

PASTURE TRANSITION TO BIOLOGICAL, SUSTAINABLE SOIL PRACTICES



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Certified Soil Food Web Advisor 2011



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ASSIGNMENT

To convert poorest paddock into a self-sustaining rotational grazing pasture for Shetland Ponies. Find solutions for drought period during summer and lack of biological activity (i.e. manures are not breaking down in the field).



Paddock, south facing

BACKGROUND

- 1/5th of an acre
- Has been alpaca and horse pasture for many decades.
- Was seeded in the past with pasture mix but not in the last 5 years.
- Currently being grazed, in rotation, down to grass height of 2”.
- Ponies are allowed one to two hour grazing times when the grass is lush. This is to guard against laminitis as Shetland Ponies thrive on poorer grasses.
- Horses get 1/4lb/day of extruded food, 1/8 cup of probiotics and receive mineral and vitamin supplements (specifically to provide selenium).
- Horses get de-wormed but less than industry standard. (i.e. done at client's discretion)

CURRENT PRACTICES:

FALL	WINTER	SPRING	SUMMER
<ul style="list-style-type: none"> • Light harrowing 	<ul style="list-style-type: none"> • Rest • Heavy rains 	<p>March:</p> <ul style="list-style-type: none"> • Dolomite Lime 125 kgs • 18-18-18 Fertilizer 30 kg <p>May:</p> <ul style="list-style-type: none"> • Significant rains • Grass grows to 12” • Ponies graze down to 2” 	<p>July:</p> <ul style="list-style-type: none"> • Ponies off • Harrow <p>Repeat cycle with ponies if it is dry enough and grass recovers.</p>

SUMMARY

- This 1/5th of an acre paddock is the poorest performing paddock on the acreage. It has been used as a pasture for horses and alpacas for the last few decades and is currently being used for rotational grazing of Shetland Ponies.
- The paddock has prolific moss growth which suggests significant nutrient imbalances especially related to excess inorganic forms of P (phosphorus) and N (nitrogen) through synthetic fertilizer applications. There are several sparse areas, probably a result of soil compaction layers that average 9.5". The lack of visible micro arthropods and worms suggests the soil is so compacted that these natural soil tillth specialists have 'given up' in this paddock.
- Basic recommendations include discontinuing the use of synthetic inputs and adopting the tools of biological agriculture: compost, organic matter, compost tea and addressing soil structure.
- Advanced recommendations include cover cropping, dormant seeding, nematode inoculation and testing for selenium in soil and plants.
- The key points from the lab test are: low mycorrhizal colonization, low beneficial nematode numbers and diversity, presence of root feeding nematodes, low ratio of active to total fungal biomass (fungal activity should be at its highest level in the autumn), low fungi to bacteria ratio for a grass system and plant available nitrogen as cycled by natural processes (i.e. the soil biology) is too low.
- The two key areas to initially address are the need to increase water holding capacity and the need to relieve compaction. Addressing these two areas may alleviate some of the issues outlined above.
- Understanding how selenium behaves in the soil and plants would involve testing of both the soil and the plants before microbes are added to the system and after microbes are added.
- Increasing water holding capacity and relieving compaction will move this grass system towards a self-sustaining system that can better endure the summer drought period. Adopting biological methods over synthetic inputs will cost the client 76% less every growing season.

RECOMMENDATIONS

The following chart displays the recommendations determined by Kathleen Millar based on biologically sustainable methods. The level of recommendations accepted (bronze, silver or gold) will be determined by the budget and time restrictions of the client.

YEAR ONE	BRONZE	SILVER	GOLD	REASON
Cease Harrowing Cease Fertilizer Cease Dolomite Lime	•	•	•	Allow microbe populations to establish (especially fungi).
Chemical Reams Test	•	•	•	Determine plant available nutrients and nutrient ratios.
Compost Tea: Highly fungal 5 gallons in spring 1-3 gallons every 10 to 30 days	•	•	•	Progress fungal: bacterial ratio towards fungal.
Compost: Biologically active 1/5 th ton			•	Long lasting microbial inoculums and microbe food.
Spring cover crop with leguminous species. Inoculate seed with mycorrhizal fungi and compost tea.		•	•	Fix nitrogen in soil with leguminous plants. Inoculate with mycorrhizae to establish colony.
Soil Food Web Test in fall	•	•	•	To determine effectiveness of management.
Chemical Reams Test in fall	•	•	•	To determine availability of nutrients and nutrient ratios.
Dormant Seeding: Seed pasture with varieties suitable for Shetland ponies.			•	To cover bare spots in pasture.
Selenium Test: Test plants and soil for selenium.			•	Determine presence of selenium in soil and/or plants.

YEAR TWO	BRONZE	SILVER	GOLD	REASON
Soil Food Web test	•	•	•	To determine biology in system.
Chemical Reams Test	•	•	•	To determine plant available nutrients and nutrient ratios.
Inoculate with beneficial nematodes.	•	•	•	To increase nutrient cycling. This recommendation is contingent upon compaction levels.
Re-test for Selenium in plants and soil.			•	To determine state of selenium in plants and soil.

OBSERVATION

- Samples and pictures taken on sunny, 15 ° C day in October.
- The paddock is in full sun.
- Taken from 10 different sections on the 1/5th of an acre, the range of the compaction layer was from 5"-14".
- Most areas are growing very low to the ground with prolific moss and bare areas.
- A few areas had longer, better established grass patches.
- Various mushrooms were visible.
- Two worms were observed in the whole paddock.
- The pioneer species observed were chickweed, clover, plantain and dandelion.



1Facing North



2Facing East



3Facing South



4Facing South West

LAB TEST RESULTS



Foodweb Analysis Soil

Report prepared for:

None
Kathleen Millar
1195 McLean Rd
Qualicum Beach, British Colum

Report Sent: 11/14/2010
Sample#: 01-110507 | Submission: 01-020846
Unique ID: 110210
Plant: grass

Invoice Number: 6164

impeccablyorganic@gmail.com

Sample Received: 11/2/2010

For interpretation of this report please contact:
Soil Foodweb Oregon
info@oregonfoodweb.com
(541) 752-5066

Consulting fees may apply

Organism Biomass Data	Dry Weight	Active Bacteria (µg/g)	Total Bacteria (µg/g)	Active Fungi (µg/g)	Total Fungi (µg/g)	Hyphal Diameter (µm)	Nematode detail (# per gram or # per mL) Classified by type and identified to genus. (If section is blank, no nematodes identified.)		
Results	0.740	48.2	928	7.90	594	2.85	Bacterial Feeders	1.48	
Comments	In Good Range	Above range	Above range	Above range	Above range		Cephalobus		0.32
Expected Range	Low	1	175	1	175		Cuticularia		0.05
	High	0.85	5	300	5	300	Plectus		0.14
							Rhabditidae		0.97
							Fungal/Root Feeders	0.60	
							Aphelenchoides	Foliar nematode	0.28
							Ditylenchus	Stem & Bulb nematode	0.28
							Filenchus		0.05
Results	11300	62574	624	3.46	4%	0%	Root Feeders	0.46	
Comments	High	High	High	Low	Low	Low	Paratylenchus	Pin nematode	0.42
Expected Range	Low	5000	5000	10	40%	40%	Pratylenchus	Lesion nematode	0.05
	High		100	20	80%	80%			
Organism Biomass Ratios	Total Fungi to Tot.Bacteria	Active to Total Fungi	Active to Total Bacteria	Active Fungi to Act.Bacteria	Plant Available N Supply (lbs/ac)	Actino Bacteria (µg/g)			
Results	0.64	0.01	0.05	0.16	100-150	3.89			
Comments	Low	Low	Low	Low					
Expected Range	Low	0.8	0.15	0.15					
	High	1.5	0.2	0.2					

ANALYSIS of LAB REPORT

Key points from the lab report. The qualifiers of 'low' and 'high' are a reference to the expected ranges displayed on the previous lab results page.

- Mycorrhizal fungi colonization is very low. Endomycorrhizal fungi are essential for healthy pasture systems. These beneficial fungi create a superhighway of strands many miles long in order to retrieve water, phosphorus and other micronutrients for their host plant. Once colonization of roots is established, they assist enormously with improving the water holding capacity of the field and are key to keeping healthy pastures during summer drought. Colonization can be established by inoculating seeds or aerating and applying the spores into the aeration holes.
- Beneficial nematode numbers are very low and diversity of species is low. Desirable nematodes consume bacteria and fungi and release the nutrients held in the bodies of the bacteria and fungi into the soil. This is the natural, normal way that nutrients become available to plants, as opposed to the excess inorganic application approach that has developed in commercial production systems in the last 50 years.
 - Of special note here is that soluble calcium is held primarily on the surfaces of fungi. Only when these fungi are consumed (by nematodes or micro arthropods) will that calcium be released into the soil and be made available to plants. Lack of calcium is one of the key factors selecting for the proliferation of many pioneer species (weeds) in pasture systems. In addition, soil compaction is made worse by a lack of soluble calcium to help build soil structure properly, thus leading to an ever-worsening problem with roots not being able to reach deep into the soil to obtain nutrients.
- There are a significant number of root feeding nematodes detrimental to grass systems. In this sample there are 0.46 root-feeding nematodes per gram, or approximately 500 root-feeding nematodes per cup of soil. (The presence of 1 nematode per gram has been shown to reduce crop production by more than a ton per acre.) The root feeding nematode species benefit from compacted, anaerobic conditions while their beneficial cousins require fully aerated, non-compacted soil to thrive. Relieving compaction in this grass system will allow the beneficial type nematodes to become dominant over the root feeding type.
- The ratio of active to total fungi is low. Fungal activity is needed to build soil structure, alleviate compaction and to hold nutrients in the soil to become available as the plants demand. As with any living organism, fungi need to be present, and then they need food and a place to live. This system needs fungal food added, such as dead leaf material, fish hydrolysate and humic acids. A sufficient population of active fungi will also protect the plants against disease causing organisms.
- The ratio of active to total bacteria is low. As with fungi, bacteria need to be present at proper diversity levels, need to be fed and the beneficials need an aerobic environment. Beneficial bacteria, therefore, need to be added to the system using compost or compost tea. Additionally,

foods to encourage beneficial bacteria need to be added such as compost and fish emulsion.

- The total fungi to total bacteria ratio is skewed towards fungi being too low and is becoming more bacterial. For a productive pasture system - where the nutrients from the soil move into the plants so the animals consuming the plants receive balanced nutrition - the ideal ratio is 0.9 to 1.5 (total fungi to total bacteria). A pasture ecosystem with the ideal ratio will be naturally disease resistant, be capable of retaining nutrients and have the ability to build soil structure. Building soil structure in this pasture system will assist enormously in relieving compaction.
- Plant available nitrogen produced by normal nutrient cycling processes is too low. This number should be around 250lbs/acre. The measurement of nitrogen in this report is based on the prey-predator interaction in the soil between the bacteria and fungi (the prey) and the protozoa, nematodes and micro arthropods (the predators). As the predators eat the prey, the nitrogen stored in the prey is released into the soil in a form that the plants can utilize. Establishing and sustaining the prey-predator interaction is vital in increasing the nitrogen supply to the plants.

GENERAL ANALYSIS

Two key points: 1) Increase Water Holding Capacity 2) Relieve compaction

1) The water holding capacity (WHC) of the system needs to be improved. There is significant rainfall in this area through the winter and spring months from November to May. This is followed by a very dry summer in July and August with almost no rainfall. As a result, it is necessary to establish excellent roots systems in the grass plants so they will have access to deeply stored water in the summer months. Once this system is fully thriving, it is possible to keep the grass from going dormant during the drought months.

How to increase WHC:

- Increase the percentage of organic matter/humus in the system. Use tools such as compost, mulches and compost tea to achieve greater organic matter percentage. The more water a system can hold through the dry period, the healthier the grass root systems will be. As seen below, a system that has a high percentage of humus, 6%, can hold significantly more water than a system with a low percentage. So, when it does rain, there is sufficient water holding capacity in the high humus system to store the water instead of it running off the property.

Borrowed from Gaia College - Organic Turf Maintenance Course

	Water Holding Capacity/acre
1% Humus	~10,000 gallons/acre
6% Humus	~60,000 gallons/acre
1" rain	~28,000 gallons/acre

- Establish colonization of endomycorrhizal fungi. Once established, the networks created by these fungal strands will locate water for the plants and assist enormously through the drought period. Mycorrhizae are inoculated by rolling seed in spores or spraying spores into an established field.

2) The compaction in this system needs to be relieved. Compaction leads to poor root penetration and diminished plant health and allows root-feeding nematodes to proliferate.

How to relieve compaction:

- Build soil structure by establishing biodiversity in the soil and letting the microbes do the aerating. The bacteria make the bricks (micro-aggregates), the fungi build the walls and hallways (macro-aggregates), the nematodes and small insects create the living

rooms and dining rooms (pore structures) and the earthworms build the swimming pools where water is stored (channels that are sealed). When these communities are established the roots have spaces to grow into and the available water increases by 50%. Establishing biodiversity is done with compost, mulch and compost tea.

- Balance the calcium to magnesium ratio. For grass systems, the ideal ratio is 7:1 that is, 7 parts calcium to 1 part magnesium. With this understanding, it becomes clear that using Dolomite Lime with a 2:1 ratio is contributing excessive magnesium to the system. Magnesium is used in drilling operations where it helps to "tighten" the soil. It does this by separating and expanding the clay particles, leading to the "tightening" or, in our case, the compaction of the soil. Discontinuing the use of Dolomite Lime will assist in balancing the calcium to magnesium ratio in this grass system.

SELENIUM AVAILABILITY

It is often repeated by horse owners in the mid-Vancouver Island area that there is no selenium in the soil and they must use supplements. Several people were questioned about this for the purpose of this report and none of them had had their soil (or plants) tested. It would, therefore, be valuable to explore this subject more thoroughly and from a scientific standpoint. The biggest question to be answered is whether there is, in fact, selenium in the soil and perhaps it's simply not showing up on tests which only detect a portion of the selenium actually present in the soil.

Mineral weathering of selenium from bedrock, stones and pebbles is an extremely slow process. Organic acids made by soil bacteria and fungi speed up the process of releasing nutrients (such as selenium) from rocks and in turn, these minerals end up in the bacterial and fungal bodies (biomass). Nutrients in organic forms (i.e. nutrients stored in the bacterial and fungal biomass) do not show up in any typical chemical analysis.^{*} In order to release this biologically held selenium into the soil, the bacteria and fungi need to be consumed by their predators – the protozoans, nematodes, micro arthropods and earthworms, for example. After being processed by these predators, the selenium is released into the soil in plant available forms.

This leads to another interesting situation. If there IS a good prey-predator cycle occurring in the soil, selenium may be getting released into the soil and being almost completely taken up by the plant. In other words, selenium may be low in the soil but be at good levels in the plants. So again, this would show up as low selenium on a soil test. In order to understand what the plant is taking up, a plant tissue assessment is needed. If the nutrient is low in the plant, then most likely the nutrient cycling of the soil organisms is all that needs to be improved – and that very situation is what is being addressed in the recommendations.

In conclusion, it is necessary to do several tests to determine what is occurring on this particular property. The tests would be to determine selenium levels in the plants, soluble selenium in the soil and total selenium in the soil.

Special thanks to Dr. Elaine Ingham for her assistance and recommendations on this subject.

* Most soil chemistry tests only give information about soluble nutrients, and do not include the nutrient held in organic forms, in the biology, or in rocks. Exchangeable nutrients (base saturation tests, for example) include nutrients held on surfaces of mineral materials as well as the soluble nutrients, but again, do not include nutrient held in organisms, in organic matter, or in the rocks. Total nutrient analysis gives the information about all these forms of the nutrient, but this assessment is rarely, if ever, done for a typical soils analysis.

CONCLUSION

The key factors to consider while moving this system towards sustainability are the water holding capacity and the levels of compaction. When water holding capacity is increased and compaction relieved, the system will be self sustaining and may possibly refrain from going dormant during the drought season. In order for this to occur, practices such as harrowing and inputting synthetic chemicals need to be reduced and ultimately cease and practices that encourage microbe population and growth (compost, organic matter and compost tea) need to be adopted.

Financial considerations are also important as adopting the biological approach by using tools such as compost tea would generate a savings of 76% for this particular paddock. See below for comparison:

	DOLOMITE LIME	18-18-18 FERTILIZER	COMPOST TEA
RATE/1/5 th acre/YEAR	125 kg = 5 bags	30 kg = 1.5 bags	~ 40 gallons
PRICE/UNIT	\$12/25kg	\$25/20kg	.60 cents/gallon
PRICE/YEAR	\$60.00	\$38.00	\$24.00

$\$60 + \$38 = \$98$ TOTAL COST OF SYNTHETIC PRODUCTS

$\$24/\$98 = 0.24 = 24\%$

$100\% - 24\% = 76\%$ SAVINGS

Of special note is the aspect of selenium availability. If it can be determined that selenium is in fact in the soil but needs to be made available to the plants through the action of microbes, this will be noteworthy to many horse owners in the area.

REFERENCES

1. Hermary H, 2007. **Working With Nature: Shifting Paradigms: The Science and Practice of Organic Horticulture**, Gaia College. <http://www.gaiacollege.ca/>
2. **The SFI Approach**, Soil Food Web. http://www.soilfoodweb.com/sfi_approach1.html
3. Ingham E, 2003. **Introduction to the Soil Food Web, Disc 2**, Soil Food Web Incorporated.

