Sabbatical Fallow for Soil Function

Walking across Tim Gow's pastures, benefits of sabbatical fallow are clear (http://www.organic-rams.co.nz/about-our-farm/). Underfoot is soft like walking on a cushion, a deep mat of litter (Photo 1) protects soil from climatic events and provides a bed and breakfast for many different life forms. In fact scientists visiting his property have found insects they have yet to identify.

Sabbatical fallowing pastures involves removing grazing livestock from 1/7 of a property for 12 months, usually from early spring to late winter for improving soil fertility and function. Pasture grows and accumulates biomass without livestock present to feed soil with litter, exudates, and sloughing root hairs. In fact the bible and other religious texts mention the practice and it was common in the UK until outbreak of the Second World War.

Tim and wife Helen have spent a life challenging conventional New Zealand pastoral farming, often attracting criticism that has proven unfounded. As pioneering organic farmers they began sabbatical fallowing in 1988 after seeing many examples travelling Asia and Middle East. This also coincided with a deep interest in genetics resulting in stud Shire® sheep and Tufty® cattle that handle pastures of greater maturity while reducing handling and production costs; a classic example of creating pasture first then finding livestock to graze it. If starting again they wouldn't waste time using conventional livestock breeds, as older, better adapted breeds like Wiltshire and German Marsh sheep and Highland cattle suited organics and fallowed pastures.

Their 469ha property Mangapiri Downs Organicstud farm® includes 70 ha of trees and is located deep in southern South Island, New Zealand. The property (altitude 200 -380 metres) is split between red tussock alpine pastures and semi developed flat pasture country. Surrounded by Takitimu Mountains it is unlike most neighbouring sheep and beef properties, pastures aren't grazed short or dotted with bales of baylage. Nor is Tim a fan of electric fencing and intensive grazing practices so common in New Zealand. The property is able to run more than its current 200 cattle and 2,000 sheep as Tim continues recovering from a severe head concussion due to a sheepyard accident.

Sabbatical fallow is usually associated with brittle climates to increase organic matter levels and lift moisture retention. Rainfall at Mangapiri Downs is anywhere up 1,500mm (60 inches), and only 300 fall in winter. It appears that all benefits for brittle climates are just as useful in non-brittle, especially in ensuring little if any erosion during winter.

Common NZ farm practice of intensive winter grazing on wet soils and lush pastures with 800-2,000 sheep/ha behind electric fences significantly impacts soil structure by reducing porosity and inducing compaction. Soil scientists concerned about soil degradation from grazing practices were amazed at what they found at Mangapiri Downs. In a study[4] involving 120 properties in Southland, root density of pastures was above average and soil structure from 20-150mm was best from 19 properties surveyed with same soil type.

Tim lists soil benefits from sabbatical fallow: better soil life, water holding capacity, porosity, tilth, deeper and greater root density. Earthworm numbers improve along with trace elements and nitrogen accumulation thereby better nutrient cycling. Decomposing litter creates a deep humus layer that is rich and biologically active with a new seed base, all of which increases topsoil. Furthermore, biomass provides a great feed bank for winter grazing.

In 28 years the whole farm has experienced sabbatical three times and many areas four. They tend to fallow paddocks together across the length or width of the farm. They have not used any fertiliser since 1988, organic or otherwise including lime, nor do they make hay thereby reducing input costs.

They originally dropped stock numbers when starting but find productivity increases and keeps numbers steady through winter and more critically through dry spells and droughts. Critical period is a feed pinch at end of winter when cleaning up last fallow and shutting gates on next. Tim is becoming more relaxed about grazing fallowed pasture into spring rather than sticking to a strict timetable.

Other documented experience

Also at that time Manawatu couple James and Barbara Wilson farmed 240ha of which 105ha was cropped with small grains, vegetables, and trees[1]. The remainder grazed up to 450 dairy beef cattle, 500 ewes, and 200 goats. They enjoyed 10 years without fertiliser and were producing at their district average without major cost of importing fertility. They were also running a sabbatical consultancy service.

They observed soil experiences a number of changes including up to 5cm of earthworm castings. Pasture pests like porina (*Wiseana* species) and grass grub (*Costelytra zealandica*) also increased but heavy trampling over winter crushed most of them. Deeper root systems lifted production by another 1,000 kgDM/ha over control site of 13,000kgDM/ha/yr. Of 14,000kgDM/ha produced, about 8,000kgs composted with 6,000 kgDM/ha available for winter feed to graze boner cows and big bulls.

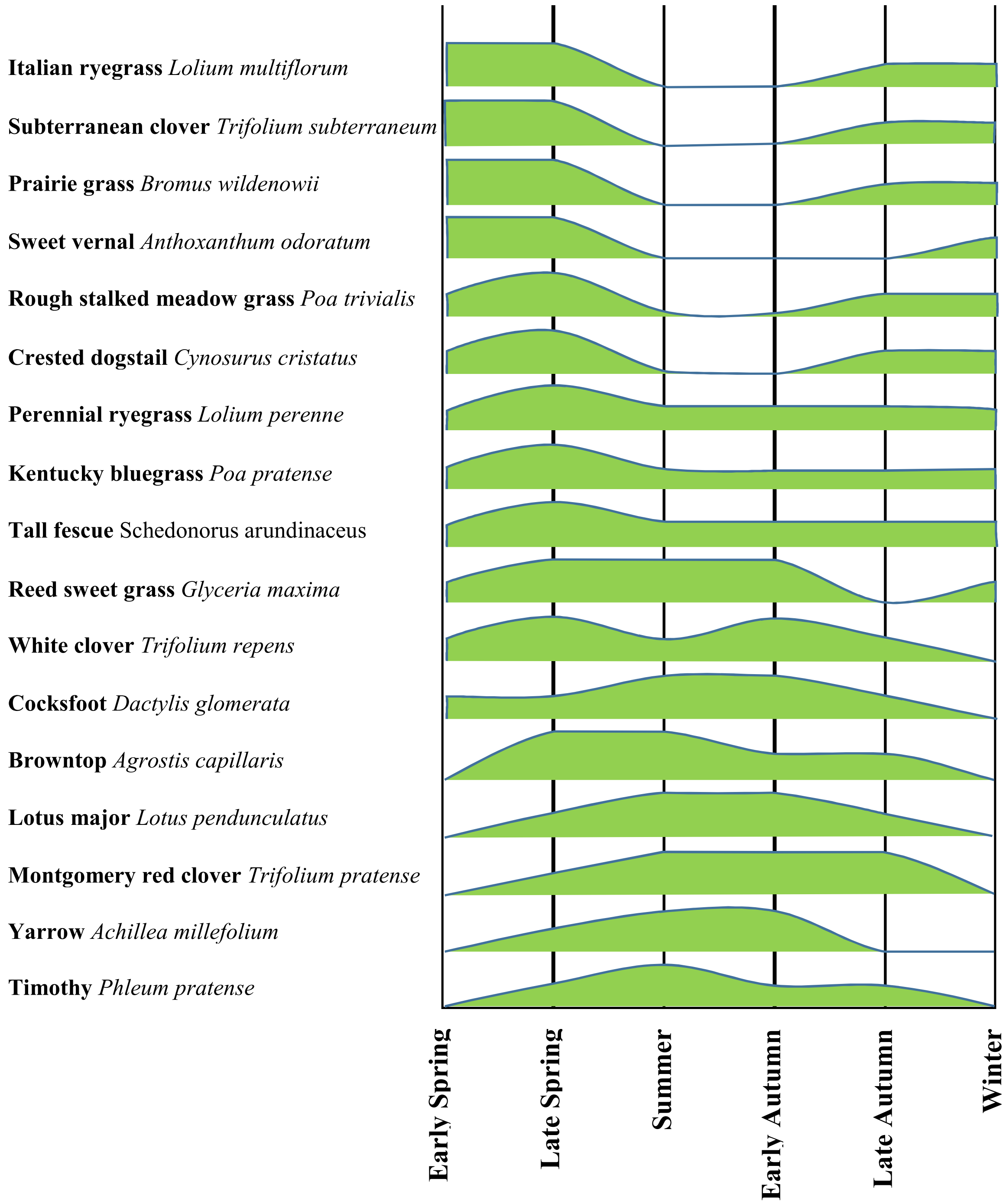
To make sabbatical work, they suggest dropping livestock numbers by 20% which is similar to strategies farmers use to cash in on spring livestock premiums. However, in their experience stocking rates recover to almost to what they were as fallow is integrated into management.

So what that might look like in the first year? Limiting factor is how many livestock can overwinter. For example, a 400ha farm divided by seven is 57ha. Assuming this area normally produces 11,000kgDM/ha/yr, and 6,500kgs is lost through composting leaving 4,500kgs for livestock feed. Also assume 500kgDM is lost through trampling thereby leaving 4,000kgDM/ha. If the property normally carries 10 sheep/ha, therefore 4,000 sheep annually, then 57ha at

4,000kgDM/ha would provide enough feed for 57 days during the winter months. If drop sheep by 20% to 3,200, that would push out 71 days.

A big benefit is cheaper fertiliser costs which lower stock numbers more than compensated for. Animal health also improved due to deeper root systems and a better balance of species eliminating bloat and reducing ryegrass staggers. The Wilson's noted their mutton lost its traditional strong chemical smell, an advantage for exporting to Japan.

Figure 1. Seasonal Growth of Common Grasses and Clovers. Adaptation Levy 1970. Sabbatical Fallow allows for natural seeding of all species in the sward. Mini fallows favour certain species and reduce overall biomass generated.



Research on Sabbatical
In 1990s NZ scientists explored sabbatical fallow and documented a number of interesting characteristics for improving productivity on southern faces of low fertility North Island hill country.

Soil Impacts
Root biomass changes over season with fallowed plots having higher root mass in spring as bulk biomass exceeds grazed areas and less in autumn reflecting senescence and decay of above ground biomass. Porosity increased under fallow due to larger pores (>1500µm) from increased soil life activity, decay of dead roots, and lack of compression from livestock. This reduces soil bulk density without drying soil like cultivation. Higher organic matter increases water holding capacity, a phenomenon that also occurs in stock camps and established livestock trails.

No significant changes in soil minerals emerged between fallow and grazing plots. There were slightly lower K and N levels with fallow possibly due to; lack of fresh dung and urine which contain rapidly available forms of N and K, high total growth rate of fallowed pasture depleting N and K reserves, and declining N fixation by legumes shaded by grasses[4].

Improvements in soil structure, breakdown of plant residues, and release of soil organic N lifted pasture production for two years after fallowing. Trampling by cattle helped carbon to mineralise with soil but mineralisation of nitrogen took much longer to initiate. Pasture and legume growth rates were higher the year after fallowing, particularly greater legume biomass later summer into autumn.

Species and Plant Dynamics
Concurring with farmer observations mentioned earlier above ground pasture mass during an annual fallow on hill country peaks over 11,000kgDM/ha over mid-summer (January) but by early winter (May) it declined to 5,000kgDM/ha as grass and legumes decomposed[2].

Fallowing reduces plant density per metre but those plants are bigger with deeper roots than grazed swards producing a useful phenomenon called self-thinning. Self-thinning occurs when increasing plant biomass reduces plants per metre and also reduces tillering[5] producing a sward that is taller and more erect. As plant density decreases it creates opportunities to introduce new sward species. Total plant population density declines 75% from 29,700 plants and tillers per m^2 to 6,910 over the duration of an annual fallow[4]. This also reduces root biomass at 0-50mm depth effectively reducing plant competition.

Therefore, sabbatical fallow is an ideal tool to introduce species by oversowing with plane or vehicle where direct drilling is impossible or difficult. What is also significant is moisture content is higher under fallow on soil surfaces and root zones which is a dominating factor in seed germination and seedling establishment[4]. Timing of sowing and complimentary grazing practices to get light on litter surfaces to stimulate germination of sown seeds were not discussed.

Timing of Fallow
Length and timing of fallow can also bring useful benefits depending on desired sward characteristics for several farming systems (Table 1). Seed production is significant with 26,300 seeds/m^2 compared to 400-1000/m^2 if sowing perennial ryegrass or cocksfoot[5] so timing of fallows can influence natural seeding rates. However, seedlings which established in months after sabbatical seldom persisted to contribute to pasture production[2]. No explanation is given for this observation.

Table 1. Possible Benefits of Pastoral Fallow in Different Pastoral Farming Systems (Mackay et al. 1991).

Farm System	Sward Vigour		Nitrogen		Improved fertiliser use[5]	Pasture Control[6]	Pest Control[7]	Soil fauna[8]	Soil physical properties[9]
	Re-seeding[1]	Re-generation[2]	Accumulation[3]	Conservation[4]					
1. Low Fertility Hill Country	1	4	5	2	5	5	?	+	+
2. Hill Country	2	4	3	3	5	5	?	+	+
3. Intensive Sheep/Beef	3	4	2	2	2	4	?	+	+
4. Mixed Crop/ Stock finishing	0	0	2	5	1	1	?	+	+
5. Dairying	4	4	2	2	2	3	?	+	+

1 **Re-seeding**. 1 = little or no re-seeding; 5 = extensive re-seeding
2 **Re-generation**. Reduce tiller density, increase tiller size and individual plant size and vigour. Increased rooting depth. 1 = minor; 5 = major effect
3 **Nitrogen accumulation**. Return of N as plant litter to site of fixation. 1 = minor improvement; 5 = significant
4 **Nitrogen conservation**. Reduce losses of N by providing a carbon source. 1 = minor role; 5 = significant
5 **Improved fertiliser use**. Reduce S and P losses by transfer in dung and urine. 1 = minor role; 5 = significant
6 **Pasture control**. Management tool for maintaining pasture quality. 1 = minor role; 5 = significant
7 **Pest management**. Impact on porina and grass grub populations. + Positive; - Negative effect
8 **Soil fauna**. Increase in earthworm and Enchyt numbers. + Positive; - Negative effect
9 **Soil physical properties**. Impact on soil surface bearing strength, infiltration rates, etc. + Positive; - Negative effects

Time for Fallow

- For systems 1,2,3,and 5 a traditional spring to autumn or summer only (mini-fallow) , although in direr areas an autumn to summer fallow might be more effective

- For system 4, a summer to spring fallow maybe more appropriate

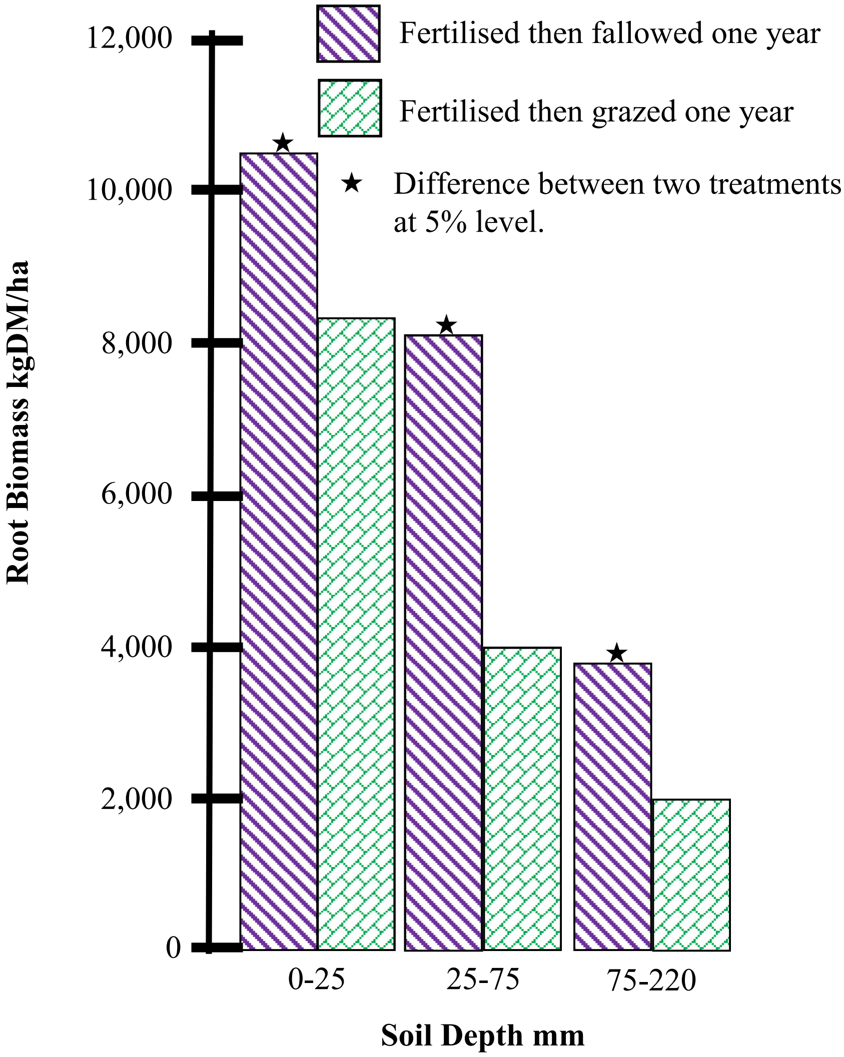
Spring-autumn fallow allows for natural seeding of all species in the sward, especially grass species (Figure 1.). Fallows starting from January onwards checked natural reseeding whereas fallows from December produced a great natural reseeding. If sward grasses are not desirable, fallows from January onwards are best option. For intensive pastoral dairy, a mini fallow from October to February ensures reseeding of dominant grass species. This also coincided with improved regrowth of recovering sward, litter breakdown and decomposition, and survival of seedlings compared to a traditional fallow[2].

Mini fallows from December onwards do not produce as greater biomass because majority of growth occurs in spring months. Nitrogen fertiliser can go some way to address this but only if there is enough soil moisture to ensure growth which may be an issue mid to late summer. Farmer concerns about losing clover when fallowing prove false as fallows starting from December and January onwards increases white clover presence through elongated internodes.

Impact of Fertiliser

Furthermore, while grass tiller densities decline and swards become open and upright, white clover growth was low over winter and yet clover stolons overran and established in bare patches of decomposing litter[2] in late winter/ early spring thereby strengthening clover content. Overall biomass accumulation does not appear to differ between fertilised (North Carolina RPR and elemental sulphur) and non-fertilised plots. Both fertilised and unfertilised fallow plots had 56% higher root biomass to 220mm verses grazed plots and C and N mineralisation rates between treatments were essentially the same[2] (Figure 2).

Figure 2. Root Biomass at Three Soil Depths on Fertilised Grazed and Fertilised Fallowed Plots at the end of Annual Fallow Period. **Adaptation Mackay et al 1991.**



However, biomass of clovers on plots fertilised two years running then fallowed was 1000kgDM/ha above plots fertilised and grazed throughout the trial[2]. An interesting observation was that when clovers are not grazed recycling of N inside the legume reduced N fixation. It was suggested if organic N accumulated in soil during fallow period it would also inhibit N fixation by clovers.

Nitrogen determines pasture decomposition rates, often a reflection of sward leaf maturity but also plant type. Timothy has a greater carbon/nitrogen ratio than clover and therefore takes longer to decompose. When herbage compounds are simple and decomposition is bacterial, nitrate nitrogen is released. When material is high in cellulose, fungi dominate and little nitrogen is released. It's percentage of carbon in any compound that lowers its decomposition rate which is why proteins decompose faster than lignin. Lignin is the greatest contributor to soil carbon and because that favours fungi its very likely contributes to lowering soil pH.

Giving pastures a vacation from livestock for a year stimulates benefits for soils and pasture species alike. Tim and Helen Gow demonstrate how fallowing regenerates soil properties and highlight changing livestock genetics assists in making it viable in a temperate high rainfall climate. The Wilsons didn't take this path but were also experiencing benefits from a low input system. Gains in both instances illustrate how this age old practice regenerates grassland function without needing addictive technologies.

References

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