The Need to Read the Weed

The topic of weeds is a controversial one as one person may support the growth of a plant and another will call the same plant a weed. In short, it is not the plant[s] that is the problem. The **plant is a neutral** part of the discussion. The so-called **weed is a product of its environment** or the local conditions that it thrives on. **It is a passenger taking a ride**. It is true that some "new" plants have [what some would describe as] invaded areas utilizing their superior adaptive abilities, but this author would suggest that there needs to be a rethinking of the old model of focusing on the "weed" as the problem or for that matter the soil seed bank [see below]. If the existing weed management model is not delivering the expected goals or actually allowing weeds to increase in number, is it not timely to question the need for a new and more relevant **biomimicry** relatable model that suggests that weeds are the symptom and not the problem? In fact, weeds can be strategically used as indicator plants of what the actual problem is. The real problem is the ongoing and accumulative decline in the Australian landscape. Weed invasion is the physical indication of a degrading landscape. The following paper discusses the use of observation to establish the role of weeds and utilizing the information provided by the weed's form and function to make more ecologically informed decisions about the potential correction and more importantly the prevention of weeds. There needs to be an educational focus on teaching landholders about their local plant succession and where their local weeds come into that scope and why. As landholders and other interested parties see relevance to their local challenges then they will be increasingly open to communications about invasive weeds and become more on side with broader governmental goals. I recently did a field day on Weeds, I said the open question, "*What do you want to get out of today*?" A farmer's reply straightaway was – "*How to kill bloody weeds*?" I wrote that on the white board. Four hours later, he was talking about it was good to see how weeds can indicate things like over stocking. That was a big change, but it is only 6 inches, between ear and ear. The greatest change you can make is to get landholders and their affiliates on side with **reading the plants first** and not the herbicide labels. There is such a thing as herbicide resistance and also landholder resistance. In the future it would be good to avoid both with a new innovative way by learning to **work with nature** and interpret **nature's adaptive repair processes** which include what many call – weeds. They are just plants that we as yet as a community have not successfully tried to understand. I am optimistic that by the time you finish this short paper you may be more open to investigate some more new long term innovative answers to our old and growing weed ~~problems~~ challenges. Below is a simplified diagram of prioritising weed management decisions. It outlines a more efficient and direct approach to weed management, where weeds are treated as the passenger or symptom that can teach us how to treat the real [degraded environmental conditions] driver or problem.

Weed Management Decisions

Eradication	Control	Weed preferred conditions.	Weed non preferred conditions.	Prevention
✓	✓	✓		
No need	No need		✓	✓
		1 viable weed seed will grow.	10,000 + viable weed seeds will not grow.	Focus on conditions, not weeds or seed banks.

By not focusing on the "weed" [passenger], but learning how to create its non-preferred conditions. This proactive management decision focuses on weed prevention, solving the real problem [driver] being declining landscape function and loss of associated feedback loops. This idea is opposite to the old reactive eradication / control methodologies. In short; prevention overcomes the need for eradication.

Reading the weed's form and function is an integrated feature that makes the above model practical.

Something to think on: If there was one weed seed in its preferred conditions or there were 100,000 weed seeds in their non preferred conditions, which would be the most likely to germinate and why ?

Reading the Form and Function of Weeds

A popular definition of a weed is "**A plant out of place**." Traditionally the focus is on the plant for it is not wanted in that locality / area at a specific time. It is either taking up valuable space or its superior growth rates have caused it to be singled out because it is highly visible. The control of that weed is normally done by targeting the weed and killing it. If the unwanted plant recovers, or if it has already seeded and a new generation of plants comes back, the process is repeated again, but this time it is often more costly. Weeds are controlled or eliminated because of the desires of a person making that decision and focusing on the weed as the problem. However, this process is **working against the Laws of Nature**. From a natural or ecological point of view, the so-called "weed" is in the right place at the right time and that is why it is growing so well there.

It is not by pure chance that plants are where they are, as weeds and all plants are in constant competition for water, light, nutrients etc.. The plants that are growing in a local area are collectively called the local plant community and as conditions change the plant community changes. All plants are in some form of natural end point sequence or succession. When plant communities have some form of longer-term stability it is referred to as a plant community equilibrium [climax]. That plant community will continue until there is an exceptional force creating disturbance. In nature plant succession is therefore, bi-directional for it can be moving toward [positive] and away [negative] from a natural [desired] plant community equilibrium.

In a natural positive plant succession, slowly the opportunist plants called weeds will be replaced by plants that form a new plant community equilibrium. In a negative plant succession, a plant community will change from desirable plants to weed plants, or from simple opportunist soft weed plants to longer living, tougher [armed], less palatable, less nutritious weed plants. In general, a negative plant succession is the result of a negative disruption on the localised environment and landscape, which includes soil health. So, if weeds are becoming a greater problem in agriculture then it is highly possible that they are reflecting a decline in the condition of the soil health, environment and landscape. The decline in ecosystem "health" has led to the emerging topic of ecosystem restoration, which is a unified and integrated approach to recovering ecosystem function and environmental repair. Global communities are becoming more aware of the need for a more ecological approach to land management and the restorative function and role of water and plants.

In the big picture of plant ecology, could it be that the weed is not the problem, but it is just a plant that indicates that there is a problem with the localised conditions? Could the problem actually be with the locality / environment and not with the "messenger" weed plant? Could it be that weeds are nature's way of self-regulating and sometimes "repairing" the localised conditions? Are weeds like a bandage that gives temporary solutions? Could weeds be loosely described as the symptom of poor soil health or landscape degeneration?

If the above theory is correct then the actual weeds themselves should indicate or reflect the condition of the environment and location they are in and have definable features / attributes. Is it possible that to a trained eye the form and function of weeds match the purpose of them to rebalance / repair their environment and or soil?

The long term sustainable control and prevention of weeds is to not focus on the individual so called weed [symptom], but on the declining environment, landscape and soil health that is the true problem. A better understanding of purpose, form, function and specific roles of "weeds" will assist landholders and land managers decision making processes to address these true problems.

In short, we need to "read" weeds and learn what their form and function is telling us.

Why Weeds?

The study of so called "weeds" in agriculture involves plant ecology [natural] and agroecosystems [agriculture]. As this is a discussion about weeds part of the debate is about what is a weed. What type of plant can be called a weed. Is a weed just a plant out of place or simply unwanted plants? If an agricultural [garden] plant is in a natural ecosystem [National Park], it is a weed, similarly if a native plant is in a cropping agro-ecosystem it could also be classed as a weed. The same plant may or may not be classed as a weed in two different circumstances.

Weeds are arbitrarily labelled according to individual and community viewpoints when the decision is made. This decision-making process is often done when the "weed" is coming to its largest volume in time within a relatively small space [high concentration and density]. When it is getting out of hand, which can also coincide with, the singular plant species approaching its climatic succession or ecosystem dominance.

When the decision is made that a weed species is a major problem, often quick decisions to eradicate the plant follow and this can lead to a desire for quick results. This short-term decision making often leads to the use of herbicides. The use of some herbicides [herbicide selectivity] can lead to what is described as a species shift, meaning that when a targeted plant is removed a new species takes its place [and role]. The removal of the primary "problem" plant, triggers the secondary "problem" plant, which was previously only in small numbers. The secondary "problem" plant starts to dominate as it now has a new opportunity to fill the role [void] that has been created. The management of this new "problem" plant can often become harder than the first plant that was removed as plants become more adaptive. If and when this new "problem" plant is removed then another new "problem" plant appears and the cycle continues as the plant is the symptom and not the problem. If the real underlying problem is not treated then the symptom called weeds just keeps coming back. It should be noted that the repeated use of herbicides can lead to herbicide resistance if a chemical approach is considered to eradicate the weeds.

A different approach to the above situation is to view the "weed" as an indicator plant and ask yourself – "What is this plant indicating about the place that it is growing in?" or "What is it telling me, what can it teach me?" Nature is always trying to establish a natural equilibrium within a plant community using self-propagating plants and other self-regulating processes to achieve this. "Weeds" are one part of nature's self-regulating reparative process. If you do not understand that the weed is telling you, you can have a very long and expensive self-educational schooling.

Seed, germination or beneficial conditions, which is the most important factor?

Treating the weed as a "problem" plant can and often gets you into more problems, for example if you remove the plant and its potential reparative role, then you will have to do the role of this plant to improve plant succession. The plant may be there by chance, but mostly it will be there, in that time and space, by natural selection, which includes self-regulating / repair / balancing processes. In the soil the amount of seed bank [and potential seed recruitment] may surprise you and this can be seen when weeds "just come from nowhere." Weeds do not just arrive and grow, first they have to germinate by seed and/or a vegetative part of it etc.. **They can only grow if conditions are beneficial** for them to reproduce and self-propagate. There are trillions of weed seeds in the soil so there is no shortage of weed seeds in the soil. This is not the main issue as the focus needs to be in understanding why or what triggers the growth of the weed species. Some weeds germinate but do poorly in some years and in other years they grow exceptionally well. The seeds were in the soil both times. Why weeds grow is because the conditions are right at that time and space, not just the amount of seed in the soil. If this was not the case then the whole world would be covered with weeds and it is not, but weeds do follow the footprint of mankind.

Understanding Plant Succession in Agriculture

"Weeds" are generally the symptom of a disturbed environment, degrading landscape and declining soil health. They become part of the existing plant community and their primary purpose and function is to restore / repair / self-regulate nutrient balance in landscapes and/or raise the succession order of the existing plant community.

The concept of plant succession is directional and can be positive or negative. Plant succession can be related to physical height and biomass. Moss and lichen are at a low successional order. As plants get taller with greater mass so the succession improves. From an agricultural point of view, different farmers will want different orders of succession. Cropping farmers often just want one [mono] succession of plants, a monocrop. Some farmers are moving to having two or more plants at the same time being a poly crop / companion planting. Graziers have many different opinions on what they want as a plant community. An extreme can be dairy farmers who want a dominant grass for grazing, whilst others want a mixed pasture and may like a few "weeds" to enhance biodiversity and ecological resilience. Therefore, in agriculture what the "ideal" plant community will range from single / mono plant species to companion plantings, rows of trees or pastures etc. The idea of what is ideal is up to the individual opinion of the manager of each property. The problem is that nature ignores individual management preferences and has a natural order to plant sequestration. Hence, Peter Andrews' term Natural Sequence Farming and his love of weeds.

From an agricultural point of view if weeds are the symptom and not the problem, it is important to identify **what is the problem - disturbed environments / declining soil health and or degrading landscapes.** Traditionally a weed was a plant out of place. The following information may clarify the previous statement that a weed is a plant out of place for the person that is making that decision, however, it might be in the right place by naturals successional order.

Weeds and What They Tell

You still may be thinking that some plants are bad "weeds". There are many ways to characterise weeds and the following diagram has grouped and introduced the dynamic within the relatively new topic of weedology. There are many related layers that involve the intervention of weeds that are progressive [positive] or regressive [negative] plant succession, which predetermines their purpose, function, form and speciality role.

Weeds can be initially grouped into their general purpose, which reflects where you can find them in their local preferred conditions. Although these are general **local condition** groupings there will naturally be many overlaps. There are in general 6 main conditions that "weeds" prefer to grow in. **Weed plants are opportunists** and can outgrow [attack – out produce] or outlast [defend – use appendage adaptation] local plants. Plants growing in these different conditions are the symptom of their environment, not the cause, which is often associated with disturbed environments / declining soil health and or degrading landscapes. This is why weeds can be turned "on" and "off," once we learn what weeds are telling us. Stable plant communities have very few weeds as there is no need for their self-regulating or reparative function to be utilized. A plant community in a relatively stable equilibrium has very little role for weeds to fulfil, therefore, few weeds grow. The following conditions act as a preconditioning or prerequisite to trigger natural inbuilt germination for "weeds" to act as self-regulating plants.

Categories of Weeds by Form and Function

The following diagram illustrates the relationship between common conditions [often poor soil health and/or degraded landscapes] and the function of the weed acting as an indicator plant of these conditions. Similarly, the function and form of the plants reflect their roles as self-regulating or repair plants, including their speciality roles. The general purpose of each group of plants is 1] Cover the ground, 2] Raising successional order and 3] Regulate excess nutrients. In brief; if a weed over time protects the soil, improves soil health, recycles excess nutrients, raises the successional order [and in a pastural situation, is edible] then it is highly possible that it will become naturalised and lose its label of being a weed.

Localised Conditions	**"Weed" Function**	**"Weed" Forms**		**Weed Speciality Roles**
1. Plant purpose to cover the ground				
Bare / Disturbed Soils:	Covers of the soil	Coloniser: Lichens/Mosses		Sponge (scab)
		Pioneer	weeds	First out of the ground
		Highrise	weeds	All rounders
Poor Ground Cover Soils:	Defends the soil	Fortress	weeds	Thick walled slow to grow
	[*Protective* weeds]	Rusty wire	weeds	Very tough leaves / stalk
		Armed sword	weeds	Thorns / spins / spikes
2. Plant purpose to raise successional order				
Compacted soils	Topsoil Builders:	Jack Hammer	weeds	Short with tap root
Mineral Depleted Soils:		Drilling rig	weeds	Tall with deep root[s]
Excess leaf removal		Gold nugget	weeds	Underground storage
Poor soil structure		Soil tiller	weeds	Fine roots
Nitrogen Depleted Soils:	Nitrogen Regulators - :	Bio (N) Lump	weeds	Fixing nitrogen
3. Plant purpose to regulate excess nutrients				
Excess Soil Nitrogen:	Nitrogen Regulators +:	Balloon	weeds	Fast growing broad leaves
	[*Productive* weeds]	Spider	weeds	Thick spreading
		Umbrella	weeds	Long spreading
Sinks of Excess Nutrient:	Ecosystem Renovators:	Tent	weeds	Makes a canopy / house
		Rope and Cloak	weeds	Climbs or smothers
		Bowl of soup wet	weeds	Slow/filter/use soluble nutrient
4. Naturized [As part of the plant ecological climax]		Exotic "weed" now naturized		

Note: There is an arbitrary line when some "weeds" have become so adaptive to agricultural ecosystems that they have become naturalised. In fact, many exotic pasture plants originated as accidental invaders. They were not deliberately introduced but started as unknown and unwanted "weeds" that increased in number and invaded native pastures. Their beneficial features justified they transitioned from a "weed" to a beneficial pasture plant. However, some people may still think these same plants are still "weeds," especially if they invade non-agricultural landscapes.

Localised Conditions

Bare / Disturbed Soils [Need – Covers & Defends the Soil]:
"*Here comes the first wave of pioneers, help is at hand*!"
The plants for these soils are *"weed" colonisers that create the needed cover.* These conditions trigger the seed bank of opportunistic "pioneer" plants which come in a range of sizes, forms and shapes.
They are the first out of the ground and their repair role is to firstly make soil [Primary succession] and secondly [Secondary succession] to quickly take up available nutrients and then cover the soil with a "green" scab, just like if our skin is damaged. These can initially be short cycle, quick succession [annual] plants. In general, if you see moss growing [has no roots] there is a major soil problem.

Local conditions include freshly cultivated soil, between crop rows, newly cleared land and where soil is [freshly] exposed. Bare ground can also result from high temperature burning and or eroded soils. Disturbed soil creates a break in the soil ecosystem feedback loops, causing a surplus of mobile nutrient together with increased soil aeration often temporarily improving nutrient availability. This is one reason why – Slash and Burn agriculture has been used. As bare soil *has no cover* is an un-natural occurrence and is a highly visible sign of the presence of human intervention / management. The succession ~~invasion~~ of new plants includes "repair plants" as their role is to very quickly cover the ground, die and leave a protective layer of organic matter on the soil surface.

Poor Ground Cover: [Need - Covers & Defends the Soil]:
Ground cover can be living or dead and includes both living plants as well as organic matter on the soil. Ideally the soil has a cover of decaying organic matter between the mineral soil and the living plant. This layer is the roof to protect soil biology and to feed it. These local conditions of poor ground cover often occur where stock congregate or where crops / pastures have been sprayed out. They include over grazed pasture [drought conditions], stock holding paddock [close to yards] and around watering points etc.. These areas can be highly degraded sites [prolonged over stocking?] and also can be due to soil compaction, flooding and chemical residues. At the micro level conditions include stock tracks, under shade trees and eroded areas. Very low fertility and arid sites can also have poor ground cover with low decomposition rates and are more vulnerable.

Note that poor ground cover can literally be in between inedible "Fortress" or "Armed sword" like weeds. In these conditions there is very little edible stock feed and landscapes are generally degraded from their ecological plant community climax.

"*Time may come and time may go, but these plants are to stay*."
The plants for these soils are [often perennial] "guardian" plants as they can defend themselves and guard the soil from further degrading for many years. These are long cycle, slow successional order plants. If areas have prolonged poor ground cover [and bare soil], then these plants can survive these conditions as they are normally inedible, physically coarse, tough [and woody] armour and or self-protecting [thorns, spins, poisons etc] plants, otherwise they would have been grazed and destroyed. Surviving plants have greater longevity in association with greater bulk density [biomass and circumference]. They are often big long lived, tough plants through natural selection.

Compacted Soils: [The need for Topsoil Builders]
These local conditions include compacted soil, associated with clay subsoil on duplex soils or physically damaged soil with hard pans. These conditions can also include compaction on the soil surface. These plants use their jack hammer tap roots to drill down and find existing cracks and enlarge them. The weed herb dandelion has a dual role with a tap root and also accumulates calcium. Clay soils are traditionally low with calcium and additional calcium can "open" up a clay soil. The weed herb chicory is known for its deep hard pan cracking and mineral up lifting.

Mineral Depleted Soils: [The need for Topsoil Builders]
These local conditions include shallow sandy soils [low CEC], highly leached soils [low calcium], over grazed or over cropped soils, repeated fodder conservation, highly eroded soils or simply just naturally low fertility soils.

Need for mineral "reaching" plants.
"*Natures biofertilizer manufacturing factory.*"
The dominate repair plants for these soils are "drilling rig" weeds often with deep singular root[s], "gold nugget" weeds with underground storage, soil tiller with their fine root systems and or a combination. The repair plants for these soils are plants often associated with low fertility soils and landscapes. The idea that "weeds" bring up and concentrate needed mineral[s] has been around for a long time. Some farmers allow weed plants to fully mature and then mulch them onto the surface or incorporate them into the soil. Often these plants are inedible and have deeper root systems. These [annual] "repair plants" particularly benefit shallow sandy soils.

A feature of these mineral "reaching" plants is their main central tap roots. They have to go mining for new minerals, so they include the big "Drilling Rig weeds." These plants can often be the only plants that can get through a hardpan. So, these plants can act like living drill bits that help drain hard pans and on their death act like wicks allowing capillary water to move through the soil profile. On their decomposition water is able to penetrate through the hardpan and the more desirable plants can then use these new entry points, enlarge them and start to break up thin [plough] hardpans.

Nitrogen Depleted Soils: [The need for Nitrogen Regulators]
These local conditions include low organic matter soils, burnt soils, flooded [longer inundated], surface sealed soils, poor soil structure [heavy clay], biologically "dead" soils, very high organic matter soils [peat] and the classic of ploughing in / incorporated dried out low nitrogen crop residues.
Common nitrogen depleted soils include over cropped sandy soil as the can hold very little available total nitrogen. Other soils include structurally damaged soil / anaerobic soils [impairing soil biology feedback loops] or excess carbon soil that have a very low carbon to nitrogen ratio. [The bigger picture of this topic is to build protein levels in the soil and recycle the excess nitrogen].

Need for Positive Nitrogen Regulators
"*You have the carbon, you now need the nitrogen.*"
The plants for these soils are nitrogen building plants: These plants are normally nitrogen fixers / legumes with their associated symbiotic soil biology. They often need higher levels of fertility [calcium / phosphorous] and raise nitrogen levels after a period of lower fertility, soil health decline or grass dominance [successional climax] and are common in early levels of succession eg clover / wattles.

Excess Soil Nitrogen: [The need for Nitrogen Regulators]
These local conditions include excess nitrogen fertilizer [plant too small to take up?], warm soils getting their first major rain event, green manuring, brigalow / wattle clearing, high stock concentrations [cattle camps / under shade trees / water points etc.]. Normally good healthy soils can switch to have excess soil nitrogen when the soil biology is temporary set back by flooding [longer inundated] and or surface sealed soils. Higher fertility soils that have poor / damage soil structure or shallow soils with high surface organic matter levels are good conditions to grow these weeds.

Stock grazing on high nitrate plants, especially when they start to wilt, can cause nitrate poisoning [glazed eyes, ears down, shitty tails, slow to lift and drop their front legs – more of a southern Australia problem] and their very loose manure concentrate forms an oblong "dung" sized new community of plants that are more acid loving plants. Micro concentration of plants that respond to high nitrogen levels will grow in dung from stock grazing on higher protein [nitrogen] plants.

On poorer soils, higher nitrogen / nutrient manures can form "dung" sized new communities of higher successional plants. As one farmer said – "*You need to be shitologist.*" But the opposite can happen on high nitrate soil as more nitrate weeds will grow in new "dung" sized plant communities.

Need for Nitrate Safety Valve Plants:
"*Let the valve blow or give it time to slowly go down by itself*?"
The plants for these soils are opportunistic plants that react to a specific nutrient excess in this case – nitrogen [nitrate]. These plants are very fast growing and hence are very soft with darker green colouration. They are reparative plants for the soil ecosystem and act like safety valves that remove high levels of nitrate out of the soil. At the same time they can also quickly cover the soil and create protective ground cover. Some people believe that nitrate "weeds" also re-mineralise the soil and thus fulfil many roles at once. They are definitely "repair plants" that detoxify the soil and move the excess nitrate out of the soil, into the plant structures and then die with the nitrogen in a more stable form.

Sinks of Excess Nutrient: [The need for Ecosystem Renovators]
These local conditions can be highly diverse as it involves not only the volume / mass of nutrient, but more importantly the concentration [dilution] of nutrients. For example, a relatively small amount of organic matter and nutrient on [O and A horizon] a sandy shallow soil can have a similar effect of a high organic matter [thatch] on a deep loam soil.

Another extreme is when a natural water course or flow line is degraded, either with excess run off nutrients or drying out with once suspended nutrients becoming concentrated. These weeds are highly correlated to degraded waterways that have lost their landscape function and need rehydrating [and changing the nutrient concentration]. They are often located in areas where water collects [and can later dry out] and low area nutrient sinks. These weeds grow quickly and have large volumes of biomass. The problem is a loss of landscape function, the weed is there because of excess nutrient, caused by "broken" feedback loops. Unless the functionality of the landscape is restored then these excess nutrient conversion sites just get bigger and can create their own new self-supporting ecosystems.

"*Give them the nutrient bricks and they will build a new jungle city.*"
The plants for these soils are plants that are dealing with excesses and have moved beyond minor rebalancing and to self-regulating nutrients within the agroecosystem. They are raising the succession order of the plant community, improve the micro climate and start to create their own ecosystems or "cities." As they build more and more long lived mini "cities" they are called invasive weeds. These plants can also be climate changes. They operate when natural nutrient feedback [recycle] loops are broken in a landscape and their role is to take up excess nutrient out of the ecosystem. They take excess [soluble] nutrients and convert and store them in a more stable form in their vegetative parts. Then spread [invade] out to redistribute nutrients back into and over the landscape.

The last group of plants are wet weeds and they slow / filter soluble nutrients to make new biological bricks to form aquatic ecosystems. The more new nutrients they hold, the bigger they get and they can act as "biological valves" to regulate flood water, wonderful plants some call weeds.

Another way to group weeds is by their form and function. This can tell us a lot when we understand why they are there as they are not there just only by chance. Remember that when we think of the actual physical form and function of a "weed" we need to think of the whole plant, roots and all. Remember that 50% of the plant is underground and that could be the most important part of many so called "weeds.".

To better understand why weeds are the symptom and not the problem, we need to understand the visual language that weeds are using. The simplest way is to look at their natural physical form. Weeds can tell us a lot by us simply making the time to stop and see what they look like and then ask yourself – *Why* ?

Below is a limited list of the different functions of weeds, which being divided into 5 general sections:

- Covers
- Defenders of the soil
- Topsoil Builders
- Nitrogen Regulators [+ or -]
- Ecosystem Renovators [Often "*Environmental*" Weeds]

Cover

The first are colonisers that act like little sponges having no roots, or flowers or seeds. In colonisation, initially lichens grow [withstanding dryness] and then mosses that need more moisture. They are short and form biological soil crusts that initiate soil formation. Lichen, liverworts, mosses = cryptograms. Lichens have about 20,000 species and are not a plant, but have a symbiotic relationship between fungi and algae or cyanobacteria. In secondary succession [agriculture] mosses are associated with surface soil compaction and surface sealing, forming a crust or scab to cover the soil surface.

Defends the soil

"Defenders of the soil" as their name implies use their physical form to protect themselves and for the soil's benefit. They are true guardians of the soil and use thorns, spines, spikes, hairs etc.. Plants on more degraded locations simply use their inedible mass and put a coarse horizontal matting on and in the soil's surface. These plants often accumulate silica and potassium and use their physical inedible mass to protect the soil as a last resort. Their enhanced resistance to decomposition slows decomposition and gives a longer lasting surface coverage. There can be linkages between these latter plants and the use of fire. Fire is often used to reduce competition, but it can also have long term effects. For example, to release and solubilize elements, especially potassium [which can be quickly leached]. This can trigger a plant's adaptive defence mechanisms to increase their surface "toughness" with greater waxes and lignin etc.. Grasses can respond with increasing silica levels that are more resistant to decay and provide more fuel for the next fire. Plants as weeds will also defend themselves by utilising chemical warfare = toxins and **poison**!

Topsoil Builders

These plants in general build topsoil and improve soil health. They often simply fill in vacant spaces and germinate in small ecological niches. They are opportunists and improve the physical and biological components of the soil. They are fast recyclers and often are the first to germinate and grow. They often have a disproportionate shoot to root ratio with more and finer root systems, so their benefit is greater in the soil than above the ground. They leave the soil in a better physical and biological condition. The next group of topsoil builders includes the plants that go deep in the soil and they can start off slowly as they focus on getting their roots down. On the surface they can physically look like they have stopped growing, but they are growing underground. When it is time for them to grow they literally telescopically grow and put spaces between their sets of leaves. These plants with their superior root systems will outlast smaller shallower plants. This means that they become very obvious as the landscape dries out and the most visible green colouration are the "weeds." They build topsoil by mining minerals from deeper down and depositing them on the soil surface on their death. These plants, after they have died, have the effect of opening up new macro pore spaces in the soil that allow other plants to take advantage of more direct and more efficient access to subsoil nutrients and especially subsoil water. They can also overcome compaction and make previously untapped minerals available. The tall woody nature of some of these plants can be associated with the need to raise potassium [ash of the pot] in the soil profile. They hold the potassium in their wood that returns to the soil or, in the case of fire, it is quickly released, but subject to leaching on the first heavy rains.

Nitrogen Regulators
There are two opposite functions in this weed {plants} group that regulate soil nitrogen. The nitrogen accumulators [legumes] and the nitrogen exploiters [nitrate loving] weeds. More commonly known are the legume plants [beans/peas] that fix atmospheric nitrogen and help self-regulate nitrogen levels. In pastures there can be perennial legumes like white clover / Lucerne that can raise soil nitrogen levels. On lower fertility soils; sub-clover, annual medics / tropical legumes regulate soil nitrogen levels. The diversity of these plants is large, one common feature is that being a legume they need vitamin B12, which comes from the synthesis of the mineral cobalt. B12 is essential for legumes and ruminant animals for cattle / sheep. This is one reason why B12 is added to Gwyn's Home made brew.

The opposite to soil nitrogen building plants are the nitrate accumulating plants. Their role in nature is to take up the excess nitrate out of the soil ecosystem. If nitrate loving weeds start to dominate ground cover, a better farming practice would be to sod seed [presoak and inoculate the seed] an annual plant to gain productive feed and to absorb the excess nitrogen in the soil. Nitrate weeds are common in Lucerne and first time cultivated paddocks. Hay paddocks can also have nitrate weeds if perennial plants have died out.

The most common area for nitrate weeds to germinate are stock camps / yards and other stock concentration areas. By their sheer numbers of plants per square metre and early rapid growth, these plants can out compete other productive pasture species. As soil health declines conditions favour the accumulation of nitrate in the soil and the degrading process often starts off with too high a **stocking rate to the amount of rainfall,** which can create a poor choice of **grazing method.** This often leads to a **loss of preferred plant** species and a decline in plant succession. The result is a lack of time for plant foliage to grow, which leads to less nutrient availability and shallower roots. An additional problem is created with a lack of time for plant roots to re-grow and store carbohydrates. As plants size and number decline, **stock eat ground cover** [which is a natural triggering for nitrate "repair" plants to quickly cover the soil on the first main rain event]. With increased **bare soil, soil erosion** increases as soil particles detach and are transported away by water or wind.

Ecosystem Renovators [They are often "*Environmental*" weeds as they change their environment!]
These are mainly big, long lived, non native (exotic) plants that naturally are invasive, due to their superior adaptations. The question must be asked as to why these plants are able to grow so fast, have nutrients for a long life and be able to use this to become invasive and literally ecosystem renovators. These plants are often not making something from nothing, but utilizing unexploited nutrients [sinks]. They tap into a nutrient supply and grow fast large and have adaptive features to create a new micro and macro ecosystem. Often described as "*Environmental*" weeds!

A common feature with these plants is that many are associated with degraded water ways or water flow lines where nutrients have been deposited. Again, often degraded sites have had soil and solubilized nutrients moved from higher in the landscape and deposited in flatter areas. It does not take a lot of nutrient concentration to create what can be described as a nutrient sink [or vault]. Once these plants access these nutrients they can then go ahead to create a canopy that literally builds an improved ecosystem with more stable ground and air temperature, improved daily water cycles, accumulating organic matter, wildlife delivering dung and urine. They structurally build their own little city with an efficient carbon manufacturing and recycling factory.

Another type of weed is on the water's edge or in the water. They are wet weeds with quick growth rates as they trap nutrient and start to make their own ecosystems. They are true ecosystem renovators and can be liked to what beavers do. The establishment of these plants in degraded/eroded waterways can be difficult due to "negative" water pressure (Andrew, 2006). A willow is a speciality plant that can survive a "negative" water pressure and historically has been used in on-going succession.

Form of "weeds" [*Creating picture words*]

Covers of the soil		Localised Conditions	Weed Speciality Roles
• **Pioneer**	weeds	Bare / Disturbed Soils	First out of the ground
• **Gold nugget**	weeds	" " "	Underground storage
Defends the soil			
• **Fortress**	weeds	Poor Ground Cover Soils	Thick walled slow to grow
• **Rusty wire**	weeds	" " "	Very tough leaves / stalk
• **Armed sword**	weeds	" " "	Thorns / spins / spikes
Topsoil Builders			
• **Jack Hammer**	weeds	Compacted soils	Short with tap root
• **Drilling rig**	weeds	Mineral depleted soils	Tall with deep root[s]
• **Highrise**	weeds	" " "	All rounders
• **Soil tiller**	weeds	Poor soil aggregation	Fine roots
Nitrogen Regulators			
• **N Lump**	weeds	Nitrogen Depleted Soils	Fixing nitrogen
• **Balloon**	weeds	Excess Soil Nitrogen	Fast growing broad leaves
• **Spider**	weeds	" " "	Thick spreading
• **Umbrella**	weeds	" " "	Long spreading
Ecosystem Renovators [Transformer Weeds]			
• **Tent**	weeds	" " "	Makes a canopy, builds an eco-house
• **Rope and Cloak**	weeds	Sinks of Excess Nutrient	Transfer of bulk nutrients
• **Bowl of soup wet**	weeds	Create / use Excess Nutrient	Slow / filter / use soluble nutrients

Suggested Reading

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King, F.C, 1951, The Weed Problem: A New Approach, Faber and Faber, London.
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Pfeifer, E.E., 1975, Weeds and What They Tell, Rodale Press, Emmaus.
Wall, K., 2019, Working with Weeds, Kate /Wall, Brisbane.
Walters, C., 1991, Weeds: Control without Poisons, Acres, USA, Kansas.
McCaman, J.L., 1994, Weeds and Why They Grow, Sand Lake, MI.

If all else fails, find a patch of weeds, sit on the ground [get into their zone] with the sun to your back between 4-5 pm [softer light], stay there for a while. To start just stare, observe, study one weed species [eg 10 minutes]. The more you look, the more you will see. Then just stare, observe, study another weed species [eg 10 minutes]. Then ask yourself what is the difference between the two weeds? Then look at both weeds and compare them to non weed plants – what is the main difference between the qualities of the weed feature and the qualities of the non-weed plants. Lastly, why are the weeds in that environment, what is their reparative role, what management decisions would reduce the role of each or either weed[s]. Remember weeds were once native plants that were given the opportunity to grow due to human intervention. As you walk away from the weed patch / area try and think of the successional order of the plants you can see – Well Done!!!

 Gwyn Jones Mobile: 0427761191 gjones@healthyag.com

SOIL COVERS [Bare / Disturbed Soils]

P**ioneer** Weeds Eg:

The speciality role of these smaller pioneer weeds is to simply be the first out of the ground. They can include small herbs and forbs and come in all shapes and forms. On re-colonisation they can often initially out compete planted plants as they are first to grow, but they normally get out shaded or quickly slow down growth as other plants increase their competition. In cropping, if this type of plant is an initial problem, so try to focus on a pre-seed treatment eg beneficial soil biology, compost teas or additional nutrient coatings etc.. This is to give the crop seed a greater advantage in competition.

Highrise Weeds Eg:

The speciality role of Highrise weeds is to be an all-rounder, incorporating a deep root system. These weeds are taller slender weeds. They cover bare spots, shade and protect the soil, plus bring up and recycle nutrients – an all-rounder. Some of these amazing plants can accumulate silica and this is reflected in their physical square stemmed structures. Their role is to go high and then slowly decompose. High silica means that they are hard to physically cut and stock teeth can wear down. *Remember silica is opposite to Calcium.*

SOIL DEFENDERS [Poor Ground Cover Soils] Change in leaf form / morphology

Fortress Weeds Eg:

The speciality role of Fortress weeds is to be defensive and slow to grow. These weeds have thick round or flat armour that is very tough. They create walls of thick coarse tubes and densely cover small areas of ground. The function of these fortress-like weeds is to 100% protect the ground and be unpalatable so stock will leave them alone. You can chop, kick and burn these plants, but with rain they just come back as they are often very long lived. They can be rushes / tussocks some very coarse old grasses etc..

Rusty wire Weeds Eg:

The speciality role of Rusty wire weeds is to have very tough leaves and stalks. These physically tough plants often occur after over grazing and/or the on-going use of fire. Normally high potassium [low calcium] or high lignin plants, especially grasses, leaving very coarse longer term organic matter on the soil. Associated with degraded landscapes.
(Inedible – *Why* ?)

Armed sword Weeds Eg:

The speciality role of Armed sword weeds is to guard the soil. These weeds are armed with many spines, thorns, spikes etc.. They are telling you to stand away and leave it alone. It is a true guardian of the soil, keeping animals away. These plants are often bare ground cover plants - thistles.

TOPSOIL BUILDERS

Change in root form / morphology

Jack Hammer Weed Eg:

The speciality role of "*Jack Hammer*" weeds is break up compacted soil. Short version of drill rig with long flat leaves [handles] and a tap root [Drill bit] eg Plantain. Associated with compact soil, they can be clay breakers. These weeds types build from the bottom [subsoil] and re-mineralise the depleted topsoil.

Drilling rig Weeds Eg:

The speciality role of "*Drilling Rig*" tall weeds is to find minerals. These weeds are big woody weeds that need a massive top in order to drill deep into the subsoil, so that new nutrients can be brought up to the surface and recycled. Woody weeds can be associated with potassium accumulation.

Gold nugget Weeds Eg:

The speciality role of these "*Gold Nugget*" weeds is to have large under ground storage vessels [stems]. These weeds hold all their main energy [gold] reserve underground as bulks, tubers, corms, rhizomes [and stolon's above ground]. These plants are often the result of overgrazing / mowing, when other plants die out they are able to compete. Their function is to survive extended periods of adverse events, especially over grazing and then quickly produce new ground cover.

Soil tiller Weeds Eg:
The speciality role of "*Soil Tiller*" weeds is to have fine [surface] hair like roots. These weeds improve soil aggregation, structure and soil health. When these plants are pulled out you will see how the soil clings to the roots. Many of these plants are grasses and include the "Highrise" weeds, especially as they mature.

NITROGEN REGULATORS (Can have "lesser" and "higher" order legumes)
N+ Lump Weeds Eg: Clover / Medic, broom, Mimosa, Wattles, [Nitrogen Depleted Soils]
The speciality role of "*N*(*itrogen*) *Lump*" weeds is to fix atmospheric nitrogen. Legume weeds have symbiotic nodulating and come in a range of sizes. Generally higher in nutritional value and prefer higher soil fertility levels, especially phosphorous, calcium and the related element boron. They are associated with raising the order of plant succession, but are often preferentially grazed if palatable.

[Excess Soil Nitrogen]
Balloon Weeds Eg: Mellow, Capeweed, Amaranthus / Pigweed, Nightshade.
The speciality role of these "*Balloon*" weeds is to have fast growing broad leaves. They are often shorter plants that look like over inflated balloons with darker green high water content leaves. Their job is to literally pump excess nitrogen out of the soil, convert it into stable organic matter and then deposit it back onto the soil surface. These weeds are mainly annuals act like nitrate safety valves as they have a luxury uptake of nitrogen, which can kill stock [never cut and wilt these plants for hay].

Spider Weeds Eg: Hogweed, Wireweed
The speciality role of these short weeds is the distance spreading of nitrate away from the root system. "*Spider*" weeds have thick transport structures / runners, radiating out everywhere, to rapidly cover the soil. Often associated with high nitrogen soils. Their function is to grow rapidly and transfer organic matter / nitrogen more evenly across the soil. Their palatability often decreases as they get older.

Umbrella Weeds Eg: Melons
The speciality role of "*Umbrella*" weeds is the long distance spreading of nutrients and accumulating them elsewhere. These weeds form large light weight leaves with often hollow runners that rapidly spread across the ground eg melons. Their function is to quickly cover the soil spreading accumulated nitrogen away from the shallow root system. They often come up after droughts with high N soils.

ECOSYSTEM RENOVATORS {Transformer Weeds}
Tent Weeds Eg: Lantana (Northern) or Blackberry (Southern)
The speciality role of "*Tent*" (bush) weeds is to make a canopy / house with solar powered air conditioning. Tent weeds create large frameworks like lantana [Northern] and blackberries [Southern] and their leaves are like the outer covering. They shade and protect the often bare soil underneath them. The canopy frame, and often fruit, encourages wildlife that increases nutrient cycling. The fully protected soil increases fertility and often darkens, which is an indication of improved soil health.

Rope and Cloak Weeds Eg: Rubber Vine [transfer bulk amounts of nutrients out of the soil]
The speciality role of Rope and Cloak weeds is "*Climbing*" as they. These big stemmed weeds rapidly climb bushes / trees or smother as their function is to try to increase the biomass above ground by recycling excess nutrients that have occurred. Especially along dried [lacking hydration] waterflow lines that act as nutrient sinks [retained in a drying / dying ecosystem]. Their role is to create a feedback loop and reconnect the excess nutrient back into the landscape, due to their rapid nutrient recycling ability. It is nature's way of stopping the nutrient loss out of a "broken" ecosystem and spreading it above ground. They are excess nutrient conversion units and that is why they are so fast growing – rubber vine weed.

Bowl of soup [wet] Weeds Eg: Reeds, rushes, willows {:*Weeds of Retention – Wilson, M, 2006*}
The speciality role of these wet weeds is to create an environment to slow/filter/use/recycle soluble nutrients. They create a mini dam [step] and slow/retain/hold water forming a bowl [pond] of initially "*soupy*" mix of nutrient rich sediment, which sinks to the bottom, building a new bottom up ecosystem.

The function of weeds is very similar to the function of many agricultural plants.
Many weeds can perform a positive self-regulation or even repair function in the landscape:

- reaching and making available un tapped mineral – "mineral reachers"
- capture and recycling mobile nutrients, especially nitrogen = Nitrate Safety Valve
- "forage" for nutrients that other plants cannot access
- redistribute nutrients through the soil profile
- improve nutrient feedback loops
- build surface and soil organic matter levels
- reduce water run off and build soil carbon
- "carpet" the soil surface with organic matter protecting the soil surface
- act as soil wicks after their roots die
- improve soil water capillary action
- improve soil carbon sequestration
- increase biodiversity [or decrease it]
- act as nature's self-regulator of nutrients

Understanding "weeds" in a new and innovative way

This discussion paper has aimed to create a new ecological and commercial awareness of the interaction between weed plants [ecology] and farming systems and landscape function to make more independent [less biased] management discussions on the control of weeds. It could of value to call a weed by any other name eg indicator plants. The reason being is that the historical use of the word "weed" means that it is a plant that is just waiting to be killed and eradicated. With the on-going spread of weeds, could they simply be a local, regional and national indicator of declining soil health and or landscape degradation? Are **weeds simply indicator plants giving a message in their form and function**, but are part of a bigger discussion of possible greater importance – the degrading of landscapes and soil health resulting in the decline of biodiversity, water quality and other ecosystem services?

Please remember that first of all, weeds are just plants and plants are important to our global survival. Think about why the weed / plant is there and observe its form and function – what is this important information telling you? Think about what ecological patterns are occurring in time and space [time of year, rain events, percentage of area covered]. Do you know and understand the plant succession in your plant community? What is the next successional plant above the unwanted plant, is it present, [if not, why is this telling you that you are still going backwards?] What is the next successional plant below the unwanted plant, is it present? [If it is then it could be confirming that you are going backwards in plant succession]. Have you thought about the results of removing an unwanted plant, remembering that you will have to do the role of the plant that you have removed? Have you or others in your region tried to eradicate this problem plant before? Have previous treatments been successful and at what dollar and environmental cost? There are certain weeds that our community has decided must be removed from a landscape. These are called **Weeds of National Significance** or WoNS. Please see: http://www.environment.gov.au/biodiversity/invasive/weeds/weeds/index.html. Also, the **Biosecurity Act 2014** is about managing diseases and pests that may cause harm to human, animal or plant health or the environment. It takes a risk-based approach and aims to be have less proscriptive obligations. Please see: https://www.legislation.qld.gov.au/view/html/asmade/act-2014-007/lh

The next paper aims to assist you in making more informed and practical decisions about long term weed management control and prevention with an emphasis on **improving soil health, nutrition and landscape function.** Learning to treat the real underlining problems can change plants succession and empower landholders to turned weeds "on" and "off," once we learn what weeds are telling us.

Queensland – Case Study*: Many weeds are growing in specific sites and by growing they are contributing to the rebalancing and aggrading the site, other weeds may appear not to.*

Having read the above is the plant Leucaena an invasive weed [in Hawaii] or productive forage legume ? *What above section[s] does it go into*?

Where do the following plants fit into the above sections and what can we learn ?

Giant sensitive tree / Mimosa pigra (Legume); germinates after flood water:

Sicklepod (Legume, but does not fix nitrogen):

Rubber vine:

Pond apple:

Lantana (Bush):
Dr Terry Beutel, DAFF scientists (2011) = poor land conditions.

Giant rat's tail GRT:
Dr Terry Beutel, DAFF scientists (2011) = poor land conditions.
{**What have we current learnt about this plant**?}

My problem weed =