Trees for Livestock

Why and How Forest Gardens Must be Used to Improve Livestock Rearing Practices, Reverse Land Degradation, and Increase Smallholder Income
“When fed to the livestock, the leaves have high nutritional value and able to increase milk production by 30% and meat production by 25%.”
– Paulino Damiano, TREES Kenya Country Coordinator, 2015

“I used to struggle to feed my 3 dairy cows and 6 dairy goats... now I have sufficient fodder leaves.”

“Tree leaves can offset the cost of cattle feed by 100%.”
– Paulino Damiano, TREES Kenya Country Coordinator, 2015
Acknowledgements

This paper draws from many experiences by Trees for the Future (TREES) and its many partners planting millions of trees across the developing world since 1989. TREES late Founder Dave Deppner, a former farmer himself, would be pleased to see many of his ideas on livestock management taking root.

Trees for the Future Founder, Dave Deppner, visiting the livestock of a smallholder farmer in Honduras.
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This Must Not Continue

Throughout the developing tropics, much destruction of forests and arable land results from the poor management of grazing animals like cattle, goats, sheep, donkeys and camels. Traditional systems, particularly open grazing, result in the continuing loss of the carrying capacity of the land through severe land degradation, soil compaction, and desertification.

On Earth Day of 2015, Bill gates tweeted about how livestock now inhabit ¾ of our planet’s non-ice covered land, drawing attention to a problem that has gotten out of control. Globally, livestock are a major contributor to desertification of an area twice the size of the state of Texas every year. This global crisis beckons the question: How we can feed the growing livestock population throughout the developing world without accelerating the loss of arable land and forests? An obvious answer is to stop the consumption of animal products all together, and while that movement grows, the vast majority of communities across the developing tropics are experiencing a steady increase in the demand for meat and dairy.

However, livestock and environmental sustainability are not necessarily mutually exclusive. After working with farming families for 25 years throughout the developing world and coming to understand farmers’ needs and constraints as they pertain to livestock, Trees for the Future (TREES) has developed a new system to make livestock production more environmentally and economically sustainable. The Forest Garden, TREES’ flagship farm optimization methodology, offers a superior system for animal fodder production that enables smallholders throughout the developing world to not only become more profitable, but also actually halt and reverse the land degradation caused by their open grazing animals.

This paper provides a global perspective on the livestock crisis and describes the application of more sustainable livestock management system that boosts farmer incomes while reversing the centuries of land degradation caused by open grazing. By planting trees that revitalize degraded farmland, using the trees’ fodder to feed confined livestock, and then returning livestock’s manure to the land.
farmland, we cannot make livestock production perfectly sustainable, but we can change it for
the better.

History: Livestock are Degrading the World

Animal husbandry has been key to virtually every agricultural system on earth since the dawn of
civilization. Breeding programs and livestock management systems began developing thousands
of years ago and closely parallels the growth of human societies. And yet while livestock have
served as a cornerstone of human prosperity, it's increasingly obvious that the livestock systems
that have proved so successful over the centuries no longer serve the needs of raisers - or of the
larger global community.

Open grazing by domestic livestock causes soil erosion, damage to grass and plant regeneration,
and eventually desertification. Desertification is occurring on a third of our planet and impact
over a billion people. Half of these people live in Africa.¹ Vast tracts of land, for centuries
considered traditional grazing lands, have suffered the effects of overgrazing. The animals eat
all palatable vegetation, often before they go to seed, and their hooves compact the soil so
water cannot penetrate. These grazing systems have prevented the natural regeneration of
grasses, trees and herbaceous and woody plants.

If anything, the animals themselves suffer nearly as much as the land that supports them.
Animals don't produce well when under stress. It is extremely stressful for a goat, standing all
day in the broiling sun, to be tied to a stake with no water and little to chew on. They commonly
end up expending the calories they consume.

As we look back over the centuries, we can follow the wake
of destruction that the domestication of animals has left in
its path. Over ten thousand years ago, forests once covered
the Middle East, Greece and Persia. These countries are
known today for their large desolate tracks of land, but it
wasn't always this way. The forests were decimated by
unselective felling, burning, and overgrazing by sheep and
goats². Similarly, in nearby Iraq, Iran, and Saudi Arabia,
ancient cedar forests were cleared and unrestricted grazing
of cattle and sheep endemic to the area arrested the land's
natural regeneration efforts. It's no wonder the birthplace of
livestock intensification was one of the first regions to suffer
from overgrazing and desertification.

From the Middle East where much of the world’s livestock
domestication originated, livestock then extended across
Africa degrading the continent in ways wild animals never
did. If you view arid lands on Google Maps or Google Earth
and zoom in on small towns and villages across the Sahel, you’ll see a growing circle of desert
radiating around many small towns. The countless head of livestock that trample Africa’s tired

¹ http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/use/?cid=nrcs142p2_054028
² http://www.fao.org/docrep/e3200e/e3200e03.htm
soils and eat the remaining vegetation and tree seedlings have greatly contributed to the anthropogenic desertification that is also advanced by destructive farming practices and the need for fuelwood.

It is thought that some time after cattle had already made it into Africa from the Middle East, swine left the Asia mainland and spread along with humans throughout the Pacific islands similar to how livestock accompanied the movement of humans in Europe and Africa. Pigs destroyed ecosystems, wiping out single species and decimating vegetation with their generally destructive nature of living, eating, and rooting.

In the modern era, livestock have caused significant destruction in the Western Hemisphere. In mountainous Central American communities, agriculture and ranching interests have cleared vast swaths of land and smallholder farmers have expanded their herds to meet the growing demand for milk and meat. Cattle trample the rugged terrain in search of forage, collapsing stream banks and sending topsoil into the ocean. Watersheds are drying up, and the growing lack of quality forage means that cattle themselves only produce a fraction of their potential. When hurricanes hit, the true cost of deforestation and overgrazing are felt by communities living on completely exposed hillside farms.

The situation may be worse in Brazil. Ranchers burn the biodiversity-rich rainforest to create grazing lands. Overgrazing quickly diminishes the carrying capacity of the land, and the degraded land quickly loses its value and ability to support livestock. It is abandoned, new virgin lands are cleared for grazing, and the process of deforestation, degradation and desertification continues. The Brazilian government has undergone tremendous scrutiny in recent climate change conferences for its contributions to environmental degradation and greenhouse gas (GHG) emission from its livestock industry. In fact, deforestation of the Amazon for cattle and agriculture has made Brazil one of the world’s top GHG emitters.

**Change Isn’t Easy, It’s Necessary**

The extent of the global destruction prompted some development planners to suggest that only eliminating livestock production – in other words, turning the world vegetarian – can save these threatened land areas. This, as of yet, is not possible. Agricultural systems in developing tropical countries require the extensive integration of crops and livestock. Livestock provide the power to till fields and the organic fertilizer to maintain soil fertility. They are collateral for loans, provide wealth and prestige, represent food and financial security, and are a means of converting agricultural products and farm waste into more marketable products.
Livestock production experts point out that some grazing animals have the ability to efficiently utilize lands that are unsuited for crop production. They also point out that livestock leave manure in their wake, adding to soil fertility, and that some seeds germinate best when passed through the digestive system of animals. These reasons, however, do not legitimize the abuse and eventual destruction of these fragile lands from overgrazing, nor do they excuse the extensive erosion and loss of biodiversity accompanying the permanent alteration of ecosystems.

If a land area is slightly overgrazed, the effects on carrying capacity are scarcely noticeable at first. But careful examination will show areas where grasses are sparse, soils are more compacted or becoming sandy, and the carrying capacity of the land has declined. Within a few years, these lands clearly produce less forage, indicating advancing desertification. By the time land degradation becomes this obvious, reversing it is extremely difficult and time-consuming, and eventually, the unsustainability of open grazing reveals itself not just in the lack of quality forage, but through the bleached bones of starved livestock scattered across the parched terrain.

What about the herders?

A major challenge to reducing overgrazing is cultural. In most countries in Africa, there are clear divisions between farmers and herders. Nomads often can't stand farmers, and farmers tend to despise herders. This mashing of lifestyles often escalates into varying levels of conflict often seen in many examples across Sub-Saharan Africa.

Yet we find that the world is changing, even for nomadic herders. Their children must go to school every day, and their families need clinics and places to buy things on a regular basis. With rural populations growing rapidly and land pressure increasing exponentially, roads, walls and fencing cut off traditional grazing routes. Even the Maasai of East Africa, the world's greatest herders, find it difficult to navigate large herds.
across the changing landscape. Like it or not, the nomadic life is coming to an end and the herders are looking for new ideas. In Tanzania, Trees for the Future is working with Maasai communities to plant Forest Gardens, a stark contrast from their traditional herding livelihoods, but a necessary change for herders in the 21st century.

**What is Cut-and-Carry?**

Although alternatives to open grazing, such as rotational grazing, support both animal and pasture health, these methods are often not practical for the poorest of the poor due to investment and equipment requirements. An alternative for animal farmers in the tropics is to produce forages of higher quality in an intensive way and *to bring the food to the animals instead of sending the animals to find the food.*

Cut-and-carry represents a smart, blended management approach that is healthier for the animals, more profitable for the farmers, and better for our planet.

In a cut-and-carry system in the developing tropics, animals are penned in a specific area. Families use walls, thorny branches, poles or multi-purpose living fences to keep cows, sheep, and/or goats enclosed. This protects them from other people, pests, diseases, and the hot sun, and it keeps them from wandering. Forage must be brought to animals, since penned livestock do not roam as freely as open grazers. This gives the owner the opportunity to select the best food for the animal.

Penning animals with cut-and-carry feeding allows farmers to control diets and minimize animals’ stress, but these animals are also sometimes allowed to roam free. Most farmers have ample space on fallow croplands or uncultivated communal lands where animals can stretch their legs. High quality forages can even be grown in and around the same penned areas where the animals spend most of their time.

Because the animals are restricted to specific areas, good hygiene, management, and nutrition—the most important factors in keeping animals healthy—are far easier. Sickness and other problems can quickly be identified and remedied before it is too late. Livestock waste far less energy than animals that spend their lives walking around in the hot sun, irritated by insects and eating grasses nutritionally equivalent to cardboard.
In their pens they are comfortably housed with forage, clean water, minerals, and often plenty of shade. Exposure and spread of disease are greatly reduced, and manure is more effectively collected and utilized. Animals in heat can be quickly spotted and bred, or isolated and quarantined from other animals. The end result is that animals raised in these comfortable conditions have a far lower minimum daily nutritional requirement, and a higher percentage of the energy and nutrients consumed is converted into meat, milk and healthy calves. Cut and carry livestock management systems help animals avoid wasting their energy sweating in the hot sun, swatting insects and scouring fields for something to eat. They also free up a considerable amount of time for the people who herd them, often young boys, to instead go to school or to spend their time productively elsewhere.

Though animals are usually penned in this system, it should not be confused with confinement rearing and animal intensification in the developed world. In the developed world confinement rearing has evolved into modern, intensive factory farming where far too many animals are packed into small spaces. These cruel living conditions, combined with unhealthy diets meant to accelerate animals’ marketability, leads many to view confinement rearing systems as unethical.

**A New Way**

In order to shift millions of smallholder farmers to cut-and-carry systems and reduce the stress on the global environment, these millions of farmers will need to grow fodder banks to have
An important social outcome of planting fodder trees in Forest Gardens is that young boys and girls can spend less time walking the countryside and more time in school.

Farmers are often surprised to learn that many of the best forages grow on trees. While this technical knowledge has been known for decades, it is largely hidden in research reports only available to the literate populations with access to the Internet.

Luckily for the millions of farmers who want to preserve the productivity of their lands for their own children, TREES has developed the Forest Garden Approach which guides farmers in designing and planting fodder tree-rich agroforestry systems that feed growing livestock herds without further degrading soils.

TREES’ Forest Garden Approach is a viable alternative that emphasizes ecological protection and restoration of the land, as well as increased and diversified production and income for the farmer. Forest Garden systems have been developed for virtually all classes of domestic grazing animals, and the approach is flexible enough to accommodate any type of agribusiness opportunities available to smallholder farmers, such as meat, milk, skins, as well as fruit and timber.

In addition to being more efficient and healthy for the animals, cut and carry forage systems cause smallholder meat and dairy producers who rely on expensive, commercial animal feed to quickly experience a dramatic reduction in their costs. Animal feed sold by dairy companies and other input providers contain a good balance of fiber and minerals such as calcium, phosphorus, potassium, sulphur, zinc and chlorine, which fodder from appropriate trees can easily replace. By simply replacing commercial feed with homegrown fodder, farmers realize an immediate savings which can easily double net revenue. TREES’ dairy farmers in Kenya, for example, apply 65% of gross revenue toward purchasing commercial feed which can be fully replaced by tree fodder.

Cut-and-carry systems supported by fodder tree-rich Forest Gardens are the obvious best environmental and economic choice. In upland areas, TREES has seen that it usually takes anywhere from 3 to 7 acres of land, depending on the type of forage, to maintain one cow calf unit. With the confinement cut-and-carry system, one acre of forage can maintain up to 20 cow calf units (approximately 50 per hectare), depending on rainfall and planting density. This is possible because fast-growing fodder trees—producing on three dimensions, vertically as well as horizontally—can produce a higher quantity and quality
of fodder per square meter of ground than pasture forage, which only grow across one plane often on degraded and compacted soil. TRES usually recommends that farmers diversify their land so that ample space is allocated for things like fruit trees, vegetables and timber. The average cattle-owning family in our programs has between two and eight head of cattle. The fodder species planted tend to occupy less than half of the Forest Garden to allow for other food and income sources such as fruit and timber.

The advantages of instituting cut-and-carry livestock management systems using Forest Gardens include:

- More efficient use of available land
- Improved gains and productivity
- Decreased time for marketability
- Ability to continuously improve soil productivity
- Reduced risk of damaging the ecosystem
- Increased feed efficiency
- Reduced input cost and replacement of costly animal feed
- Healthier for animals, better disease management, reduced costs for treatment of illness
- Efficient manure management
- Increase quality of certain products such as meat and milk
- New market opportunities
- Able to be implemented with 100% appropriate (i.e. locally available) technology
- Social benefits such as freeing children from herding responsibilities and more time for school

Possible disadvantages of planting Forest Gardens include:

- High labor requirements
- Difficulty determining smart, balanced rations from diverse sources
- Difficulty knowing how to maximize fodder production from different trees
- Pushback from the animal feed industry
- “Not free range” possibly perceived as less ethical
- Changes in milk taste and quality as well as lactation
- Potential need for mineral supplements
- Period of adjustment for animals
- Production constraints in the dry season
- Lack of tools for proper pruning and harvesting of fodder trees
- Processing and storage constraints in the rainy season

**Fodder Trees in Forest Garden Design**

The Forest Garden Approach is aimed at improving and sustaining food security and income-generating opportunities in an environmentally responsible manner. This is achieved by diversification of crops for better food availability and more revenue sources. The Forest Garden incorporates fruit, fodder, fuel, and timber tree species as well as other food and vegetable crops together in a horizontal and vertical design to meet household needs and market opportunities. For the millions of smallholder
livestock owners across the developing tropics, quality animal forage is a major need. Most are surprised to hear that some of the best forages grow on trees.

The main phases of the Forest Garden Approach are protection, diversification and optimization. Trees that provide massive amounts of high quality animal forage tend to have multiple uses, contain leaves with high amounts of protein and can be integrated into Forest Gardens in many ways.

In the **protection** phase, farmers learn to incorporate fodder trees into the green walls that surround each Forest Garden. The trees serve as windbreaks inside the protection of thorny living fences, and they serve as barriers around gardens and orchards to control pests. They are also planted along contours to stop erosion.

In the **diversification** phase, fodder trees help meet several needs of farmers. They are often planted in woodlots for fuelwood or in rows across the field for fertilizer. They are also planted around gardens and segments of orchards to control pests.

In the **optimization** phase, Nitrogen fixing fodder trees are planted near gardens and fruit trees. Gaps in the field are filled in with these trees, and species that are provide quality fodder in the lean season are planted.

It is possible to integrate fodder production into fields with minimal reduction in the production of other cash crops. TREES encourages this in Forest Gardens by planting dense rows of fodder trees in the otherwise unused spaces around and within cropping areas. When fodder trees are planted in rows, lines, perimeters and contour strips, they are usually spaced between 30 cm and 2 meters apart depending on species and the purpose of the agroforestry formation. When planted in hedge rows, fodder trees are typically planted in two staggered rows with trees spaced 30-50 cm apart. In windbreaks they are often planted at 1 meter intervals, similar to many grass forages.
Examples of fodder tree integration:

Selecting Forage Species

The ultimate goal of rearing animals is to provide them with living conditions that will help them stay healthy and reproduce quickly. Just like people, animals need a well-balanced, diverse diet. Grass alone is not enough. Animals need protein, macro and micronutrients, minerals, and plenty of clean water.

There is a wide range of great animal forages that farmers utilize around the world. But which species of trees are useful for forage production? Almost every country in the tropical world has many types of trees, bushes, grasses and other vegetation whose leaves and soft plant matter can be used as quality animal forage.
Picking the right fodder trees to plant requires consideration of the needs of livestock, the needs of the farm, and the needs of the family. The best fodder sources can address several needs on the farm, including fuel wood, green manure, soil fertility, wind and soil erosion control, protection and even food for human consumption.

Important characteristics include adaptability to specific climatic and soil conditions, growth characteristics, nitrogen fixation, versatility of usage (e.g., fuel, honey, and charcoal, etc.), protein content, digestibility and palatability. It is important to note that digestibility is often related to tannin or other secondary chemical compound content which, if high enough, can interfere with digestibility and metabolism of nutrients in certain animal species. In some cases consumption of certain amounts of fodder high in secondary chemical compounds can cause illness or even death. If no specific guidelines are provided for fodder diet percentages, one single species should provide no more than 30% of ruminants’ total diet and no more than 5-10% of total diet for non-ruminants.

Grazing systems are especially difficult to maintain in tropical areas with distinct rainy and dry seasons. It is particularly important to select some species that produce leaves through long dry seasons without requiring extensive irrigation. Regions with particularly long dry seasons may require additional land to produce forage, or a greater share of the Forest Garden dedicated to fodder species.

**Processing and Storing Leaf Fodder**

Forage trees should first be cut or coppiced when they reach 2 meters, and then again after every 0.5-1 meter in new height when re-growth is optimal. Cutting during the rainy season can be as frequent as every 2 weeks (6-8 times over the season). During the dry season, harvests may be reduced to accommodate unfavorable growing conditions. Some farmers may choose to let the trees grow and then harvest them when the stems have reached a useful size for other purposes, such as fuel or stakes.

Processing and storing fodder takes into account many considerations such as: the time of year (dry or rainy season), animal preference and tolerance, available technology, type of final product (leaves, meal, cakes or pellets, etc.), market availability and even mode of transportation to market.
Feeding fresh forage to livestock is usually the best as it generally contains the most nutrients. However, this may not be an option all the time due to seasonal constraints, limitations in quantity and quality, and other factors. Although many tree-based fodder species produce during the dry season, they are often not as prolific as during the rainy season. Therefore, proper processing and storage is necessary to ensure supplies year-round. This also opens the door to possibilities for market options as demand for affordable, high quality feed rises during the dry season.

Options include drying forages, cutting and storing them, and/or processing them for later use either alone or mixed with other crop by-products. Other parts of the plant aside from edible leaves and petioles (herbage mass) may include seed pods, seeds, fruits and young branches.

When drying forages for storage, it is best to dry them in the shade on screens or other raised platforms that allow for plenty of ventilation. It may be necessary to check the material and turn it from time to time to prevent molding. Drying may increase the digestibility in some species by reducing the fiber content; this also reduces nutrient content. Drying during the rainy season may be problematic due to spoilage. It should be done in accordance with weather forecasts or with improved drying methods that provide low-humidity heat. Making silage
(usually fermented grasses) in bags or pits provides a more digestible product, particularly to non-ruminants, which can be easily stored.

Forage Agribusiness Opportunities

Leaf meal can be marketed, but usually depends on equipment such as grinders and requires a binding agent (usually molasses). These types of feed supplements are more expensive to make but are very nutritious and can have a high resale value. Leaf meal is typically part of a feed ratio mixed with other food. However, leaf meal may be bulky and expensive, especially during the dry season. Leaf meal and stored forages need to be compressed to increase transportation efficiency for both short and long-range transport. From: Franzel, S., Wamburu, C., Nanok, T., Kavana, P., Njau, T., Aithal, A., Muriuki, J., and Kitalyi A. 2007. The production and marketing of leaf meal from fodder shrubs in Tanga, Tanzania: A pro-poor enterprise for improving livestock productivity. ICRAF Working paper No. 50. World
and traders in leaf meal. This is a high-value good and has a lot of potential if processing can be made affordable and easily accessible to rural populations.

A major question is whether forage-based leaf meals can substitute for typical dairy meal in terms of not just quality and benefits, but also price and availability. Forage grown on trees can be either a supplement or a substitute.

Monetary considerations that go into forage production and/or purchasing decision making include the cost of the purchase (including transportation) versus the cost to raise and manage the forages (labor, seed, less land for other crops), the difference in outputs and market options such as changes in quantity and quality of the meat or dairy products that result, and market availability and costs of feed. All of these factors determine the strategy: substitution, supplementing and/or purchasing.

Highland Fodder Trees Popular in Kenya and Tanzania
Above 1500 meters above sea level.

As of 2016, one of TREES geographic priorities is East Africa where destructive livestock rearing is often the primary form of income for impoverished farmers. We are now implementing projects in Kenya and Tanzania to prove the model of using fodder trees for sustainable fodder production at scale. TREES’ experience in Kenya indicates that it takes 500 trees to support one dairy cow. Practitioners in the field report a single tree can produce 90 lbs. of fodder in a year. When selecting species to cultivate for fodder, it is important to choose species that are appropriate for your agro-ecological zone. The following lists describe the top fodder species grown in Forest Fardens by elevation.

Each species listed has different advantages, disadvantages and growth requirements which form part of the selection decision. All coppice and/or regrow fast and efficiently, forming fodder banks.

Calliandra calothyrsus
*Calliandra* leaves, with 24% protein content, are wildly popular in highland communities. It is often used to supplement grasses of low nutritive quality, or to replace commercial feeds. *Calliandra* does not tolerate frost yet is adaptable to various soil acidities, and it is partially shade tolerant, fixes nitrogen, and likes well-drained soil that is not waterlogged. Its forage is high in protein (17-22% crude protein), and is relatively digestible (35-40%). Trees may produce 6-16.7 tons/ha/year dry material. However, the high tannin levels limit digestibility so one needs to limit percentage in diet. Goats love *Calliandra* while cattle need an adjustment.
A close-up of the L. trichandra leaf.

A close-up of the L. trichandra leaf.

Sesbania sesban planted in an open area of a Forest garden in Kenya.

Mulberry leaves, the large leaves hanging out of the trough, are often mixed with Calliandra and other uplands tree forages to provide a mixed diet.

period. Ruminants tolerate it more than non-ruminants. Rabbits and fowl should only have 5%, and in general no more than 30% of a diet should be comprised of Calliandra. Leucaena trichandra

L. trichandra is a Nitrogen-fixing tree that does not tolerate frost. It does not do well in acidic soils, and it prefers well drained soils. Its nutritive quality is lower than L. leucocephala but it is better adapted to higher elevations. Its forage is high in protein (17-33% crude protein). The quality of the fodder, including tannin content and digestibility, varies considerably with the seed source. This species is disease resistant, adapted to cooler climates but without frost tolerance, and has multiple uses. It is written that it is not well adapted to hot tropical environments, but in the Kenya highlands, where temperatures are kept at bay because of the altitude, it is popular among farmers. It does not compete strongly with grasses when establishing like L. leucocephala, so weeds should be kept clear until the trees are established. Due to this characteristic, it makes a good companion crop with fodder grasses.

Sesbania sesban/grandiflora

Sesbania is often used for soil stabilization and improvement, and is also readily eaten by livestock. Sesbania tolerates light frost and a wide variety of soil conditions and it fixes Nitrogen. It has a relatively high protein content (15-20 % crude protein) with very in vitro digestibility 75-90%). Sesbania trees produce around 20 tons/ha/yr dry matter. Sesbania is a very fast-grower but is relatively short-lived and should only be harvested five or fewer times per year. This is a popular fodder species and used for rotational fallow and honey production. It is often combined with other protein sources to provide a complete forage regime.

Morus alba

Mulberry is not suited well to grazing, but makes an excellent fodder for cut and carry systems. It can tolerate frost and prefers alkaline well-drained soils but does not fix nitrogen. It has a relatively high protein content (15-25 % crude protein) and very high digestibility (75-80% in vitro digestibility). They produce 5.6-11.2 tons/ha/yr dry matter. This tree may compete with crops due to its need for Nitrogen and other soil nutrients, so they should be integrated with nitrogen fixing species when

planted in Forest Gardens. It is valuable due to its high protein, palatability, frost tolerance, edible fruits and silk worm production.

**Mid-to Lowland Fodder Trees Popular in Kenya and Tanzania**

Below 1500 meters above sea level

**Leucaena leucocephala**
The *Leucaena* genus of tree’s leaves have the ability to greatly increase growth rate and milk production due to high levels of protein. An average herd of dual-purpose cattle needs a ration of about 11-12% protein. Commonly used grasses have about 6% protein in the rainy season and 4% in the dry season, whereas the leaves of the *Leucaena* tree have about 27.5% protein, high levels of vitamins A & B, and are palatable for animals (National Research Council, 1984). *Leucaena leucocephala* grows well under a wide range of conditions, particularly in lowlands. It fixes large amounts of Nitrogen, making it a good tree for intercropping. It quickly grows back when cut, producing a large quantity of leaves (up to 60 tons per hectare per year), even during the dry season.

**Sesbania sesban/grandiflora**
*Described above.*

**Leucaena pallida**
*L. pallida* tolerates light frost and prefers neutral to alkaline and well-drained soils. It does not tolerate waterlogging and is particularly at-home in very dry areas. It fixes nitrogen and, like other Leucaena species, has a very high protein content (29-35% crude protein) and very high digestibility (55-64 % in vitro digestibility). This *Leucaena* species is psyllid resistant. It’s easy to grow, establishing more vigorously than *L. leucocephala*, and tolerates more acidic and cooler sites than *L. trichandra*. However high tannin levels may limit digestibility and utilization of nutrients, so moderate amounts should be used as fodder.

**Leucaena diversifolia**
This *Leucaena* tolerates light frost and prefers slightly acidic and well drained soils. It fixes Nitrogen, is highly palatable, and has a high protein content (25-32% crude protein). Its high tannin levels may limit digestibility. This species of *Leucaena* has a tolerance of low temperatures and is resistant to psyllid insects. It makes good charcoal and fuelwood. It is a prolific seed producer, so it should be highly harvested and maintained to limit invasiveness. No more than 30% of total diet for ruminants and unsuitable for non-ruminants (give no more than 5-10%).
Nutritionists have pointed out that *Leucaena* is in the *Mimosae* family, and the leaves contain an irregular alkaline (amino acid) called mimosine, which can reduce calving rates under certain circumstances. So these leaves should be fed to single-stomach animals in limited amounts (25% for goats and sheep, none for horses or mules) but can be fed to large ruminants as up to 30% of the total ration.

**Morus alba**  
*Description above.*

**Senna siamea**  
Senna siamea grows particularly well in lowland, humid environments, but will grow in a wide range of conditions. It requires full sunlight to maximize productivity, and is susceptible to frost. It is a popular fodder for goats, but secondary plant compounds are highly toxic to non-ruminants such as pigs and fowl. This plant also has a host of other uses such as fuel, medicine and textiles.

**Other valuable animal fodders available in Kenya and Tanzania**

**Chamaecytisus palmensis** *(Tree Lucerne or Tagagsaste)*  
Tree Lucerne thrives on a wide range of soil types, but grows best on well drained sandy soils on slopes and hillsides. It has a very deep root system, making it extremely drought tolerant as well as frost tolerant. It fixes Nitrogen and has a high protein content (20-30% crude protein) and is extremely palatable (77-82% in vitro digestibility). It produces 10 tons/ha/yr dry matter. This species improves the soil and is good for honey production. It is easily digested and palatable, but it may take animals some time to become accustomed to it, and it can be sensitive to fungal diseases.

**Gliciridia sepium**  
Mother of cocoa, its name translated from Spanish, does not tolerate frost or water logging, but it does tolerate a wide range of soil pH and fixes nitrogen. It offers 18-30% crude protein, 60-65% in vitro digestibility, and 20 tons/ha/yr dry matter. It is described as having low palatability but does well when mixed with other forages. This species is especially good for ruminants and propagates easily through cuttings or seed. It may be poisonous to non-ruminants, so do not
Pigeon pea is a hardy species that is tolerant of drought, high temperatures, acidic sandy and alkaline clay soils. It is a very adaptable species with high palatability. It’s an excellent fodder species with crude protein values of 15-24%. The seeds contain a high portion of the nutritive value of the fodder, so it should be harvested when the pods are mature. However, pigeon pea is deficient in some amino acids so should be mixed with other feed. A ration of 3-4kg per day per animal, mixed with Napier grass for instance, can lead to good weight gains.

**Cajanus cajan (Pigeon pea)**

Pigeon pea is a hardy species that is tolerant of drought, high temperatures, acidic sandy and alkaline clay soils. It is a very adaptable species with high palatability. It’s an excellent fodder species with crude protein values of 15-24%. The seeds contain a high portion of the nutritive value of the fodder, so it should be harvested when the pods are mature. However, pigeon pea is deficient in some amino acids so should be mixed with other feed. A ration of 3-4kg per day per animal, mixed with Napier grass for instance, can lead to good weight gains.

**Pennisetum clandestinum (Kikuyu grass)**

Kikuyu grass is used for permanent pasture, grows best on fertile soils and tolerates a low pH. It may be used for hay or silage. It performs well in areas of low and high moisture regimes. A tropical plant, it does not tolerate frost. This forage needs to be cut to produce quality forage and is demanding of nutrients. It provides quality forage with high protein and digestibility levels with new growth. Caution must be used when foraging on new growth after long dry spell as over-consumption can cause toxicity.

**Pennisetum perpureum (Napier or Elephant grass)**

Napier grass has become one of the most important fodder options for cut and carry systems in Kenya and Tanzania due to it’s wide growing range (up to 2,000 meters). It is very effective for weight gain and milk production when supplemented with fodders of higher nutritive value, such as *Calliandra*, *Leucaena*, or *Gliricidia*. It can produce dry matter of up to 16 tons/ha/year with little to no fertilization, surpassing the yields of most common pasture grasses. Hay and silage can be made for dry season use, but it should be cut when young for making hay. Napier grass grows well in alley cropping systems with leguminous shrubs.

**Desmodium intortum**

Greenleaf desmodium grass grows well in cooler regions and fertile soils. It has a long growing season, producing fodder with moderate protein content (16-24%) and digestibility (55% in vitro digestibility). The high tannin levels can increase the efficiency of digestion, but the also reduce palatability until animals develop a taste for it. It is an annual species that does not fare well in the dry season.
Conclusion

Our planet is rapidly losing its forests, species and arable land. Agriculture and livestock are a major contributor to the planet’s environmental degradation. We must make significant changes in the way we grow crops and raise livestock if we are to feed a growing global population. By empowering smallholder farmers to grow their own animal forage on trees, and by planting those trees in diverse Forest Gardens, we can bring livestock rearing closer to environmental sustainability.

Many research papers available through the Internet present findings on livestock productivity gains when fed a variety of different tree and other forages. In fact, much of the information presented in this paper should not be a surprise to the scientific community and many agroforestry researchers across the globe. As this critical information in packaged in the Forest garden Approach and ‘implementable’ in away so that massive numbers of smallholder farmers can replicate the technology, we can begin to have an impact at healing the planet, improving livestock health, and changing the lives of people whose existence is so dependent upon the success of their animals.

A Kenyan farmer shows her fodder tree nursery.