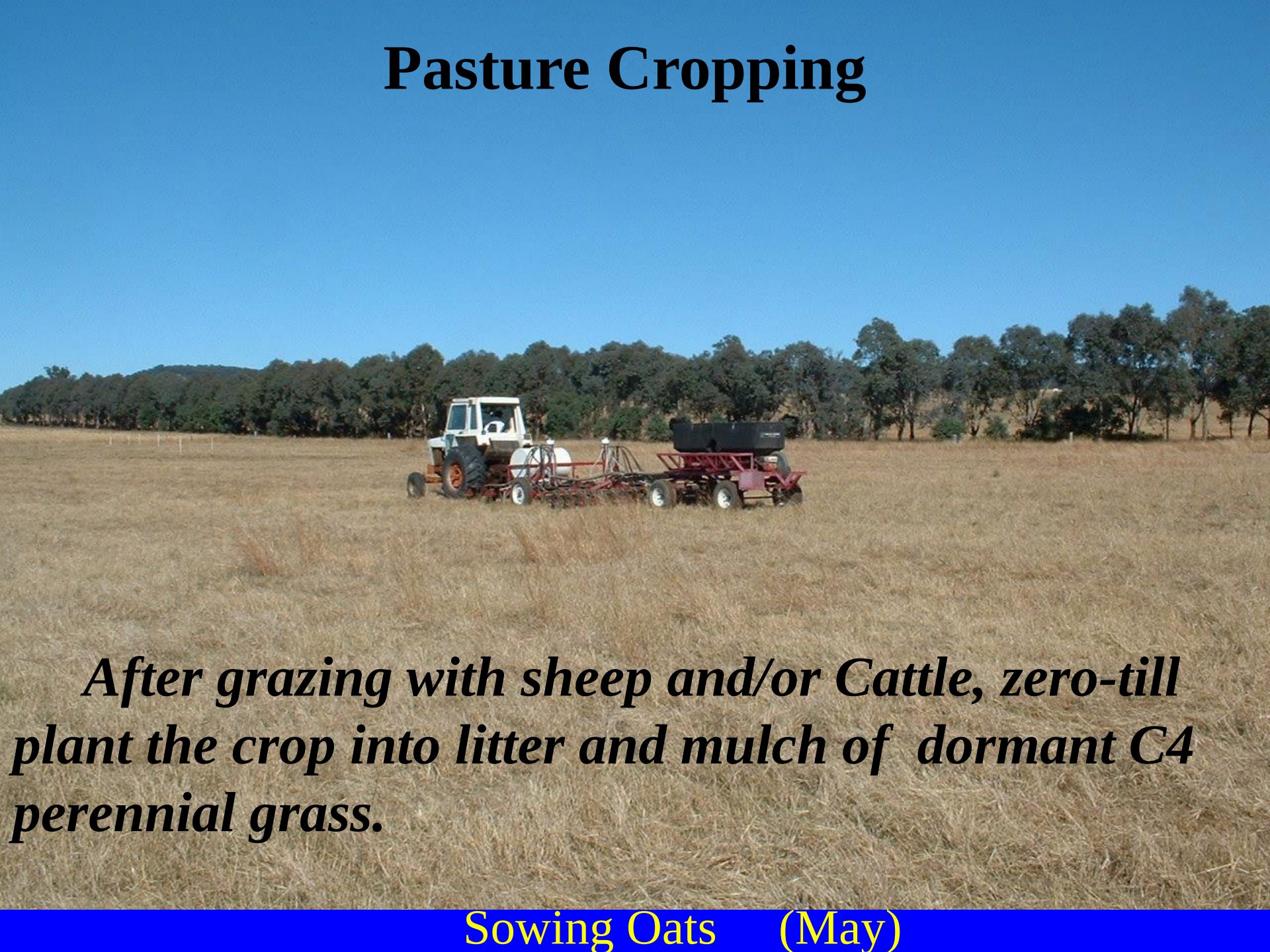
Perennial grassland consisting of 50-60 species.

February *(Summer)*

Pasture Cropping

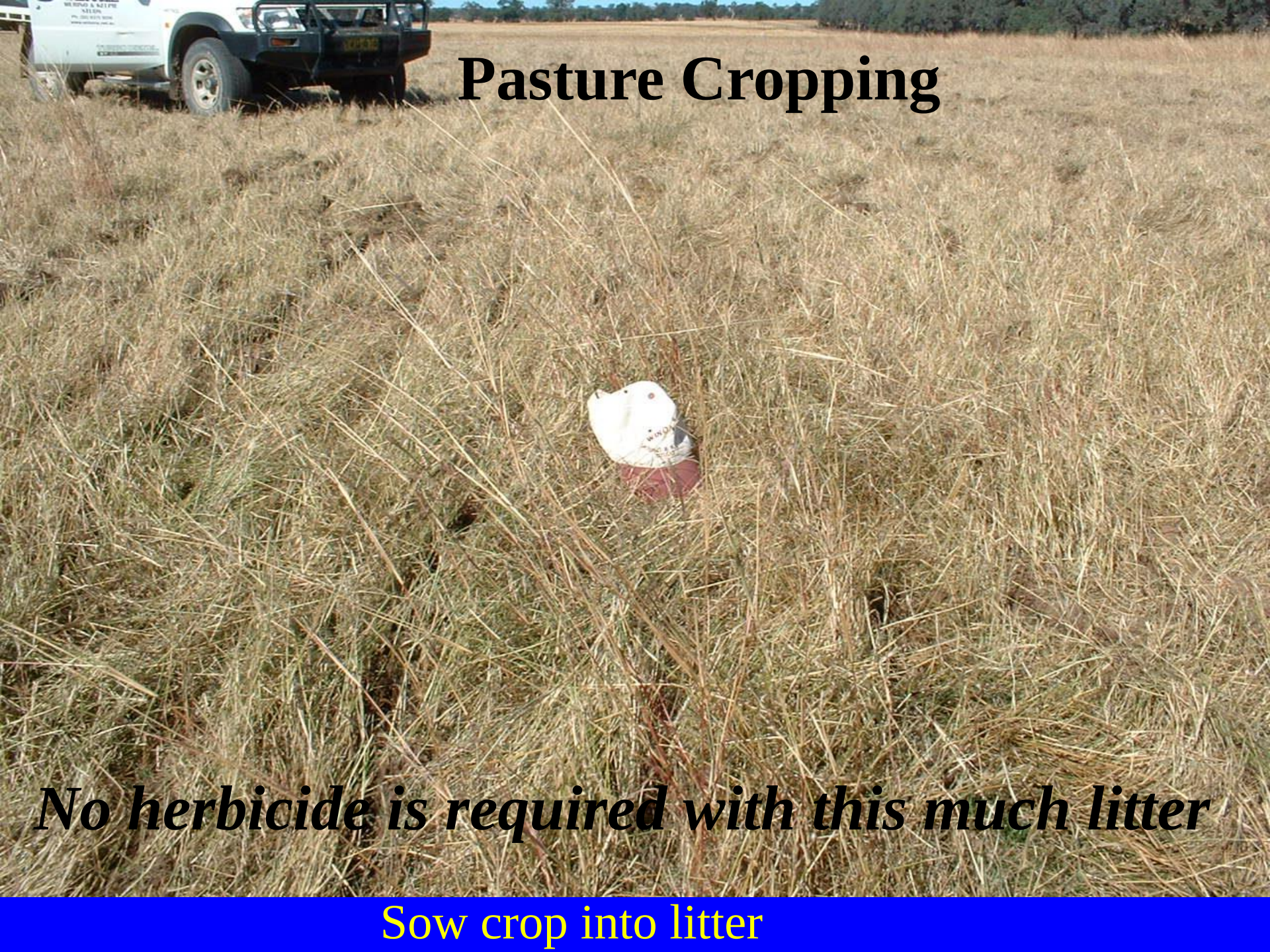
Harvesting native grass seed *(Summer)*

Pasture Cropping



After grazing with sheep and/or Cattle, zero-till plant the crop into litter and mulch of dormant C4 perennial grass.

Sowing Oats (May)


Pasture Cropping
No herbicide is required with this much litter
Sow crop into litter

Pasture Cropping

Emerging Crop

Pasture Cropping

The crop can be grazed by animals

Pasture Cropping

14th October

Pasture Cropping

Harvest the crop with emerging perennial grass beneath


Graze grassland after the crop is harvested (summer)

Native grass seed can be harvested after the cereal crop is harvested and before the crop is sown

Seed is sold for re-vegetation and, in the future, will be sold for human consumption

Multi-Species Pasture Cropping

I developed
‘Multi-Species Pasture cropping’
in 2010

How do we produce excellent quality forage while:

- Restoring grassland / perennial pasture.
- Reducing fertiliser and pesticides
- Improve soil structure
- Improve soil health.
- Improve soil nutrients.

Multi Species Pasture Cropping

Perennial grassland consisting of 50-60 species.

February *(summer)*

Multi Species Pasture Cropping

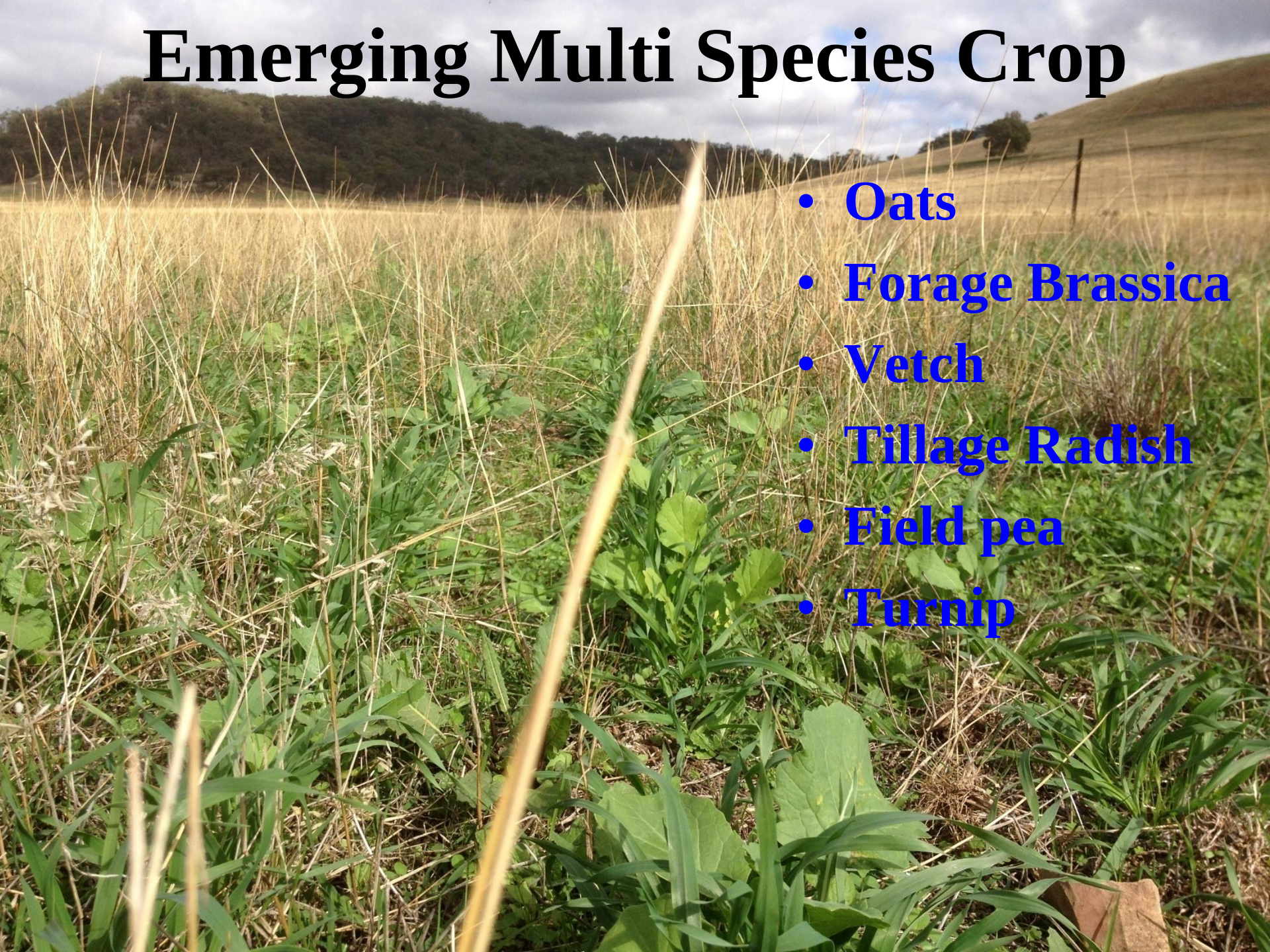
Harvesting native grass seed

Multi Species Pasture Cropping

After grazing & mulching with sheep and/or Cattle, zero-till a <u>multi species crop</u> into litter and mulch of dormant warm season perennial grass.

Sowing multispecies crop

Emerging Multi Species Crop



- Oats
- Forage Brassica
- Vetch
- Tillage Radish
- Field pea
- Turnip

A mix of 4 to 10 species are sown into a dormant grassland.

- Produce superior quality and quantity stock feed.
- Faster improvements in soil health, soil structure, carbon and nutrient cycling.
- Add Nitrogen with legumes & scavenge other nutrients.
- Weed control.
- Insect control (*flowering plants attract beneficial insects*
- Harvest cereal crop after grazing

Oats, vetch, radish, pea, turnip, clover, forage brassica sown into grassland. (September 2015)

Harvest multi-species crop for grain.

Grain from Multi species Harvest

Grassland June 2016

After grain harvest, perennial summer grass provides excellent stock feed

Native grass seed can be harvested after the cereal crop is harvested

Seed is sold for re-vegetation, and in the future, sold for human consumption

Over a 12 month period the paddock has produced

1. Grazing of grassland *(pre sowing the crop.)*
2. Grazing of the crop *(sheep & cattle)*
3. Grain from the crop
4. Grazing of grassland after harvest (sheep & cattle)
5. Native grass seed.
6. Improved soil structure, soil health and nutrient cycling.
7. Insect and crop disease control.
8. Reduced or no fertiliser
9. No insecticide
10. No fungicide
11. No ploughing
12. **Restored Grassland & Soil**

A Summer multi-species crop can be sown if you have winter pasture species & enough summer rain

How does ‘Pasture Cropping’ restore the grassland??

‘Pasture Cropping’ has been shown to improve existing pastures and restore grasslands

‘Pasture Cropping’ does this by stimulating perennial grass seed germination of

seed in the soil.

How?

- Small soil disturbance while planting
- Micro-climate created by the crop
- Root Exudates from the crop
- Improvement in soil health.

Multi-species Grazing Trial

MLA / Landcare

Multi-Species Grazing Trial 2020 *(Pasture crop)*

Barley

Multi-species

MLA / Landcare Trial 2020

- The paddock was subdivided into two – 6 ha paddocks
- Both paddocks were ‘pasture cropped’
- The areas were grazed heavily pre herbicide application. (1st March – 5th March)
- Herbicide**:** Both Areas 7th March - Basta @1.2 lt/ha with 100lt of water/ha
- Sown 10th March

As well as lamb weights, the trial also monitored;

- Soil Carbon
- Change in perennial species diversity
- Crop biomass
- Soil chemistry change
- Profit

Barley Crop:

Sown with 50kg/ha of barley

50kg/ha of croplift 15
(N 14.6 - P 12- S 11.6)

Multi-Species crop:

Barley - 30 kg/ha
Field pea- 10 kg/ha
Faba bean- 10 kg/ha
Forage brassica- 2 kg/ha
Tillage radish - 2 kg/ha
Turnip - 1 kg/ha.

50kg/ha of croplift 15
(N 14.6 - P 12 - S 11.6)

Cost of seed - March 2020

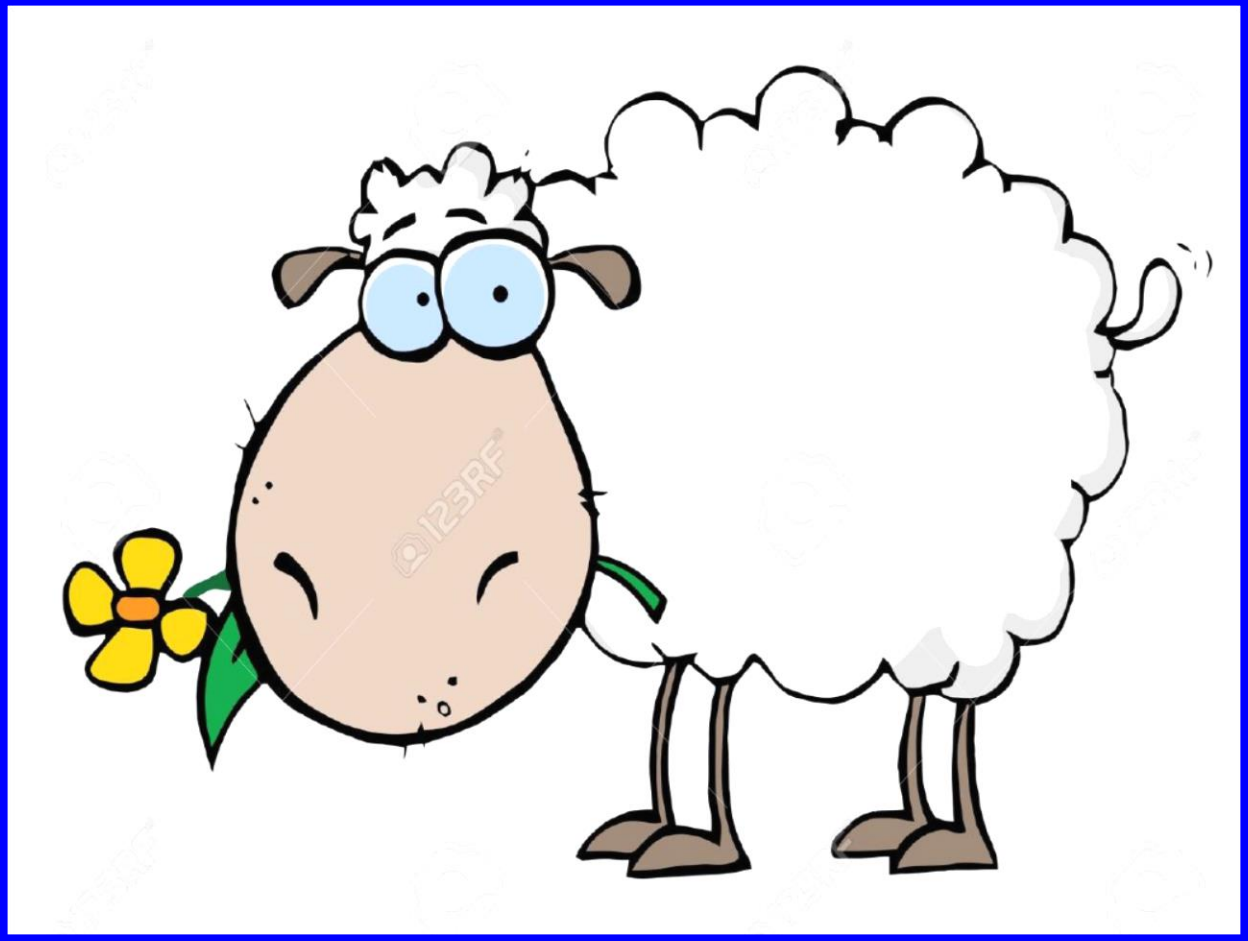
- **Single species** sown at 50kg/ha of barley = **$100/ha**

- **Multi-species**
- Barley 30kg/ha = $60
- Winfred 2kg/ha = $20
- Radish 2kg/ha = $16
- Turnip 1kg/ha = $10
- Field pea 10kg/ha = $17
- Faba bean 10kg/ha = $20
- **Seed cost** **$143/ha**

Cost of Multi-species crop
$183 /ha
(Seed and fertiliser)

Cost of barley crop -
$140 /ha
(Seed and fertiliser)

Grazing Results



Weight gain & profit

Barley Crop

- **228 Merino lambs – 57 days**

Weight gain per day – 149 grams

Weight gain -57 days – 8.5 kg

Lamb price/kg dressed - $7

4.75 kg x $7 = $33.25 / lamb

Gross /ha = $1263.35

Minus cost of sowing crop- $140/ha

Profit/ha $1123.50

Multi-species crop

- **228 Merino lambs – 57 days**

Weight gain per day – 300 grams

Weight gain -57 days- 17 kg

Lamb price/kg dressed $7

8.5 kg x $7 = $59.50/lamb

Gross /ha = $2261

Minus cost of sowing crop $183/ha

Profit/ha $2078

Additional benefits of a multispecies crop compared to a single species

Improvement in:

- Animal health
- Insect control
- Soil structure.
- Nutrient cycling
- Water infiltration
- Soil Carbon
- Soil ecosystem

Soil nutrient increase or decrease

- **Multi-species crop**

- Carbon + 21%
- Total Nitrogen +16%
- Phosphorus *(Colwell)+* 125%
- Calcium +13%
- Magnesium + 3%

- **Single species crop**

- Carbon – 15%
- Total Nitrogen -21%
- Phosphorus *(Colwell)+* 62%
- Calcium – 3%
- Magnesium – 8%

Note: Not all of the nutrients/minerals increased in the Multispecies Some minerals in both crops declined.

Trials and Research

Winona is one of the most researched properties in Australia

- CSIRO 2005 (*water, nitrogen and plant biomass)*
- Sydney University 2010 *(ecological study)*
- ANU Canberra *(entomology study)*
- Sydney University *(Pasture cropping)*

- The Land institute Kansas USA

- As well as numerus studies on soil, microbiology, & plants

What did I do on ‘Winona’?

- Changed grazing management to ‘Holistic Planned Grazing‘ in 1993

- Changed the way I grew crops, to “Pasture Cropping” in 1993

- I did not plant/sow any native grass species.

What were the results on ‘Winona’?

Sydney University ecological study

- **Restored perennial grassland!!**

Native grassland species

Increased from 10% to over 80% since 1999

Increase from 9 to 60 native grassland species

- **Weeds**

Decrease from 60% to less 5% since 1999

On Winona no insecticide has been used for over 25 years.

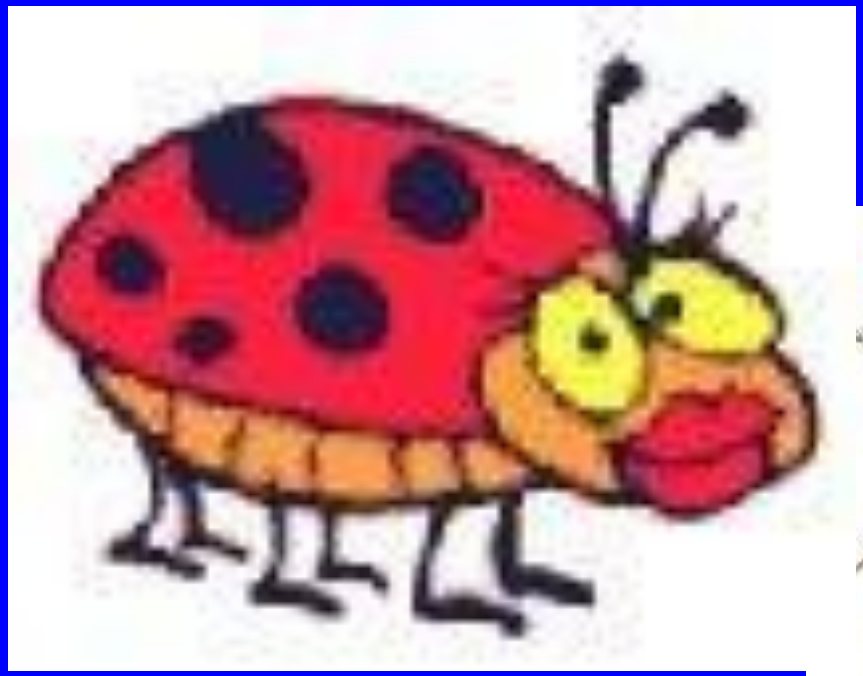
We have no insect attack in crops and pasture.

How??

Increase in insect numbers and diversity with increased grassland plants

(*Elise Wenden, Canberra ANU 2007)*

- ***On Winona insects numbers have increased by 600%***
- ***Insect diversity has increased by 125%***
- ***We no longer have insect attack on crops or pasture***



Restoring grassland or diverse perennial pasture will repair the farm ecosystem

Restoring the grassland has increased insect numbers and diversity

The property no longer gets insect attack in crops or pasture

Insects

1. Insect attack in crops and pastures can be controlled by having more insects.

2. Insecticides are not selective, they also kill predators like spiders and wasps that will control insects naturally.

3. Insecticides will ultimately lead to more insects and more insecticides.

No fungicide used on ‘Winona’ for over 25 years

No crop or pasture disease

How??

Soil microbe tests on Winona have shown

Total fungi increase 862%

Total bacteria increase 350%

Total protozoa increase 640%

Total beneficial nematode increase - over 1000%

Having healthy soil, with a large diversity of soil microbes, will control plant disease.

No fertiliser on pasture for over 43 years.

Crop Fertilizer reduced by 70%

How??

The difference in land management techniques

Adjoining Paddocks

Pasture Cropped and Holistic plan Grazed

Conventional grazing and cropping

102.7 t carbon/Ha **43.4 t carbon/Ha**

- Winona's soil now has over 200% more organic carbon.

- Has sequestered 59.3 t /Ha of carbon
  (213 ton/Ha of carbon dioxide)

- Holds over 200% more water.

All of the soil nutrients including trace elements have increased by an average of 162%

e.g. Calcium increase of 8166 kg/ha or 277%

- Ph has changed from
  5.2 - 6.01

Soil Carbon and soil water storage

- An increase in soil organic carbon level of 1% to a depth of 30 cm (1 ft) can increase the water holding capacity of soil by an extra 168,000 liters/Ha. **On every rainfall event.**

The Two previous paddocks:

- Winona (Pasture Cropped) 360,000 lt/Ha
- Adjoining (conventional) 188,000 lt/Ha
- Difference 172,000 lt/Ha of extra water holding capacity

on every rainfall event

360,000 lt/HA **188,000 lt/Ha**

Is it profitable?

Yes!!

I now save over $80,000 annually

By changing agricultural practices I have:

- Saved over $50,000 on pasture fertilizer *(do not fertilize pasture)*
- Saved $20,000 on cropping costs. *(Fertilizer reduced by 70%)*
- Do not re-establish pastures
- Have perennial pastures with over 60 species.
- Do not have insect attack or crop disease.
- Winona is regenerative and resilient.
- Winona functions in an ecologically sound way
- **We are profitable**

Compared to previous high input agriculture

- Annual income is higher
- Winona is running more livestock.
- Crop yields are similar.
- Wool quality is better.
- Harvest and sell over 2000 Kg of native grass seed
- Soil organic carbon levels are increasing
- Soil Phosphorus, calcium, ph, magnesium and trace elements are increasing

With over $80,000 less inputs and less labour

How does a change in grazing management, and a change in the way crops are grown, improve our farms?

- A change of grazing can produce larger plants with bigger roots.
- Growing a diverse multispecies crop will produce a diverse range of plants and roots.
- ‘Pasture Cropping’ will stimulate the germination of perennial pasture species, restore grasslands, and the soil ecosystem.

How do plants restore the farm and soil ecosystems, & make soil nutrients available?

After increasing plant diversity and restoring the soil ecosystem, the dramatic, and often fast changes in plants and soil has puzzled scientists for many years.

It is against what many people believe is possible!!!

How do plants make soil nutrients available?

- Myrorrhizal Fungi supply P, N trace elements and water
- Protozoa and nematodes eat bacteria & fungi which supplies N and other nutrients
- Free living N fixing bacteria supply Nitrogen *(up to 40kg/ha)*

Living, growing plants are the drivers of soil health, soil structure and nutrient cycling

- Soil microbes require plants for food
- Plants supply root exudates, and decaying plant organic matter to soil microbes.
- In return microbes supply nutrients to plants.

Soil Microbes drive the change

- Soil microbes stimulate change in nutrient cycling, plant growth, plant disease suppression, and overall change in the soil ecosystem??

When we are walking on the ground, we are walking on the top of another world.

Below our feet is a world that is more complex than the world we live in.

Soil Food Web

Photos: Soil Biology Primer

Soil is a living, breathing, sub-aquatic ecosystem.

Photo: Gabe Brown

- Soil microbial diversity is created by plant species diversity. *(More than 10 plant species)*

- A mix of plants produces different root exudates.

- These root exudates feed & support a diverse and vast range of soil microbes.

That is why plant monoculture do not work, and why excessive use of microbe killing inputs like high rates of fertiliser and pesticides destroy the soil ecosystem

Plants will restore our farm, and soil and profit

How do we restore our farms??

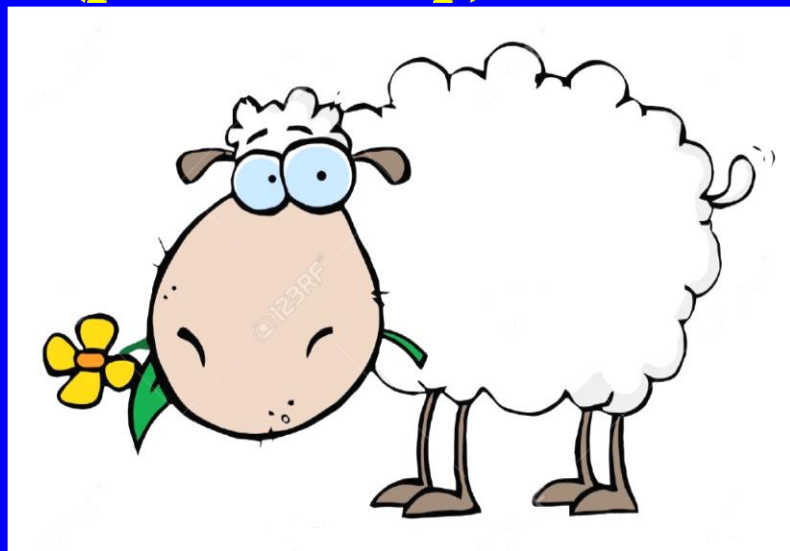
- **Restore the grasslands!!!!!**

- **Change the way we graze animals.**

- **Grow crops without killing existing grassland.**
  Stop ploughing & reduce pesticides (pasture crop)

- **Grow multispecies crops**

All of the above.



Our Farms should function as ecosystems