

“Cover Crops Uncovered”

Colin Seis



Workshop Handbook

“Winona”, Mudgee, NSW

Colin and son Nick Seis
2000 acres (840ha)
Central Tablelands, 300km NW of Sydney, NSW
Granite soil, pH 5.50 - 06.0
600mm annual rainfall



Enterprises on “Winona”



Merinos, cereals, merino rams, cattle trading, kelpies, native seed production



“Cover Crops Uncovered”

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History of Agriculture



- Started in Mesopotamia over 10,000 years ago
- Sumerian people started to harvest einkorn wheat from the grassland
- Sheep and goats were domesticated
- The plough (ard) was developed 8000 years ago, and later oxen were domesticated and trained to pull the plough.
- The Egyptians, and later the Romans, fine-tuned the techniques which were adopted by Europeans.
- The plough and domestication of animals have created deserts around the world



For 10,000 years we have killed grasslands and destroyed soil to grow crops.

Until the early 1950s, Australian agriculture was practiced without pesticides and small amounts of fertiliser.

After World War II, the Green Revolution was developed to address producing enough food for the increasing world population.

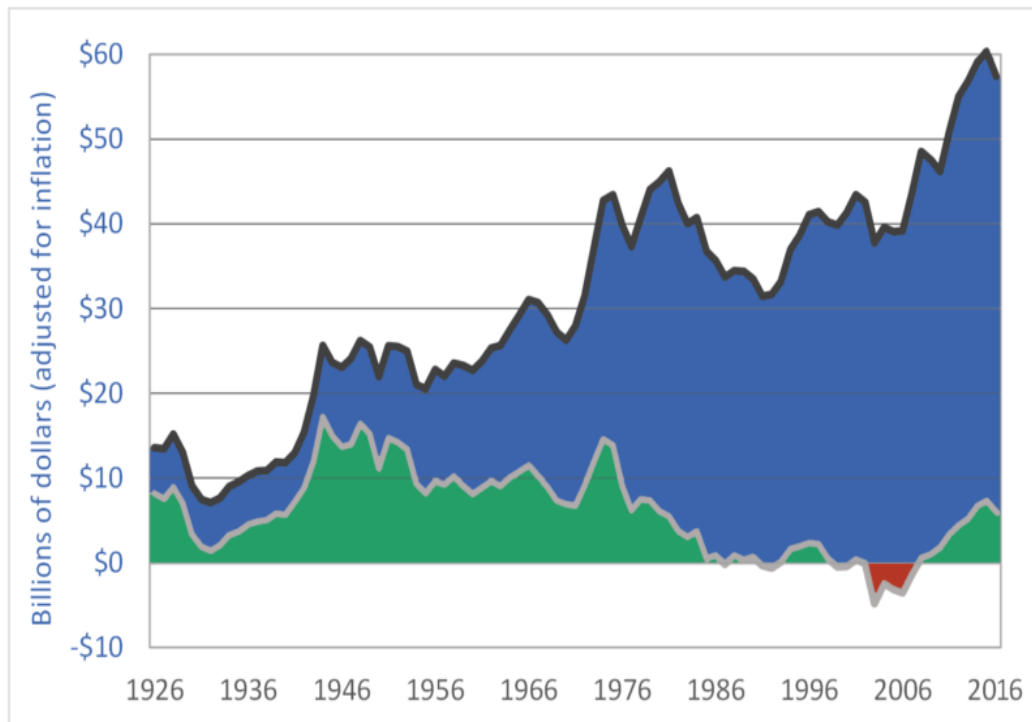


The 'Green Revolution' developed new, high yielding crops, and fertiliser and pesticides to help crops yield to their maximum.

However, it has created many problems

- Declining soil health
- Dependency on fertiliser
- Dependency on pesticides
- Ecological disaster for our farms and the planet
- Reduction in food quality
- Human health problems

Wealth is now with Multi-National Companies



Green = Farmer share
Blue = Agribusiness share
Red = Farmer debt

Solutions

- Change how we farm and graze animals
- Allow the farm and soil to function as an ecosystem
- More diverse pasture/ grassland/crops
- Better nutrient cycling – less fertiliser
- No insect attack- no insecticide
- No plant disease –no fungicide
- Less animal disease
- More profit by reduced input costs
- Grow plants, plants and more plants
 - Plants will restore our farm, and soil and profit
 - Diverse plants, not monocultures
 - Perennial grassland (50- 100 plant species)
 - Perennial cover crops (pasture crop)
 - Multi- species, annual cover crops (4-10 species)

Grasslands

For millions of years, grasslands have dominated two thirds of the planet, feeding millions of grazing animals, as well as predators and humans.

These grasslands did not suffer from disease, insect attack or nutrient deficiency.

In balanced grassland ecosystems,

- nutrients are cycled and made available to the plants;
- plant disease and insect attack are controlled by their natural enemies

The plants:

- Cycle soil nutrients
- Creates top soil
- Create good soil structure
- Build soil carbon



The case for Perennial Plants

Research by Tim Wily (Western Australia Dep. Agriculture) showed increased levels of plant available nutrients directly beneath the crowns of perennial plants

	Bare soil	Beneath plant	Difference
Organic carbon %	.24	1.04	433% increase
Phosphorus	21	71	338% increase
Potassium	44	150	341% increase
Sulphur (ppm)	2.7	7.9	293% increase
pH (water)	6.4	7.8	1.4 unit increase

How do we Restore our Farms?

1. Change the way we graze animals.
2. Grow crops without killing existing grassland (pasture crop)
3. Grow multispecies cover crops
4. All of the above.

Cover Cropping

Cover Cropping can function as a grassland and can be:

1. Annual – uses annual crops to create mulch, control weeds and improve soil health.
2. Perennial – uses perennial grass to create mulch, control weeds and improve soil health

Annual Cover Cropping

Annual Cover cropping is sowing an annual crop between periods of regular crop production with the main purpose being to create thick mulch, into which the following cash crop is planted using zero till planting methods. It is a biological soil primer



Multi-species forage crops are also used as biological soil primers

Perennial Cover Cropping

Perennial cover cropping is also known as 'Pasture Cropping'.

Single species cover crops only address some of the problems.

Multispecies cover crops address many problems.

It is important to include in the mix:

1. Cereals
2. Brassicas
3. Legumes



Why Use Multi Species Cover Crops?

Different combinations of plants can be used for:

- Forage
- Prepare soil for a following crop
- Increase in soil organic matter. (C:N ratio)
- Increase nitrogen. (C:N ratio)
- Nitrogen fixation – legumes
- Capture, recycle, redistribute nutrients
- Weed suppression
- Reduce soil compaction
- Attract beneficial insects
- Disease control



1. Improve grazing outcomes

- Healthy animals
- Faster fattening
- Faster growth rates
- More feed
- Less metabolic disease when compared to single species forage crop like oats
- Using different plants to fix problems

2. Prepare soil/paddock for following crop

- Soil biology primer
- Carbon to Nitrogen ratio
- Litter / ground cover
- Restore compacted soil
- Increase available nutrients



3. Improve Soil Structure

- Plants like radish, turnip, swede, are excellent 'biological sub-soilers', breaking plough pans and aerating poor structured soil
- Improved water infiltration

4. Reduce weeds

- Include plants like forage brassica, radish & cereal rye
- Some plants produce chemical exudates that can inhibit weed growth (allelopathy)
- Weeds can be controlled by shading and competition
- Creating ground cover with plants and litter will control weeds



5. Increase nutrient availability

Soil nutrients can be made available:

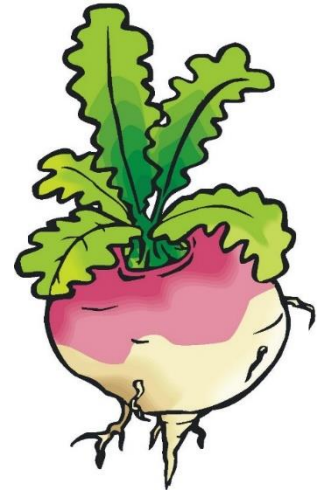
- Deep rooted plants like radish, turnips, can scavenge nutrients from depth and make them available to plants.
- Legumes in the mix will produce Nitrogen
- Having a C:N ratio of 24:1 will produce Nitrogen



6. Manipulating C:N ratios in the soil

- By growing different combinations of plants, soil nitrogen can be increased and/or soil organic matter can be increased.
- Ideal microbial diet is 24:1 carbon to nitrogen ratio
 - Cereal Rye straw 82:1
 - Oat Straw 70:1
 - Annual vetch 11:1
 - Forage Brassica 12:1
 - Annual Ryegrass 20:1
 - Clover 21:1
 - Daikon Radish 19:1
 - Millet 42:1
- A multi-species crop with the correct C:N ratio can supply N and other nutrients and /or maintain ground cover
- Use high C:N ratio crops of 30:1 or greater to increase soil organic matter (OM)

- A multi-species crop with an ideal C:N ratio can supply N and other nutrients and /or maintain ground cover
- A mix of oats, forage brassica vetch and pea will produce a crop with a C:N ratio of 26:1
- Include deep rooted plants like turnip or radish in a mix will cycle nutrients from depth and store them in their bulb.
- Nutrients are released and used by a following crop



Recycling of nutrients by Oilseed radish
(David Brandt, Iowa, USA)

Nutrient	lbs/acre	Kg/ha
Nitrogen	265	48.64
Phosphorus	23	9.3
Potassium	230	93.1
Sulphur	150	60.7
Calcium	150	60.7
Magnesium	20	9.1

Nutrient Sequestration- Cereal Rye
(U.S. Dep of Agriculture)

Soil Health - Soil Carbon

	Nitrogen	Phosphorus	Potassium	Sulphur	Calcium	Biomass
12" Rye	82	51	76	5	11	2000
18" Rye	120	20	128	6	18	4000
28" Rye	134	30	169	10	31	6800
Dead rye	84	29	39	3	29	3500



A mix of species helps form water stable aggregates which affects infiltration, aeration, drainage and soil bulk density.
Provides root exudates and energy for soil organisms that are essential for maintaining a healthy soil and increasing soil carbon.

7. Aid Insect Control

Reduce crop insect damage with beneficial insects, by including flowering plants

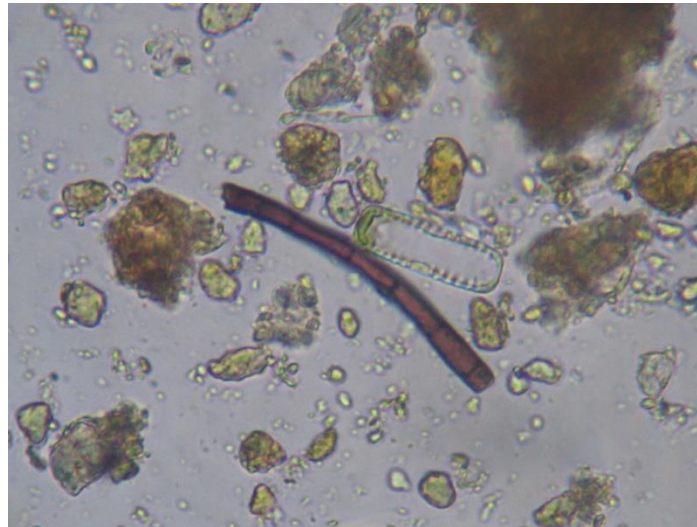


8. Assist disease control

- In balanced soil ecosystems disease is controlled by their natural enemies
- A diversity of soil microbes will interrupt and control many fungal and bacterial crop diseases.
- Suppress nematode populations.

9. Increase plant diversity

- A diverse range of plants increases the number and diversity of soil microbes.
 - Total fungi increase 862%
 - Total bacteria increase 350%
 - Total protozoa increase 640%
 - Total nematode increase over 1000%
- Having healthy soil with large numbers and large diversity of soil microbes will control plant disease and improve nutrient cycling.



10. Improve Soil Moisture

- Multi species cover crops can increase soil moisture
- Increase soil carbon
- Increase water infiltration
- Improving soil structure
- Crop residue reduces evaporation
- Improve the soil ecosystem

Selecting Multi Species Crops

Winter Multi Species Crops

Cereals	Legumes	Brassicas	Other
Oats	Field pea	Forage brassica	Ryegrass
Wheat	Vetch	Radish	
Barley	Lupin	Turnip	
Triticale	Clover	Swede	
Cereal Rye	Lentil	Kale	

Cereal Crops

- Winter: Multi Species Crops
- Oats, Wheat, Barley, Triticale, or Cereal Rye can form the basis of a winter multi species mix.

Winter Legumes

- Annual vetch
 - Is excellent stock feed.
 - Can fix large amounts of N
 - Makes soil phosphorus more available.
 - Provides excellent habitat for beneficial insects.



Field Peas

- excellent stock feed and capable of fixing large amounts of Nitrogen.

- Forage Brassica
 - Forage brassica are high protein, and highly digestible feed.
 - Swede, turnip and newer varieties. e.g. Winfred is a cross between turnip and kale.
 - Varieties like daiken radish and turnip can be used as "biological sub-soilers".



Winter Multi Species Mix 2019

	Kg/ha	Price/kg	Price/ha
Oats	40-50	\$1	\$40-50
Forage brassica	1-2	\$12	\$10-\$20
Tillage radish	1-2	\$12	\$10-20
Annual vetch	5-10	\$2	\$10-20
Field Pea	5-10	\$2	\$10-20
Turnip	.5-1	\$2	\$10-20
Total			\$80-100

Summer Multi Species Cover Crops



Millet

- Millet is an ideal base for a multi species summer crop.
- Heat and drought tolerance.
- Low cost seed.



Forage sorghum

- Productive and fast growing
- Heat and drought tolerant.
- Good weed control.



Cowpea

- Excellent stock feed
- Legume that fixes lots of N
- Provides food and habitat for beneficial insects.
- Rapidly shades out weeds.
- Tolerant of hot, dry conditions



Sunflower

- Good stock feed.
- Sunflowers are deep rooted summer growing broad leaf annual plants.
- Very good at 'mining' mobile nutrients deep in the soil profile and making them available other plants



Selecting Summer Multi species crops

Crop	Legume	Broadleaf	Other
Japanese millet	Cow pea	Sunflower	Forage brassica
Pearl millet	Peas	Buckwheat	Turnips
Shiroie millet	Beans		Tillage radish
Maize	Lupins		
Oats/rye?			

Sowing Multi Species Crops

The overall cost of multi species cover crop seed is more expensive, but the seed rates are usually sown at 25% - 50% of recommended rates for single species crops.

Seed Drills

(Zero till or direct drill)



Multi Species Seed Mix

- A mix of seeds can be more difficult to sow
- Larger seeds like oats, cow peas, field peas can be sown with the normal seed box, as a mix.
- Smaller seeds like forage brassica, turnip, millet etc can be sown with a pasture box. (small seed box)
- Seeds can be mixed together with disc seeders because they usually do not place the seed deep.



Weed Control

Pre-sowing

- If weeds are not going to impact the growth of the cover crop, they may not require controlling, and can become part of the cover crop mix.
- Weed control with herbicide may be necessary if weeds are going to impact crop establishment and growth

In crop weed control

- Herbicide use with Multi Species crop is normally not possible without killing crop species.
- Some weed control is possible with fast growing canopy closure providing a weed smothering effect and allelopathic properties from plants.

Emerging Multi Species Crops

- Oats
- Forage Brassica
- Vetch
- Daikon Radish
- Clover
- Field pea
- Turnip



Grazing Multispecies Crops

- Better quality feed and less dietary problems.
- Reduction in metabolic diseases.
- First graze should not start until all plant species are well established.
- Allow plants time to recover from the initial graze before re- grazing. (3-4 grazings are possible)



Before grazing (May)



After three grazings (August)



Harvest the crop with emerging perennial grass beneath



Grassland after grain harvest (March)

Grain from Multi species Harvest



Terminating Cover Crops



- Grazing
- Crimp rolling
- Herbicide



Phil Lyn
Glen Innes NSW

Multi Species Crop Mixes

1. Species for Animal performance (C:N 23)

Good C:N ratio for animal performance

- Oats 50kg
- Field pea 8kg
- Vetch 8kg
- Forage Brassica 3kg
- Turnip/swede 1kg

2. Species for compacted soil (C:N 31)

(Biological sub soilers)

These species sown as a multispecies mix will help penetrate compaction layers and add organic matter as roots and ground cover

- Oats 30kg
- Cereal Rye 30kg
- Tillage Radish 5kg
- Turnip 2kg
- Vetch or pea 8kg

3. Species for increasing soil Carbon. (C:N 32)

(increasing organic matter and root exudates.)

- Oats 30kg
- Cereal Rye 40kg
- Vetch 10kg
- Forage brassica 2kg

4. Species to improve following crop (C:N ratio 24)

(increase nutrients, improve soil health, soil biology priming)

- Oats 50kg
- Field pea 10kg/ha
- lentil 10kg /ha
- Vetch 10kg /ha
- Tillage radish 3 kg /ha
- Turnip 1kg /ha

C:N Ratios of Summer Multi Species Crops

1. Species for Animal performance (C:N 26)

Good C:N ratio for animal performance

- Millet 4kg/ha
- Cow pea 4kg/ha
- Sunflower 1kg/ha
- Peas 10kg/ha
- Turnip 1/2 kg/ha
- Buckwheat 10kg/ha

2. Species to improve following crop (C:N ratio 24)

(increase nutrients, improve soil health)

- Millet 4kg/ha
- Cow pea 4kg/ha
- Sunflower 1kg/ha
- Buckwheat 10kg/ha
- Tillage radish 2kg/ha
- Turnip 1 kg/ha
-

3. Species for increasing soil Carbon. (C:N 35)

(increasing organic matter and root exudates.)

- Corn 8kg/ha
- Millet 4kg/ha
- Sunflower 1kg/ha
- Buckwheat 10kg/ha
- Cow pea 3kg/ha

Case Study – Winona, Gulgong, NSW

Results with multi-species pasture cropping on Winona

- Restored perennial grassland!
 - Increase in native perennial species cover from 10% to over 80% and from 9 to 60 native grass species since 1999
- Annual weeds
 - Decrease from 60% to less 5% since 1999

- Insects

- No insecticide has been used for over 20 years.
- We have no insect attack in crops and pasture.
- Insect numbers have increased by 600%
- Insect diversity has increased by 125%
- Insect attack in crops and pastures can be controlled by having more insects.
- Insecticides are not selective; they also kill predators like spiders and wasps that will control insects naturally.
- Insecticides will ultimately lead to more insects and more insecticides.



- No fungicide used on 'Winona' for over 20 years
 - No crop or pasture disease
- Soil microbe tests have shown that having healthy soil with a large diversity of soil microbes, will control plant disease.

- Total fungi increase by 862%
- Total bacteria increase by 350%
- Total protozoa increase by 640%
- Total beneficial nematode increase by over 1000%



- Fertiliser

- No fertiliser on pasture for over 30 years.
- Crop Fertiliser reduced by 70%
- There are more ways of supplying nutrients to plants than applying fertiliser
- Mycorrhizal 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)

Adjoining Paddocks with different land management



Pasture Cropped and plan Grazed



Conventional grazing and cropping

Soil changes

- 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 more water.
- All of the soil nutrients including trace elements have increased by an average of 172% e.g. Calcium increase of 8166 kg/ha or 277%
- Ph has changed from 5.2 - 6.01

102.7t Carbon/ha



43.4t Carbon/ha

Soil Nutrients

	Available	Total
Ca	234%	277%
Mg	110%	152%
Zn	250%	195%
Cu	185%	215%
B	150%	161%
Si	116%	113%
N	103%	151%
P	102%	155%
K	198%	150%
S	92%	159%
Fe	87%	130%
Na	45%	88%
Al	28%	140%

Soil Carbon and soil water storage

An increase in soil organic carbon level of 1% to a depth of 30 cm can increase the water holding capacity of soil by an extra 168 000 litres/ha on every rainfall event.

360,000 litre/ha



188,000 litre/ha

Case Study – David Brandt, Iowa USA

- David is a pioneer of cover crops in the US.
- He began no-till farming in 1971 and has been using cover crops since 1978.
- David uses a diverse cover crop mix of 10-15 species of cereals, legumes, brassica, and other broadleaf plants
- Recycling of nutrients by Oilseed radish - Ohio State University

<u>Nutrient</u>	lbs/acre
○ Nitrogen	265
○ Phosphorus	23
○ Potassium	230
○ Sulfur	60
○ Calcium	150
○ Magnesium	20

- Results from David Brandt on-farm research
 - Hairy vetch produced up 200 pounds/acre of N
 - Buckwheat increased P reading from 6 to 19
 - Sunflowers released zinc and copper.

- David is growing corn, soybean, wheat, crops into his covers
 - Corn yields over 12 ton/ha
 - 75% less fertiliser.
 - No fertiliser after 5 years of using covers
 - 70% reduction in herbicide



Case Study - Gabe Brown, Brown's Ranch, North Dakota



Gabe is a pioneer of the soil-health movement and has been named one of the twenty-five most influential agricultural leaders in the U.S.

Gabe and Shelly Brown and son Paul farm:

- 15 inch rainfall in North Dakota
- Run cattle, sheep, pigs & chooks.
- Grow corn, soybean, wheat, oats.
- Corn yields are 20%- 30% higher than district average
- Fertiliser has been reduced by 90%
- Herbicide reduced by 70%

Gabe Brown terminates cover crops by grazing, then plants a cash crop with a disc drill into the cover crop residue



There is great change happening around the planet, and farmers are creating the change

The adoption of cover crops in the US

- From 2012 to 2017 the acreage increased by 49.7%

- The US cover crop acreage is around 20 million ac.



In the US more crops are sown by planting into the green growing cover and terminating after.



Having green growing plants all of the time will restore the soil ecosystem

- Planting into green covers
 - Greater above- and below-ground biomass.
 - Increase water infiltration & water holding capacity
 - Legume covers will fix more nitrogen.
 - The cover crop scavenges and recycles more nutrients
 - Increase soil carbon and soil structure
 - Hair-pinning problems eliminated or greatly reduced.
 - Less problems with slug and cutworm pests
 - less soil, or residue-borne disease.

There are many good agricultural practices being adopted around the world.

We have been let down by our farm advisers and many of our scientists

The companies that develop pesticide and fertiliser do not want people to stop using their products.

We need to encourage scientists and politicians to catch up.

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.

Microbes can work together like a super organism.

- In the microbial world the term 'Quorum Sensing' refers to density dependant, coordinated behaviour, that regulates gene expression in the microbial population and/ or in the host plant.

Quorum Sensing

- Microbes in the soil or plant can switch the plants genes on or off.
- Which can stimulate plant growth, plant health, create tolerance to drought, and plant disease suppression.
- Microbial diversity and numbers are created by plant species diversity. (*More than 10 plant species*)
- A mix of plants produces diverse range of root exudates.
- The large mix of root exudates feeds/supports a different and vast range of soil microbes.



How do we restore our farms?

- By growing a diverse range of plants, plants and more plants.
- Change the way we graze animals.
- Grow crops without killing existing grassland (pasture crop)
- Grow multispecies crops (cover crop)

**Plants will restore our farms, soils
and profit!**

Acknowledgements

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Content by Colin Seis, "Winona", Gulgong
colin@winona.net.au

Compiled and edited by Celia Leverton, President of Regenerative Agriculture Network
Tasmania
regenagtas@gmail.com