The Supplemented Fodder Treatment with a fodder supplement guide and applications.

Fodder supplements such as beneficial microorganisms, biochar, humates, molasses, rock dusts, seaweed, etc., as well as seeds, can be fed to livestock, usually mixed with fodder. These can improve livestock health, increase plant growth, promote soil life and improve soil structure and fertility. The livestock do the work of dispersing the supplements and seeds in their manure. Dung beetles, earthworms, microbes and in some places, termites, will further disperse and incorporate the supplemented manure deep into the soil. Tunnels formed by dung beetles and earthworms, along with the supplemented manure, will improve nutrient availability and soil structure, including air and water infiltration, and facilitate deeper and wider root growth, resulting in greater plant growth and flourishing soil life. Livestock can treat/seed areas such as pastures, crop fields, orchards and degraded land. This can improve soils and establish or enhance vegetation. The combined effects lead to greater ecosystem health and economic prosperity.

The Supplemented Fodder Treatment will work best with Holistic Planned Grazing, where livestock are concentrated into small areas to treat a specific area, and frequently rotated, rather than set stocking. Treatments are repeated for ongoing improvements. Ongoing monitoring and adjustments are likely to be needed.

It is a general principle that the best thing that can be done to improve most soils is to add organic matter (material which contains carbon). Organic matter generally improves fertility and soil structure, which improves air and water relations, and root penetrability. Organic matter in soils comes mostly from plants through root exudates, soil life such as mycorrhizal fungi, plus decomposition of plant and animal materials. This all comes from carbon dioxide in the atmosphere. Fast-growing plants, (high biomass plants), plus a diversity of plant species, fix more carbon, so that more carbon is added to soils, which improves soils, which enhances plant growth, which adds more carbon to soils, and so on, in a synergistic process.

While the Supplemented Fodder Treatment is about working smart rather than hard, by making the most of the natural activities of livestock and soil life, it still requires an investment in time, money and work. Even though this is the case, combining the SFT with HPG should produce synergistic and ongoing benefits that greatly outweigh the costs, in a relatively short period of time.

Some of the suggestions presented here are speculative and need more research, however, since I first published this idea on my reforestation.me website in November 2010, there is now much more research and on-farm practice which have proven many of these ideas to be effective. It is wise to do your own research, and simply typing in a query such as “can you add clay to livestock fodder”, for example, should return an AI summary, which is usually good. For more in-depth research, search for Google Scholar, and type in key words, to be directed to scientific research papers. Even so, research is limited, especially on the interactions between a combination of supplements, so it is recommended to use small quantities at first and only increase quantities of supplements if the results appear to be beneficial.

Dispersing supplements and seeds using animals

Large numbers of active animals bunched together will break up soil crusts with their hooves (which improves seed germination and water/air penetration), and deposit and distribute supplemented manure. Dung beetles then make tunnels, burying supplemented manure down to 30 or even 100 centimetres deep. Their outward circle of influence may be about 90cm in diameter, therefore manure piles that are an average of about 1 metre apart or less, should give a reasonable distribution. Their tunnels are likely to last more than 10 years and form channels for root growth, and water and air infiltration. They also increase the permeability of subsoils, encouraging deeper biological activity and root growth. Their activity mixes soils, by bringing subsoil to the surface and burying topsoil. Manure, which is quickly buried, will experience very little in the way of losses due to volatilisation, leaching, or surface run-off of nutrients into rivers and lakes.

Dr. Bernard Doube concludes that "dung beetles, plus deep-rooted perennials, plus managed sporadic heavy grazing is good for farm profitability and good for storing carbon deep in the soil profile". He also estimates that introducing dung beetles results in 20-40% more roots and at least a 20% increase in dry matter production in almost any soil, with an equivalent increase in stock carrying capacity.

Earthworms also make tunnels and spread the supplemented manure, as well as making nutrients more available to the growing seedlings (through the action of grinding and bacteria in their digestive tract, earthworms produce casts in which nutrients are more available for plant uptake and growth). Earthworm activity also improves soil structure and relieves soil compaction. In some parts of the world, manure is also mixed into the soil by termites.

Following the Supplemented Fodder Treatment, which may include seeds, livestock will need to be excluded for as long as it takes for the plants to establish or to recuperate, and possibly long enough to produce seed for the next generation. Rabbits or other pests, and fire, may need to be controlled.

The first rule when feeding soil improvers and seeds to livestock would be to "do no harm" (to the animals, or the environment) and preferably be healthy, or at least neutral, for the livestock. Some of the materials suggested have not received much scientific research, and some dosages suggested are speculative, so local advice should be sought from veterinarians, animal nutritionists and soil scientists.

A soil test may help to discover which nutrients are deficient and therefore to decide which supplements to use, for the soil, but also considering what is good for the livestock, and in what quantities/proportions. Small additions of a severely deficient nutrient can produce a disproportionately good result, but this may not always be necessary as an increase in soil life will make existing soil nutrients more available for plant growth. A foliar spray of a deficient nutrient or nutrients is quicker and provides more even coverage than manure deposition, and so is a good starting option. Advice should be sought from local soil experts.

To entice livestock to eat supplements/seeds, it may be necessary to add molasses or some other syrup, or sea salt, diluted with warm water and mixed into fodder. Other possibilities include various malts, yeasts and apple cider vinegar.

Nutrient-rich fodder.

A fodder production area or fodder bank could be established to grow palatable and nutrient-rich fodder (a cut-and-carry system). A fodder bank could be set up with drip irrigation and high levels of fertilization, with all the major nutrients and trace elements, with particular attention to nutrients which may be locally deficient. Nutrients could come from organic or inorganic sources, depending on cost, availability, or personal preference. When this nutrient-rich fodder is fed to livestock, it should be beneficial for the livestock, plus the benefits should flow on to the soil life and the plants. Fodder plants would be selected based on the local climate and soil type.

Feeding supplemented fodder to livestock may need to be supervised by the farmer to ensure the feed is evenly distributed between individual animals.

Another possibility for palatable fodder is using sprouted seeds of barley grass or maize, germinated in trays, also known as hydroponic fodder. Trays could have supplements added to them, such as biochar, and perhaps rock powders such as basalt, and humates, with seeds germinated on top.

Nitrogen-fixing Azolla is another option, being high in protein and nutritious. Azolla can be grown with manure and synthetic fertilizers such as single superphosphate and potassium. Nitrogen fertilization is probably unnecessary.

Manure.

Manure production should be about 80% of feed consumed, with most manure passed through from perhaps 24 to 48 hours later, but up to 96 hours. Deposition is likely to be 5 to 12 times per 24 hours per animal. The quantity of manure produced could be as high as two tonnes dry matter per year for a stabled or yarded, 500 kg horse, but is more likely to be 1 tonne DM or less, per year, for cattle in less ideal conditions. Adult goats with supplementary feed in Nigeria produce 138 kg dry manure per year.

Supplements

As a broad recommendation, in most situations, feeding nutrient-rich fodder, plus biochar and humates to livestock will be beneficial. Beneficial microorganisms and seeds are also worth trying in most situations, but with less predictable results, and may need repeated treatments to be successful.

Azolla. Azolla is a floating water fern which fixes nitrogen and is high in protein and nutrients. Azolla is a fodder which is palatable to livestock including most mammals, plus poultry and fish. It grows best with partial shade and in warmer climates or warmer times of the year. It can be grown in ponds, dams, or large containers. It has been used to add nitrogen in wet rice culture for centuries and is gaining popularity as a livestock fodder in East Africa and Southeast Asia. Azolla fed to livestock may also reduce livestock emissions of greenhouse gases. Azolla may be useful as an easily digestible protein source at times of the year when pasture is mostly dry roughage. Azolla can be made into silage, or dried and stored.

Beneficial microorganisms. These include nitrogen-fixing bacteria, mycorrhizal fungi, and others. Mycorrhizal fungi grow in a symbiotic relationship with plants, nourished by carbohydrates exuded from plant roots. Their spreading hyphae represent a major proportion of the carbon in soils, improving soil structure by forming a crumbly structure, and ultimately forming humus.

Mycorrhizal fungi increase the surface area of contact between roots and soil and change the root architecture, thus improving nutrient (especially phosphorus) and water uptake, resulting in improved growth and drought tolerance. Plants may grow 10-20% faster, or even more.

Mammals and birds appear to be effective dispersal agents of mycorrhizal fungi. Research in Australia found spores in 57% of dung samples from 12 out of 17 small mammal species. Inoculation experiments showed that spores that passed through the animals successfully colonised the roots of host-plant seedlings. Larger animals such as swamp wallabies are known to eat and spread the spores of mycorrhizal fungi, and dingoes eating animals which have eaten fungi, spread the spores for kilometres, up to ten kilometres, in their droppings.

Nitrogen-fixing bacteria are another beneficial microorganism. It is a common practice to coat seeds of legumes with nitrogen-fixing bacteria, with major economic benefits. Seeds and spores can also potentially be spread by livestock.

The spores of beneficial microorganisms could be mixed into fodder along with appropriate seeds (and possibly deficient trace elements, biochar, humates and diluted molasses) and fed to animals to disperse them. A mix of diluted molasses, spores and biochar could be stirred vigorously in a container before directly feeding to livestock, or added to fodder.

Theoretically, spores may find refuge deep in the micropores in biochar, (and perhaps humates or clay), and so have an increased survival rate passing through the gut of an animal, and then survive better in manure piles, and ultimately inoculate soils. If seeds are added, then the roots of germinating seedlings will provide a host for the microorganisms.

Earthworms are also known to disperse microorganisms as well as increasing the availability of nutrients in the soil.

Another possibility would be to feed spores of probiotics to stock. This may improve digestion and growth rates as well as be beneficial in soils (e.g. *Lactobacillus subtilis* and brewer’s yeast), providing a dual benefit for a single cost.

To inoculate soils with beneficial microorganisms may require repeated treatments and may be best applied when soils are moist and plants are actively growing. If there is no existing vegetation, seeds need to be fed to livestock, to provide a host. A product with a very wide range of beneficial microorganism species should be selected, since it is largely unknown which species will be successful. A manufactured product may not contain species or strains that are suited to the climate or area. Existing microorganisms in the soils may outcompete those which are introduced. Where products are not available, are too expensive, or seem to be ineffective, feeding a small amount of soil (from a nearby and undisturbed site in nature) with roots that have nitrogen-fixing nodules to livestock may supply both nitrogen-fixing bacteria and locally adapted mycorrhizal fungi. Establishing a dense multi-species cover crop should cause existing beneficial microorganisms to flourish. By contrast, bare soil is likely to reduce the population and activity of beneficial microorganisms.

Biochar. Charcoal or biochar in soil is resistant to decay and can be considered a long-lasting form of organic matter, sequestering carbon for probably thousands of years, as proven by Terra Preta in the Amazon.

The porous surface area of biochar may promote the growth of beneficial soil life and hold water and nutrients. Biochar (and bone char) could be produced in fuel-efficient cooking stoves, particularly in developing countries, as part of a cost-effective, synergistic system.

Activated charcoal is used for the treatment of humans and livestock in cases of poisoning, and for people, 60-100 grams is administered orally. A suitable dose might be around 2-8 g per kg of bodyweight, for livestock, or allow free access. Activated charcoal is not absorbed, so overdose is not a problem. All of the biochar will pass through animals to the soil.

Biochar has been shown in some research to reduce livestock methane production.

For compacted, infertile soils, using farm machinery initially to incorporate bulk quantities of industrially produced biochar and other soil improvers may well be a worthwhile investment, to kick start the system. By comparison, the SFT has the advantage of being much more energy-efficient but involves incorporating smaller quantities over more time.

Bone char or burnt bone

Bone char is reported to have a high available phosphorus content compared with unburnt bone, as well as calcium and magnesium, and unburnt bone may not decompose and release its phosphorus for hundreds of years. Bones from mammals, fish, poultry, etc., could be burnt and crushed into powder and fed to livestock. It would be sterile and disease-free (because of the high temperature), although it is illegal to feed bone to livestock that will be eaten by humans in some countries (it can spread anthrax, botulism, and mad cow disease). A suitable dose might be 1g per kg of bodyweight of the animal. Seek veterinary advice. It may be better and less risky to feed bone char to earthworms (which should further increase phosphorus availability) and use the vermicompost to grow nutrient-rich fodder, or just add the bone char to the soil in which fodder plants are grown. This should circumvent any potential disease problems.

Brown Coal/humates. Humates can be thought of as prehistoric organic matter, examples being powdered brown coal, with various names such as lignite, leonardite, etc. Farmers in Victoria, Australia, have spread brown coal dust on their pastures, with reports of an increase in earthworms and dung beetles, and an improvement in the health of dairy cattle. Humates fed to stock (at around 1-3g/kg, but more could be safe) would provide a quick additional input of organic matter to soils, which should quickly form humus, and improve water holding capacity and cation exchange capacity. Researchers in North Dakota showed that humic acid improved sodic soils and that humic extracts from lignite increased the population of nitrogen-fixing bacteria. Combining nutrient-rich fodder, humates, nitrogen-fixing plant seeds, and the relevant nitrogen-fixing inoculant, should therefore work well.

Clay.

Clay is a tried-and-tested positive addition to animal diets. Bentonite clay fed to cattle improves feed intake, conversion, and absorption by 10 – 20%, resulting in superior growth rates. It could be that non-stop feeding of clay to animals may hinder absorption of some nutrients, so it would be best to use it intermittently. The same may apply to charcoal and biochar. Clay is commonly eaten by many animals to deal with plant toxins, or for minerals which may be present, from macaws in South America, to elephants in Africa. Clay is particularly helpful added to sandy soils, because it increases water holding capacity and cation exchange capacity. It may be safe to allow animals free access, as they will probably self-regulate intake. An enticement to eat clay such as molasses mixed in may be needed.

Medicinal plants and supplements. There is a great deal of anecdotal evidence for the medicinal properties of various plants, but this is not always sufficiently backed up by scientific research, to be used with confidence, Garlic and sulphur (sulfur) may be a repellent to ticks, garlic or garlic chives could be helpful for intestinal worms. Dried neem leaves fed to livestock may act against ticks. *Moringa oleifera* leaves may promote overall health. More research is needed.

Rock dusts. These are finely ground/crushed rocks, also referred to as rock powders or rock flours. Limestone, dolomite, calcium phosphate, gypsum, sulphur (sulfur) and rock phosphate, have all been successfully fed to livestock, or applied to soils. Phosphate rock from some sources may contain high levels of fluorine and so be unsuitable as a livestock fodder supplement. Others include powders from basalt, scoria, zeolite, granite, and glacial deposits. Since glacial deposits are likely to consist of a variety of rocks, containing a wide range of minerals, they may often be the best, followed by volcanic basalt powder. In a trial in Queensland, Australia, volcanic basalt dust increased soil pH in acidic soils, cation exchange capacity, available P, and exchangeable Ca, Mg, and K (in a leached tropical soil). Some of the most fertile soils in the world are derived from volcanic rocks. Rock dusts could be fed at perhaps 1-3g per kg bodyweight, and the dose increased if all seems well.

Instead of waiting for natural weathering processes to turn rocks into particles, adding rock dust to soil could be viewed as a way of accelerating the restoration and formation of topsoil. Rock dust should work even better if combined with humates, plus biochar and mycorrhizal fungi and other beneficial soil microbes. and passed through livestock. It therefore becomes possible to “grow” new topsoil, or speed up the process.

Sulphur (sulfur) for alkaline soils, or lime/dolomite/ash for acid soils, could be fed to livestock to adjust pH over time, and trace elements as needed.

Rock dusts could be used to grow nutrient-rich fodder.

Seaweed meal. Water and nutrients flow downhill, and nutrients lost from higher altitudes end up in water bodies, and therefore in water plants such as kelp and other seaweeds. Seaweed usually contains the full range of trace elements.

Feeding seaweed, or freshwater plants such as duck weed or azolla to stock which then deposit manure at higher altitudes, would be an efficient way of recycling nutrients and organic matter from water bodies back up to higher ground.

These plants could be a significant part of an animal's diet. Seaweed can also reduce methane and nitrous oxide emissions.

Seeds. Feeding seeds to livestock can increase species diversity in pasture or forests/grassy woodlands, orchards, etc., or add improved varieties, and is called interseeding or faecal seeding. The effective establishment of nitrogen-fixing *Acacia* and *Prosopis* trees by ungulate manure dispersal has been observed on four continents.

Seedlings may establish better if grazing is down to ground level, especially if weed control is part of the program, and if there is high animal impact on soil crusts (if present). Hoof indentations provide microsites where seeds, detritus and water collect, potentially enhancing seed germination.

While seed germination in manure can be spectacularly successful, direct seeding by any means tends to be a hit-and-miss affair and may require repeated treatments and experimenting with many species. On level pastures, direct drilling is likely to be more successful and provide a more even distribution than SFT. On undulating or rocky ground, where farm machinery cannot be used, SFT provides another option.

Dispersing seeds by means of animals is likely to work best with large numbers of small seeds, perhaps particularly seeds of nitrogen-fixing legumes, through large animals. Seed survival after passage through the digestive system may be as little as ten percent, in smaller animals such as goats. Legume seeds commonly have a hard seed coat which may require hot water or acid pre-treatment. There may or may not be improved germination, but seedlings should grow well in a pile of supplemented manure, which includes appropriate beneficial microorganisms and nutrients. Seeds could be up to perhaps 50% of the feed, by volume, with molasses. The seeds of some plants could be fed as whole fruit or pods.

Synthetic chemical fertilizers. Most fertilizers, such as granular NPK, are not suited to feeding to livestock. Instead, these could be used to fertilize fodder plants, which take up the nutrients, to create nutrient-rich fodder, and then fed to livestock (for the benefit of the livestock, the soil, and the plants).

Urea is commonly used, and mono and diammonium phosphate provide both nitrogen and phosphorus to stock, and then to soils.

It may be beneficial for the establishment of legumes if very small quantities of molybdenum, cobalt, iron, calcium and superphosphate are added along with *Rhizobium* inoculants, but these may be more safely provided through nutrient-rich fodder

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Dosage for tried-and-tested fertilizers could be .1-1g per kg of bodyweight. Seek local advice.

Wood Ash. Ash is usually high in potassium and calcium. Ash should normally be helpful to make acid soils more alkaline, especially if lime or dolomite is not available or expensive, which may be the case in developing countries. In Brazil, adding 5 tonnes per hectare of ash from burnt bark (4.7% Ca and 1.4% Mg) to a 6-year-old *Eucalyptus grandis* plantation growing in a sandy soil, increased stem volume from 38 to 86 cubic metres! Elephants, chimpanzees and domestic stock have all been observed eating ash. A suitable dose for animals might be 1-3g per kg of bodyweight.

Applications for the Supplemented Fodder Treatment.

Some possible applications for the SFT.

Carbon sequestration. Adding beneficial microorganisms will increase soil carbon through root exudates, the soil life itself, as well as increased plant growth and animal growth. Humates should quickly become humus, lasting for years or decades. Biochar sequesters carbon in the soil for potentially thousands of years. Trees could be established and also grow faster due to using the SFT, and waste materials such as bark and thin branches could be made into biochar and fed to livestock, in a synergistic cycle. Also, bamboo and agricultural wastes such as rice hulls, can be made into biochar and cycled back to the soil via livestock.

Contours. Sloping Land Agricultural Technology (SALT) was invented in the Philippines and involves planting nitrogen-fixing plants horizontally on the contour on sloping land**.** This intercepts water and nutrients, and recharges ground water. The SFT could achieve this using portable electric fencing in strips on the contour and should be especially effective with dung beetles making tunnels to aid the infiltration of runoff water. In arid and semi-arid regions, swales and demi-lunes could intercept, store, and infiltrate even more water. The additional stored water provides an opportunity to grow trees where they might not otherwise be able to grow. They can be established on the above and below edges of the swale.

Cover crops. Cover crops can quickly increase carbon in the soil. Cover crops are also known as improved fallows. Cover crops may be just one species but are usually a mixture of different plant types from various families, with different root systems, and different above ground structure to fully intercept sunlight and thereby maximise the production of root exudates. Some farmers use as many as twenty-five species or even more, often including plants in the Asteraceae, the Brassicaceae, the Fabaceae, the Poaceae, and the Chenopodiaceae, etc. Local advice should be sought to select species and combinations suited to the site, which are not invasive weeds, and to fit in with the goals of the farmer.

Cover crops are normally successfully established by initially applying herbicide or cultivation, to limit the growth of existing pasture or other vegetation, and then direct drilled. This usually results in even and dense coverage. The SFT could still play a role, where, instead of herbicide or cultivation, plants can be grazed down to reduce competitiveness, before seeding. The livestock could be fed with nutrient-rich fodder, biochar and beneficial microorganisms, to facilitate the establishment of the cover crop. Direct drilling may not be required if the manure covers 50% or more of the ground. The SFT could be applied again at the end of the cover crop/mixed improved fallow, with appropriate supplements.

Developing countries. In developing countries, many products may not be available or may not be affordable. Charcoal (as the next best alternative to industrially produced and standardised biochar) and ash from wood fires used for cooking and heating are likely to be freely available, as well as clay, and could be fed to livestock.

Nutrient-rich fodder could be grown by farmers using ash and charcoal (and clay in sandy soils), plus bone char, and human urine and animal manure. On sloping land, fodder could be grown in Zai holes, Tumbukiza, or demi-lunes (half-moons). In arid regions, the best option is likely to be Zai pits within demi-lunes.

In warmer climates, Super Napier grass, Gamba grass, Guinea grass, *Tithonia diversifolia*, *Moringa oleifera* and *Leucaena leucocephala* would be good choices for fodder plants. In cooler climates, possibilities include hybrid poplars, Phalaris, tall fescue and Bokhara clover. Plants should be selected which are not invasive weeds in the area. This fodder could be used in the SFT, to improve soils in cropping fields and pastures.

In developing countries, subsistence farmers typically grow small fields of grains such as maize, sorghum or millet, rotated occasionally with mixed improved fallows. The SFT may be useful before a crop, or after, or both. The SFT with seeds could establish mixed improved fallows, but distribution of seedlings will be patchy, unless manure coverage is around 30% or more. Another approach would be the SFT, and then immediate sowing afterwards of *Mucuna pruriens*, for example, as a high biomass nitrogen-fixing green manure crop.

Supplemented manure, produced in cut-and-carry stall-fed livestock systems, could be a valuable product to sell to grain or other crop farmers.

Emissions reduction. The emissions of gases such as methane and nitrous oxide can be reduced by feeding seaweed to livestock, and research has also shown that biochar can reduce methane in many cases. Azolla has also been shown to reduce emissions. Combining two or more of these may be even more effective. More scientific research is needed to assess the possible increased effectiveness of combinations.

Eroded gullies. The application of the SFT can help with solving the problem of eroded gullies and other degraded areas. In this case, the topsoil has been eroded leaving bare subsoil, so there is a need to recreate topsoil and establish vegetation. A combination of rock dusts, such as basalt, plus biochar and humates, along with beneficial microorganisms would be appropriate. Seeds could include broadleaf spreading ground covers, and grasses which spread by stolons or rhizomes, along with shrubs and trees. Dung beetles will be important to create tunnels into what is commonly compacted subsoil. Water retention dams may be helpful. The edges of gullies could also be treated, to reduce runoff into gullies, which causes erosion.

Forestry and agroforestry. Once trees are established, the SFT could improve soils and therefore the growth rates of trees. A multi-species cover crop, followed by heavy grazing and the SFT, before planting trees would be beneficial in most cases.

Fire. Where natural forest or grassland meets farmland or suburbia, herds of goats can browse and graze highly flammable trees, shrubs and grasses, reducing the fuel load and therefore the intensity of fires. Seeds of plants which are less flammable could be fed to goats, to attempt to change the vegetation to less flammable vegetation, but large numbers of seeds would be needed because most would be destroyed before being deposited in manure.

High ground. Nutrients and water flow downhill, so establishing healthy vegetation and increasing soil fertility on high ground is important. The tunnels of dung beetles would also help with recharging water tables, rehydrating lower slopes. Raising the level of nutrients and organic matter in the soil should be a priority, so nutrient-rich fodder, rock dusts, biochar, humates, and beneficial microorganisms could be fed to livestock. Seeds of trees could be included, because cloud stripping by trees on the tops of mountains can increase precipitation. Even at lower elevations, water can condense on trees on cold nights and drip onto the ground, in some places.

Infertile sandy soils. Feeding fodder, which is purpose grown to be nutrient rich, especially in deficient nutrients, could go a long way to improving infertile sandy soils for agricultural or forestry purposes. Clay would increase water holding capacity and cation exchange capacity. Humates, biochar and beneficial microorganisms would improve water holding capacity, nutrient uptake and store carbon.

Orchards. Nutrient-rich fodder, with appropriate supplements, can improve soils and thereby increase productivity and profitability, and may also increase the nutrient value of fruit and nuts. The SFT plus seeds could increase ground cover biodiversity, with, for example, nitrogen-fixing plants, and plants which attract beneficial insects.

Semi-arid and arid regions. Swales, dams, and demi-lunes are probably the most effective techniques in arid regions (see the work of Peter Andrews). It would be advantageous to apply the SFT in a strip on the mid slope contour, to intercept and infiltrate water, and then more strips above and below the mid slope could be established later. Rodger Savory recommends bunching cattle together for long enough to completely cover the ground in manure. He calls this a biological carpet, and the idea is that this supplies a wet and dark environment for seeds to grow. The challenge would be to bring in enough hay or other fodder from offsite to produce enough manure, since there is unlikely to be enough feed on location. The SFT could add biochar, humates, beneficial microbes, and seeds to accelerate restoration, and the seeds of ground covering broad leaf plants and grasses which spread by rhizomes or stolons (e.g. *Cynodon* spp.), as well as succulents, should be prioritised. Regarding trees, seeds of indigenous plants in the genera of *Acacia*, *Prosopis* and *Faidherbia albida* would be good choices.

Saline and sodic soils. Gypsum could be fed to livestock. Gypsum is calcium sulphate, and the calcium ions may displace sodium ions, which may then leach to deeper soil levels. Biochar and humates may help, with seeds of salinity tolerant plants such as Atriplex spp. saltwater couch, Bokhara clover and tall wheat grass, or these could be sown or planted later. Seek local advice on plant species. Spreading groundcover plants and mulch such as hay would reduce evaporation, which brings salt to the surface through capillary action.

Water courses. Vegetation growing along water courses reduces the runoff of nutrients into the water and reduces flash flooding along with erosion. The SFT plus seeds can be applied, but dung beetles and perhaps earthworms would be important to incorporate manure quickly, so that manure is not washed into water courses causing algal blooms. See the work of Peter Andrews for more possibilities.

Windbreaks. Trees and shrubs with small seeds, or hard-seeded legumes can be established with the SFT. This would probably work best using cattle, confined with portable electric fencing. In wet tropical regions, *Leucaena leucocephala* and *Calliandra* spp. would be obvious choices. Many Acacia species could be suitable, in a variety of climates. The fine seeds of *Eucalyptus* and other Myrtaceae could be successful. Establishment of trees by this method is unpredictable, so it would be wise to hedge your bets, and plant a diversity of tree and shrub species in the spaces between manure deposits. Browsing animals may need to be controlled, as well as competitive weed growth.

The Supplemented Fodder Treatment – a synergistic and holistic system

The Supplemented Fodder Treatment provides a cost-effective method for ecological restoration or even enhancement. With repeated treatments, the Supplemented Fodder Treatment, plus seeds, grafted into Holistic Planned Grazing, should result in increased livestock health and gains, and increased plant growth and improved soils, all of which combine to improve economic prosperity.

With the tunnelling and dispersal of supplemented manure by dung beetles, and the action of earthworms making nutrients more available, and the introduction of beneficial soil life, treated soils should have greatly increased carbon storage, increased fertility, reduced nutrient losses from volatilisation and leaching, increased cation exchange capacity, improved structure with better water infiltration and water holding capacity, improved aeration and drainage, reduced bulk density with easier root penetrability, more soil life and activity, faster nutrient cycling, and reduced erosion problems.

The holistic nature of the SFT increases animal, plant, and economic growth, producing outstanding results for minimal costs, in a relatively simple and low-tech system which is accessible to farmers and land managers in both developed and developing countries.

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