

Benefits of Biodiverse Forage

by Jerry Brunetti

The resurrection of interest amongst graziers in medicinal plants seems to parallel the burgeoning movement of livestock operators in organic (and ecological) meat, milk and egg production, rotational managed grazing, and the stockman's increasing interest in reducing dependence on pharmaceutical drugs — due to their costs, side effects and concerns over residues in meat, milk and egg products. There are numerous books available on the medicinal properties of various plants, many of which are considered weeds in pastures and meadows on farms.

Sadly, the trend in crop management, even on organic farms, is oriented toward high-yielding, domesticated grasses and legumes. This is due to the ability of these forages to efficiently and economically contribute to yields of milk and/or gain of bodyweight.

Evidence points to the profitability of managing warm and cool season cultivars in one's meadow or paddock, but it is very important to recognize that indigenous herbs, many of which are deep-rooted perennials, provide a number of other attributes, including medicinal properties, nutrient density (*i.e.* forage quality), drought resistance, palatability, perennial persistence, soil conditioning characteristics, and abilities to accumulate minerals — they are also valuable indicators of soil conditions. Many agricultural authors have made strong cases for incorporating various herbs and other plants in paddock seed mixtures and hedgerows.

Newman Turner, who in *Fertility Farming* discusses the importance of subsoiling every seven or eight years, goes on to state, “once deep-rooted herbal leys have been all round the farm, and are continued in the rotation, even subsoiling should not be necessary. There is no better means of aerating the subsoil than by roots of herbs like chicory, burnet, lucerne, and dandelion, all of which pen-



trate to a depth of 3 or 4 feet and more in as many years.” He continues, “I have seen my Jersey cattle going around patches of nettles, or docks, eating off the flowering tops and relishing something that they have been unable to obtain from the simple shallow-rooting ley mixture. So the thing we must do is to get back into our dairy pastures as many herbs as possible to assist the health of the cattle grazing the leys and to benefit the topsoil in a way any amount of chemical dressing can never do. All my leys contain a high proportion of these weeds deliberately sown — burnet, chicory, plantain, wild vetch, sheep's parsley, dandelion, sweet clover, chickweed — and when the leys have been down four years and developed roots to a depth of several feet they are then most relished by cattle. The cattle did anything to get from the younger shallower-rooting leys, when I still had some, to those herbal leys that had penetrated the valuable untapped resources of the deeper subsoil.” He adds that “bloat has become a thing of the past since such leys were used, whereas before I lost cattle every year when I practiced the method of sowing leys with three or four ingredients only.”

Turner's recipe for seeding a paddock after the harvesting of oats appears on page 8. He stresses that adequate organic matter and calcium are prerequisites in

order for this mixture to become adequately established and emphasizes that “a mixture containing deep-rooting herbs is essential to soil, crop and animal health, assisting in the aeration of the topsoil of important minerals and trace elements.”

Turner adds, “Hedgerows should contain comfrey, garlic, raspberry, hazelnut, docks and cleavers, etc.”

He was amazed that soil samples taken from fields that hadn't received lime for 10 years indicated no need for supplemental lime. “It is now evident that organic methods, which include subsoiling and deep-rooting herbs over a period of years, maintain a correct soil balance even on farms which are sending away large quantities of milk.” He adds, “subsoiling will be unnecessary once deep-rooting herbs have been included in a ley on each field.”

In his subsequent book, *Fertility Pastures*, Turner reports on a test to determine which forages were most and least preferred by his Jersey cattle. In 1952, Turner planted 35 individual plots, each sown with a single ingredient of the herbal ley, using a half-pound of seed of each of the herbs, clovers or grasses. Plots most relished were single stands of sheep's parsley, plantain and chicory (in that order); least preferred were ryegrasses, meadow fescue and hard fescue. Next in preference were burnet, kidney vetch, sainfoin and alsike. Interestingly, lucerne

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Goosegreen Herbal Ley Mixture

<i>pounds/acre</i>	<i>variety</i>
4	Perennial Ryegrass (S.23)
4	Perennial Ryegrass (S.24)
5	Cocksfoot (S.143) lighter soil
5	Cocksfoot (S.26) medium soil
4	Timothy (S.51) heavy soil
4	Timothy (S.48)
1	Rough Stalked Meadow Grass
1	Meadow Fescue
3	Red Clover (Montgomery)
1	White Clover (S.100)
1	Wild White Clover
2	Chicory
4	Burnet
½	Yarrow
2	Sheep's Parsley
1	Alsike
2	American Sweet Clover
1	Kidney Vetch
2	Lucerne
1	Plantain
1	Dandelion
½	Fennel
6	Italian Ryegrass (or bushel of oats if sown direct)

(alfalfa) and American sweet clover went untouched in the presence of other options. The grasses most preferred were short rotation ryegrass and meadow fescue; all other grasses appeared to be desired equally, except hard fescue, which was not grazed at all.

Turner points out a significant issue: "It would be interesting to know whether soil conditions . . . deficiencies and varying availability of the different minerals and trace elements, organic content and moisture, and even breed of cow had any bearing on the choice for the cow. The only way that this information could be provided, and I think it is vital that it should be, would be for my experiment to be repeated on all classes of soil in different parts of the country and with different breeds of cattle."

Looking at yields was another matter, except in the case of chicory, which pro-

duced the heaviest bulk, followed by lucerne and American sweet clover. Research conducted in the late 1890s and early 1900s and reported by Robert Elliot in his classic *The Clifton Park System of Farming* features the remarkable properties of chicory, as well as other unconventional forages. During a severe drought in 1895 in Scotland, Elliot noted that chicory, burnet, kidney vetch and yarrow survived almost completely intact. Apparently, chicory was first introduced and cultivated in England in 1787 by Arthur Young, who brought it from Italy, where it was ubiquitous forage. The English farmers found that chicory was much more prolific than lucerne, producing 11 tons of hay per acre (compared to lucerne at 4.5 tons), with six cuttings yielding 30 green tons in northern Scotland in 1788. Elliot had actually observed the roots of chicory traveling 22 inches in five months and 30 inches in 15 months.

It didn't take Thomas Jefferson long to hear of this remarkable plant that grew in a wide range of soils and provided unrivaled nutrient density for cattle, sheep, horses and hogs. It was the basis of an American political scandal, as Jefferson was attempting to import chicory into America when British-American relations were strained. Based upon bulk yield as the sole criteria, Newman Turner proposes a mixture, in order of preference (without suggesting proportions), of the following: chicory, lucerne, New Zealand ryegrass, cocksfoot, timothy, meadow fescue, perennial ryegrass, late-flowering red clover, S.100 white clover, sheep's parsley, yarrow, tall fescue.

Turner's field and grazing experiments resulted in his various formulas for "herbal ley mixtures," which include:

- Early Grazing Herbal Ley Mixture, which circumvents "forcing" growth with nitrogen fertilizers and their attendant impact of reducing energy and increasing non-protein nitrogen.
- Midsummer Grazing Herbal Ley, to withstand drought damage.
- Herbal Ley Mixture for Autumn & Winter Grazing, chosen from herbs and grasses growing later into autumn and winter.
- Herbal Ley Mixture for Very Thin, Dry Soils, consisting of species predominantly of the deepest-rooting varieties.
- All-Purpose Herbal Ley Mixture, providing maximum grazing yield for most of the year.
- Herbal Hedgerow Mixture, to supplement existing pastures, particularly for goats, and to be sown in or near the hedgerows.

There are also mixtures for light land and heavy land, both direct seed and under-sown with a nurse crop, and pig and poultry leys, with a large emphasis on chicory, plantain and a lesser amount of burnet, sheep's parsley, yarrow and kidney vetch.

Turner credits much of his inspiration of herbal ley mixtures to Robert Elliot's *The Clifton Park System of Farming*. Elliot conducted a trial that lasted four to five years and compared two fields of similar soils but seeded to different mixtures. Field #1 used a simple mixture consisting of cocksfoot, perennial ryegrass, late-flowering red clover, S.100 white clover and one pound per acre of chicory, a total of 25 pounds of seed being sown per acre. Field #2 contained the same legumes and grasses as Field #1, but with the following additions: three pounds per acre of chicory, four pounds burnet, two pounds sheep's parsley, two pounds kidney vetch, one pound yarrow, two pounds lucerne, and two pounds American sweet clover, for a total of 45 pounds of seed per acre.

Both fields achieved equal establishment, yet despite the variation of growth, which was deliberately varied for test purposes, whenever cows were led from Field #1 to Field #2 (the herbal ley) milk yields always increased. This was so even when cattle were removed from Field #1 (with ample grazing available) and moved to

Field #2 where grazing might even been less than adequate.

These results make the case that there is more to nutrition than the usual parameters surrounding protein, energy, total digestible nutrients (TDN), neutral detergent fiber (NDF), acid detergent fiber (ADF) and so on. Perhaps the diversity of such a mixture in a paddock provides critical trace elements or various plant hormones, enzymes, aromatic oils, tannins, amino acids, fatty acids, alkaloids, pigments, vitamins and their co-factors, unidentified rumen flora stimulants, etc. The point is that there is no substitute for diversity; there is no way to quantify all the possible and synergistic interactions among both identifiable and unidentifiable components.

Livestock producers must have faith (and many professionals in animal husbandry do not) that animals are the best judges of their diet (when not in confinement), that such livestock are able to make dietary choices that reflect the fertility of the soil, and that livestock health is a primary, not secondary, consideration with regard to farm profitability. Only then will the attributes of diversity be more closely investigated and researched to determine how it can contribute in so many ways to a stockman's bottom line.

The foremost concerns or questions by stockmen in regards to the grazing of unconventional forages are probably their palatability and toxicity. In cooperation with Utah State University, the Natural Resources Conservation Service, Grazing Lands Technology Institute, and Utah Agricultural Experiment Station, researcher Fred Provenza, Ph.D., has compiled a vast amount of data on this topic, which is available in a publication entitled *Forage Behavior: Managing to Survive in a World of Change*.

Provenza suggests that livestock develop a "nutritional wisdom" as a result of interactions between flavors, nutrients and toxins. Decreases in palatability occur with foods containing excessive levels of either nutrients or toxins, and with foods causing nutrient imbalances and deficits. Animals are able to discriminate between foods based on sensory feedback from nutrients, including protein, energy and mineral levels. Grazing animals typically eat a variety of plants because no single food contains all the necessary nutrients, and all plants contain various amounts of



toxins. Livestock thus "learn" that eating a variety of plants not only helps them obtain their nutrient requirements and regulate their intake of toxins, but also provides compounds that can either neutralize toxins or activate metabolic pathways to eliminate them. This is a healthier model than constraining livestock to a single food, even if that food is nutritionally "balanced."

Since animals prefer familiar foods to novel ones, rotational grazing methods that incorporate low stock densities may have actually detrimentally modified the behavior of generations of livestock to "eat the best and leave the rest," thus accelerating a decline in biodiversity. According to Provenza, heavy stocking for short periods encourages diet mixing. Mothers then "teach" their young — beginning as early as in the womb and later through the mother's milk as well as grazing examples — which plants are suitable and desirable to consume.

Recognizing the fact that rhizospheres of plants are actual eco-systems in and of themselves, it's agronomically critical to take into consideration that a diverse num-

ber of species — perennial deep-rooted herbs, legumes, perennial grasses, annual grasses, biennial legumes and herbs — provide an indescribable substrate upon which a very complex food web can be established. The food web includes multiple species of bacteria, protozoa, fungi, arthropods, earthworms, nematodes, and so on. This diversity in the soil creates the same opportunities for the higher life forms that are dependent upon the "plankton of the earth," whether these ecosystems are grasslands, rain forest, coral reef, bayou or the savannah.

Life begets life continually because predation, digestion and recycling occur effectively when there is this diversity. One example that explodes the monoculture myth is a tale of two plots on the same field on a farm in Ohio. Plot A consisted of only perennial ryegrass seeded to glyphosate-treated soils. The soils were generously fortified with lime, phosphate, potash, boron, gypsum (for sulfur) and of course, nitrogen. Plot B consisted of the same soil fertility program (without nitrogen), but Alice clover, festulolium, red clover and orchard grass were included in the seeding.

The ryegrass-only plot took off running and clearly was in the lead for producing more dry matter per acre. But by mid-summer, and during hot and humid

conditions, the ryegrass-only plot exploded with a devastating outbreak of rust. The diverse plot next to it was completely unscathed. Clearly, the only difference in these two plots was forage diversity, and just as clearly, the results made a strong case for diversity creating plant immunity against disease. Who can specifically determine what mode of action was at work in this protection? How many identifiable, as well as unidentifiable variables, were involved in this phenomenon?

Back to Elliot's observations in *The Clifton Park System* of the late 1800s: "A grass mixture should consist of the seeds of plants, some of which are of deep-rooting and drought-resisting character, so as at once to draw support from the lower strata of the soil . . . when other plants should, besides, be of a kind especially calculated to promote the health of the stock, and also act as a preventive against disease."

THE MIRACLE OF ROOTS

Elliot conducted a remarkable experiment aimed at breaking up hardpan on a "deep, strong soil on a low-lying alluvial flat." He explains: "The following mixture, on the 25th April 1895, was sown with a thin seeding of oats: 5 lb. each of cocksfoot, meadow foxtail, and tall fescue; 7 lb. of meadow fescue; 4 lb. of timothy and 1 lb. each of wood meadow grass and rough-stalked meadow grass; 2 lb. each of white clover, alsike, and perennial red clover, kidney vetch, and lucerne; 3 lb. chicory, 8 lb. burnet, 1 lb. of sheep's parley, and one-half lb. of yarrow. The field of fifteen acres was in 1896, cut for hay, which amounted to 36 tons, 14 cwt., or nearly 2½ tons per acre, and the aftermath grazed with lambs, was an excellent crop. Two trenches were cut in the field to a depth of about three feet, and on 11th September 1896. . . . I carefully inspected the land in order to estimate the depth to which some of the plants had penetrated. The results were particularly interesting as regards chicory, which seemed to have a profound contempt for the very hard pan, which we found at about 14 inches below the surface, and which was about 10 inches to a foot in thickness and was so hard that a powerful man with a sharp spade had to use great force to break it open when we were tracing the descent of the chicory roots, which had passed straight downwards without any deflec-

tions. . . . In passing through the pan, the strong roots of these plants, notably the chicory, had succeeded in disintegrating the apparently impenetrable pan. This pan was composed of very small particles of soil washed down from the soil above. This pan evidently was not formed solely from ploughs and horses, but owed much of its hardness and compactness to the smallness of the washed-down particles, which may be so small as to arrest capillary attraction. Altogether, we estimated that the roots had gone down about 30 inches. The burnet and vetch roots had gone down about 20 inches, and the lucerne from 8 to 10 inches. . . . Altogether we came to the conclusion that the roots of these plants are capable of doing all the work of a subsoiler." All this occurred in only one year!

It's interesting to see that lucerne (alfalfa) only penetrated this soil to a depth of 8 to 10 inches. Elliot pointedly states, "Of all the cultivating agencies, then, roots stand by far at the head, and it is by applying this principle to our arable lands that we shall at once manure, aerate, and cultivate them in the cheapest manner."

Hugh Corley's British classic *Organic Small Farming*, first published in 1957, gives praise to the same deep-rooting champions as his other English compatriots and stockman did. He points out that "it is necessary to sow deep-rooting and tap-rooting plants, so that the greatest possible depth of soil is permeated by their roots. And it is sensible to sow a variety of herbs to ensure the health of the grazing animals, and the palatability of the herbage. These herbs probably benefit the soil, too, toning up the soil organisms and making better humus when ploughed in. Bacteriological work by the Soil Association at Haughley suggests that phosphate-dissolving bacteria thrive best in compost made from a big variety of different wastes. Similarly, the humus made from a mixture of herbs and grasses may well be much more beneficial than that made from one grass and one clover."

THE SOIL CONNECTION

It is my responsibility to alert the reader that this discussion does not address forage quality and pasturing success as it pertains to sound pasture management. This of course includes managed intensive rotational grazing, with adequate rest periods for recovery, etc. Nor does this discussion fully address soil fertility and agronomic practices necessary for optimum forage quality. There are soil fertility parameters that have a direct correlation to the nutrient density of forages, which in turn are necessary for livestock to be productive and healthy. On soils that tend to be imbalanced and/or in poor fertility, species diversity — including deep-rooted herbs — can assist in bringing up fertility from below and hastening the decay process in order to recycle nutrient residues associated with urine, manure and forage, both foliage and roots. This can be especially helpful when the soils in question are natively deficient or depleted from abuse or neglect, and the economics of purchasing fertility from off-farm sources becomes a prohibitive option.

Starting with soil fertility, the model developed by William Albrecht, Ph.D., has a long history of success, utilized on hundreds of thousands of acres with a wide range of crops. Using a method that incorporated what is known as base (cation) saturation, the goal is to provide a saturation of the soil colloid comprising: calcium, 65-75 percent; magnesium, 12-15 percent; potassium, 3-5 percent; sodium, less than 3 percent; phosphate levels (P₂O₅) should be in the range of 250-500 pounds/acre; sulfur, 50-100 pounds/acre; boron, 4-5 pounds/acre; copper, 4-10 pounds/acre; zinc, 10-20 pounds/acre; manganese, 50-80 pounds/acre; and iron, 100-150 pounds/acre. These numbers of course are ranges dependent upon a Mellick III Extraction Method and certainly allow for some flexibility.

This information is provided to note the relevance of forage quality and is hardly meant to be a synopsis on the concerns of productive soils. Most nutritionists used a wide range of lab determinants to gauge quality. My first inclination is to look at the mineral levels to see if I'm "on target," *i.e.*, certain mineral levels and mineral ratios give clues as to the quality of protein, the presence of energy, the ability of that forage to supplement an

animal's needs for immunity and reproduction, and so forth. If the minerals are absent, I am suspicious as to whether this forage can supply the necessary essentials for productivity and health, regardless of the crude protein or relative feed values. Of course, the "proof of the pudding is in the eating," and ultimately livestock will prove the quality of their forage based upon production, reproduction, immunity to disease, healthy offspring, milk and meat quality, including flavor, keeping and cooking characteristics, and so forth. Keep in mind that typical soil and forage analyses often do not test for all the critical trace elements required by livestock, including selenium, chromium, cobalt, iodine, silica, vanadium, etc. This fact makes a strong case for diversity, especially of deep-rooted plants, which lessens the vulnerability inherent in forage that includes only a few species that, although efficient in accumulating certain minerals, would be inefficient in accumulating others.

The table on this page lists the levels of various minerals associated with a productive forage.

MINERAL CONTENT

For domesticated forages, having calcium levels approaching 2 percent provides a superior quality of protein than that of forages with less than 1.5 percent. Additionally, high calcium levels indicate forages rich in energy, synthesized as calcium pectate. Although crude protein levels are preferred in the 20-22 percent range (or 3.3-3.5 percent nitrogen), sulfur levels should be at least 10 percent of the nitrogen. That is because a 10:1 or lower nitrogen-to-sulfur ratio indicates that there is less non-protein nitrogen (NPN), and therefore the protein content has a more complete amino acid profile. Sulfur is also a vital component of the essential amino acid methionine, as well as cysteine, precursors to glutathione, a tripeptide antioxidant that also happens to be a building block of glutathione S-transferase, an important liver detoxifier, and glutathione peroxidase, a critical immune activator. Phosphorous is a necessary element of ATP and ADP, energy molecules associated with the Krebs Cycle. Magnesium is associated with over 300 enzymatic reactions, including energy production in animals.

Targets for Conventional Forage Quality

Nitrogen:	3.50 percent
Calcium:	1.60+ percent
Potassium:	2-3 percent
Magnesium:	0.50 percent
Phosphorous:	0.50 percent
Sulfur:	at least 10% of Nitrogen level
Chloride:	0.40 percent
Iron:	< 200 ppm
Manganese:	35+ ppm
Copper:	15+ ppm
Boron:	40+ ppm
Zinc:	30+ ppm
Aluminum:	<200 ppm

Trace element deficiencies, quite common in today's conventionally grown crops, are associated with soil depletion, soil erosion and hybridization. Volumes have been written on their multiple catalytic properties, so necessary for immunity, reproduction, growth and performance. Zinc, for example, is associated with at least 200 enzyme processes in the body; copper is a component of healthy red blood cells; manganese is absolutely necessary for conception; boron is associated with the parathyroid gland. These comments address just a few of the many elements necessary for optimum health and production, and we've barely begun to list their numerous functions and benefits as they relate to profitable livestock production.

CONCLUSIONS

Incorporating plant biodiversity on a livestock farm increases the diversity of animal-required nutrients, including minerals, vitamins, pigments, enzymes, amino acids, fatty acids, sugars and other carbohydrates, sterols, hormones and the numerous phytochemicals that are able to provide countless medicinal and metabol-

ic properties. Increasing the farm's plant biodiversity provides weatherproofing from heat, drought, frost and excessive moisture. It minimizes the vulnerability that monocultures face through the vagaries of weather, because different plants have different strengths and weaknesses with regard to climatic influences. Complex plant polycultures also create numerous microclimates, which are able to buffer the extremes of temperature and moisture. Shade from trees and hedgerows can offset production losses associated with heat and humidity impacting liveweight gain and milk production. Windbreaks can reduce winter feed requirements by effectively reducing, even eliminating, the "wind-chill" quotient.

An extended food supply can be more readily realized with a biodiverse livestock operation, starting with early growing grasses, legumes and herbs, then later-arriving leaves, and finally berries, fruits and nuts late in the season. Woody plants have the advantage of actually having a year-round growing season, thus proving more efficient than grasses and certainly row crops in producing biomass. Winter browse on terminal buds provides exceptional medicinal components and a high level of nutrient density.

Plant diversity also increases the diversity and number of other wildlife, including songbirds and bats, which consume insect pests affecting plants and animals. These in turn attract raptors, which then prey upon rodents. Pollinators and predatory insects are able to find habitats and in turn help increase yields of crops bearing seeds, fruits and nuts. The soil food web, or soil ecosystem, is enhanced due to a permanent polyculture of plants growing on undisturbed soils. This means more efficient nutrient recycling and healthier root systems for all plants, again contributing to farm productivity. A healthy polyculture also means improved water percolation and purification, translating into cleaner groundwater and surface water, devoid of silt and excessive nutrients, and this situation ultimately benefits the ecosystems of invertebrates and fish in streams and lakes.

Plant diversity with livestock can readily provide the opportunity of two or three income streams for the farm, while also improving the farm's health. Animal products such as livestock, meat, eggs and

dairy products; the use of timber as lumber or fence posts; fruits, nuts and berries to offset purchased feed and/or sold directly to the human marketplace — all offer multiple economic rewards that don't necessitate additional (net) human labor investments. This is especially true when factoring in the reduction or elimination of conventional agricultural practices and/or equipment.

Jerry Brunetti is managing director of Agri-Dynamics, which specializes in products for farm livestock and pets, and consults on a wide variety of other issues. He works with such materials as seaweed, herbs, enzymes, probiotics, vitamins, chelated minerals, rare-earth minerals and more. He can be reached at Agri-Dynamics, P.O. Box 735, Easton,

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Newman Turner's Fertility Pastures and Cover Crops is available from the Acres U.S.A. bookstore for \$20 plus shipping. Hugh Corley's Organic Small Farming is also available, for \$18 plus shipping. To order, call toll-free 1-800-355-5313 or visit <www.acresusa.com>.

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