Optimising nutrient cycles with trees in pasture fields

Photo: Author

Tall trees provide shade which moves over the grasslands through the day. Cattle will follow this shade, thus manure and wear are better spread over the field.

The main weakness in sustainable grassland farming in humid ecosystems is the leaching of soil nutrients below the root zone of most forage species. Nature's solution is a tree-dotted savanna – a system where the deeper roots of trees bring up leached minerals, via leaf and fruit drop. You can re-design pasture farms to copy such natural systems, as this example from the Northeast United States shows.

Karl North

Most off-farm inputs, such as inorganic fertilizers, are dependent on cheap fossil fuel. To the farmers at Northland Sheep Dairy in New York, U.S.A., sustainability means relying more on the farm's own natural resources rather than off-farm inputs. Basic requirements for farming system sustainability are:

- healthy water and mineral cycles, apart from minerals lost in product sales, which we replenish with rock powder inputs;
- good energy capture and use, for example in the shape of soil organic matter; and
- optimum biodiversity.

What is Pulsed Grazing ?

Pulsed Grazing is a method of repeated grazing of paddocks (fenced off parts of a field) in a pasture. It controls livestock density and the timing of livestock movement to maximise forage production over the growing season. This in turn maximises manure production to build soil organic matter. Forage plants experience repeated pulses of growth and removal of biomass, both above and below ground, over the growing season.

Key aspects:

- Livestock enter a paddock before forage leaves its vegetative stage and growth slows.
- Livestock leave a paddock while there is still sufficient forage leaf area to jump-start regrowth.
- Grazing causes forage roots to die back, which adds soil organic matter from the dead root mass.
- Livestock return to the same paddock when leaf and root regrowth have fully recovered vigour and ability to recover from another grazing.

Soils high in organic matter are central to establishing water and mineral cycles. Soils in humid temperate regions are exceptional in their ability to accumulate organic matter over years. Fifty years ago, André Voisin's book "Grass Productivity" stated that "pulsed grazing" (see Box) on permanent pasture is the fastest soil organic matter building tool that farmers have, at least in temperate climates. So we tried to design our whole agro-ecosystem to adapt and improve on the natural grass-ruminant ecosystems that helped create the deep topsoils of midwestern North America. In summary, the design focuses on three crucial areas:

1. Pasture management for a wide variety of productive, palatable perennial forages, kept in a vegetative state via pulsed grazing throughout the growing season to maximise biomass production;
2. Manure storage in a deep litter bedding pack under cover that is refreshed daily during the cold season to maximise nutrient retention (i.e. so that no nitrogen escapes as ammonia) and livestock health;
3. Composting the bedding pack to a proper carbon/nitrogen ratio during the warm season to maximise organic matter production, nutrient stabilisation and retention, and spreading the compost during the warm season as well, to maximise efficient nutrient recycling to the soil.

This design is working well on our farm and confirms Voisin's thesis: within a few years our forage production tripled, and soil organic matter is slowly improving. The weakest link in the mineral cycle in our wet climate is nutrient losses to leaching.

Integrating deep-rooted trees into the system

Our solution was to design such a model for our area: forage fields that will incorporate enough trees and other deep rooted plants to mend the break in the mineral cycle (see Figure). Trees can make the system more productive and healthier than forest and pasture separately. In Cuba we have seen such systems for orchard or timber production in pastures surrounded by live legume fence posts that were regularly cut for forage. We can take our cue from the Cuban model, but we must adapt it to the temperate climate of our area.

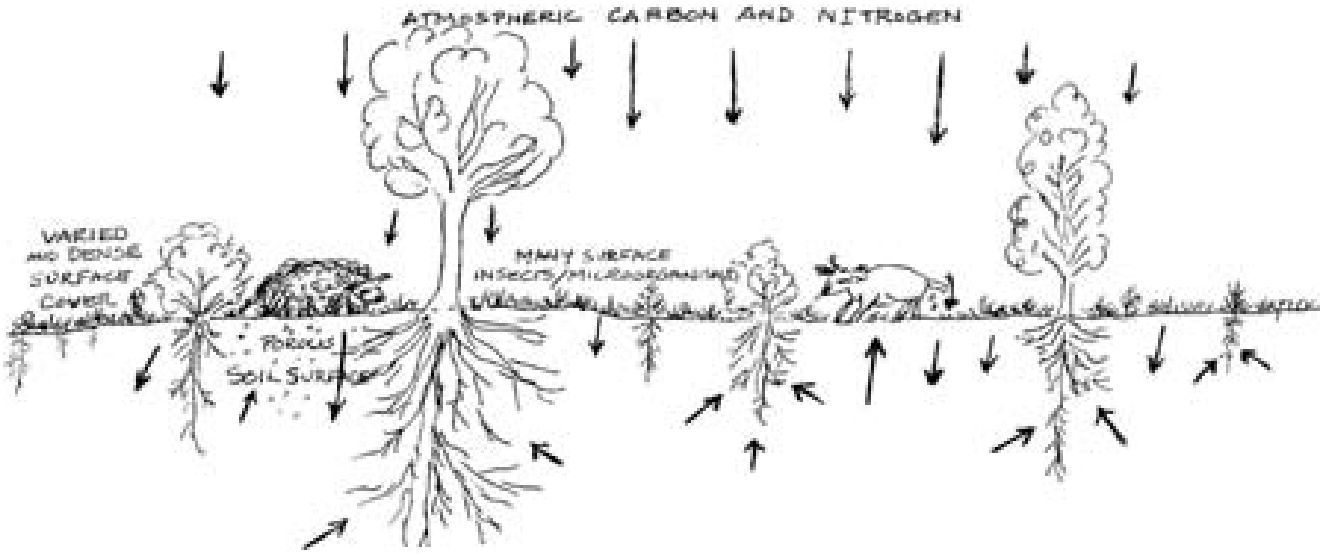

Figure: Trees reach down into the deep soil, bringing up minerals that would otherwise have leached out into groundwater.

To mend the mineral cycle broken due to leaching, we aimed to maximise trees per acre, along with deep-rooted perennial forages like chicory that we added to the hay/pasture species mix. But we needed to space the trees to complement and improve hay and pasture production, not compete with it. So there were conflicting goals, and we had to find a balance between them. We chose tree species and spacing to achieve:

- High shade. To spread shade, and therefore spread lounging livestock, manure and wear on the vegetative cover evenly in the field. Tall, narrow trees spread shade through the day in a wide arc that covers much ground. Short blocky tree shapes throw a shade pattern that covers less ground over the day.
- Optimal shade. For soil moisture retention, forage growth and forage species diversity. Forage in hotter climates will benefit from closer spacing.
- Easy machine harvesting of forage in between the tree rows. Of the three machines we use (mower, tedder/rake, and baler) we based the spacing on the widest machine.

In view of these conflicting requirements we have proceeded cautiously by spacing trees widely at first, and adding more later on as experience shows the need. We started with a tree species called "honey locust" (*Gleditsia triacanthos*) because it serves multiple functions. It is a legume tree that adds nitrogen to soil; it is a nutritious and palatable forage for either cut-and-carry or browsing by large animals like our work mules; and its shape and small leaves provide the light and high shade that our pasture and sheep management requires.

Later we plan to add trees that can produce a food product such as hazelnuts or chestnuts. For several years we have been thinning an old apple orchard and grazing it with sheep and horses. We are trying to find the optimal spacing between trees to achieve the best sun/shade mix for pasture grass growth. We feel that there is much to learn about how trees, grazing animals and grasslands can be managed to work together to maximise the productivity of the whole beyond that of each one managed separately. In the area, farms practising similar systems are still rare. Interest in low input systems is growing as inputs become too expensive, but policy support is still poor. ■

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Call for articles

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Climate change and resilience

Throughout history, farmers have adapted their agricultural systems, responding to crises such as droughts, floods, soil degradation and social conflict. They have also responded to positive opportunities such as new crops and emerging markets. Failure to adapt often results in disaster: people have had to leave the land and some agricultural systems have died out.

There is now wide scientific consensus that the global climate is changing, affecting rainfall patterns and boosting temperatures around the world. In some areas, it may lead to further desertification and decline of food production. Ironically, agriculture is one of the major contributors to climate change. Fertilizer production emits large quantities of greenhouse gases and its application acidifies soils. Because of practices such as deforestation and intensified agriculture, soils are also losing their carbon content to the atmosphere.

Climate change has been described as "a threat to humanity", and there is no doubt that those in poorer areas will suffer more. The (sub-)tropics are expected to be hit hardest by climate change. Sustainable agriculture can help reduce the threats from climate change. On the one hand, it can reduce the impact of agriculture on the climate through sustainable methods (e.g. integration of diverse crops, soil management, low fossil energy input, local marketing). On the other hand, it can help rural societies cope with drastic changes, as farmers adapt and respond to new opportunites, and build more resilient farming systems.

The coming climate change issue of the magazine will look for concrete examples on how LEISA helps to build resilience. How do farmers perceive and deal with changes in their environment? What do they anticipate? How have they been dealing with shocks and stresses in the past and how can such strategies be important in the years to come?

Deadline for submission of articles is 1st September 2008.