Use of forage trees to meet the needs of livestock can enhance the productivity of farming systems.

The use of tree legumes in tropical farming systems dates back to the beginning of domestic agriculture. They were traditionally used for a variety of purposes, including food, fuelwood, construction and shade. In some areas, however, particularly in the arid and semi-arid zones of the world such as the Sahel and North Africa, tree legumes have always been primarily used for forage. In these dry regions, tree legumes – principally *Acacia* spp. – continue to provide a part of total herbage intake and most of the protein intake for livestock, especially during dry periods (Baumer, 1992). The introduction of tree and shrub legumes in agroforestry and livestock feeding systems offers promise for meeting the increasing demand for feed resources worldwide.

The International Livestock Research Institute (ILRI, 1997) expects that demand for milk and meat will double by 2020, with the increase in demand taking place primarily in the developing countries. Inadequacy of feed resources is the key constraint to meeting the increased demand, especially for smallholders in peri-urban locations. The use of forage trees, in conjunction with crop residues, will be one of the principal strategies to meet this constraint. In grazing areas of Zimbabwe, for example, where cattle have an important role in farming systems and where forage is currently short, agroforestry systems designed to improve forage production are expected to make a significant contribution to farm productivity (Campbell, Clarke and Gumbo, 1991).

In Australia, leucaena is being planted on a large scale because leucaena-grass systems, which are both sustainable and highly productive, will allow farmers to produce cattle for high-value domestic and export markets in East and Southeast Asia (Larsen et al., 1998).

Apart from their value as feed for livestock, tree legumes are recognized for their multipurpose contributions to the productivity of farming systems, to the welfare of people and to the protection of the environment (see Box on p. 26). The flexibility of their use makes them especially significant for smallholder subsistence farms and large-scale commercial farms alike.
Tree legumes managed for forage purposes must have high nutritional quality in order to achieve the economic animal responses required to justify farmers’ investment. The most important measure of forage quality is intake of digestible dry matter (nutritive value) and ultimately the production of animal product. This information is available for well-researched species such as *Leucaena leucocephala*, *Sesbania sesban*, *Calliandra calothyrsus* and *Gliricidia sepium*, but there is much less information on other species.

While all species have adequate levels of protein, many tree legume species contain condensed tannins which reduce the protein availability and compromise digestibility. Other antinutritive compounds may also be present.

In terms of palatability, different species and even breeds of animal have different preferences. However, animals can often become accustomed to new feeds.

In semi-arid and arid Africa, cattle, sheep, equines, wildebeest, most antelopes and gazelles graze forage tree legumes in the dry season to balance their diets. During the wet season, they prefer grass. Goats, camels, eland, impala, kudu, elephant, giraffe, black rhino and a number of antelopes are primarily browsers of forage tree legumes (Wickens et al., 1995). The ability of herbivores to graze browse trees often depends on their ability to handle thorns, woody materials or high-tannin foliage. Goats have greater preference for high-tannin species than sheep or cattle, because proline in their saliva reduces the astringency of the tannins (Kaitho, 1997).

Tree legumes are generally unsuitable as feed for monogastric animals because of their high content of anti-nutritive compounds (which non-ruminants exception with its exceptional ability to tolerate severe defoliation, by either cutting or grazing, over extended periods (10 to 30 years).

Species must be adaptable for a wide range of environments (humid tropics, seasonally dry tropics, cooler high-altitude tropics and arid zones) and a variety of soils. No single species is suited to the entire range of conditions. Species are available for cold, acid and waterlogged environments. Disease and insect resistance, however, is not yet available.
have greater difficulty handling), their high fibre content and their low energy content.

MANAGEMENT AND CONSERVATION ISSUES

The development and improvement of tree legumes for farm use is contingent on the availability of germplasm from the centres of origin of the species. The in situ conservation status is listed as threatened for some species. It is therefore imperative that native tree legumes be protected from exploitation and overuse.

In many introduced populations genetic diversity will not be sufficient to ensure long-term stability. For example, the introduction of *Gliricidia sepium* from Trinidad to Sri Lanka was made with seed from one tree (Stewart, Allison and Simons, 1996).

An added problem is that farmer choices have narrowed diversity. In Flores, Indonesia, a wide diversity of tree legume species was grown in mixed farming systems in the 1960s. With intensification and commercialization, there was greater reliance on few species, notably leucaena (Djogo, Siregar and Gutteridge, 1995). The arrival of the leucaena psyllid in this region was particularly devastating.

According to Wickens et al. (1995), the former *Acacia* communities in the Sahel in North Africa and the Near East have deteriorated almost beyond recovery, principally because of excessive demand for fuelwood, but also because of overgrazing and demand for more agricultural land, all driven by increasing population pressures. Rehabilitation of these areas will be very slow where desertification and soil movement has occurred, as there is little soil seed reserve. Preventive measures, based on low-cost participatory approaches, are essential.

Stands of *Faidherbia albida* in Wadi Aribi in western Sudan are endangered because of indiscriminate lopping for browse by camel nomads (Wickens et al., 1995).

Most *Albizia* species are severely depleted in their native range in Mexico and Central America. Most species remain abundant in only a few areas. Promotion of greater use of the species would assist with their in situ conservation (Hughes and Pottinger, 1997).

Most *Leucaena* species are in no danger. However, *L. matudae, L. magnifica* and *L. involucrata* are rare and of strong conservation concern. There are less than 400 known individual plants of *L. magnifica* (Hughes, 1998).

*Prosopis africana* is seriously threatened in the semi-arid lowlands of West Africa in Burkina Faso, the Niger, Mali and Senegal. ICRAF has organized seed collections of this species to capture the

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**Most-used tree legume species for forage purposes**

**HIGHER-QUALITY SPECIES**

- *Albizia lebbeck*
- *Chamaecytisus palmensis*
- *Cratylia argentea*
- *Desmodium rensonii*
- *Desmodium virgatus*
- *Gliricidia sepium*
- *Leucaena leucocephala*
- *Leucaena diversifolia*
- *Sesbania grandiflora*
- *Sesbania sesban*

**LOWER-QUALITY SPECIES**

- *Acacia aneura* ¹
- *Acacia nilotica*
- *Acacia tortilis* ¹
- *Albizia chinensis*
- *Albizia saman*
- *Calliandra calothyrsus*
- *Erythrina spp.*
- *Faidherbia albida* ¹
- *Flemingia macrophylla*
- *Prosopis juliflora*

¹ Principal application is in indigenous semi-subistence systems.

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**Desirable features of forage tree legumes**

**AGRONOMIC**

- Easy establishment, and rapid early growth to compete against weeds
- Effective nodulation and nitrogen fixation with naturally occurring *Rhizobium* in the soil
- High productivity under repeated cutting, grazing or browsing
- Provide fodder for out of season and drought feeding
- Little or no fertilizer requirement, resistance to environmental stresses such as cold, acid soils, pests and diseases
- Thornless, deep-rooted and long-lived
- High seed production or reliable vegetative propagation

**NUTRITIONAL QUALITIES**

- High protein, digestibility and mineral contents
- Low tannin content in leaf, sufficient to provide bypass protein
- Palatable to livestock
- Absence of antinutritive factors

**Sources:** Smith, 1992; Gutteridge, 1998.
Exotic versus native species
Exotic species are often more vigorous and produce higher yields than indigenous species and in many regions they have made invaluable contributions. It has been estimated that 150 to 200 million people use gliricidia worldwide, the majority of whom live outside its native range (Simons, 1996). Leucaena is now naturalized in the Philippines, where it is the principal source of tree fodder and of fuelwood, and this species underpins a sustainable and highly productive beef cattle production system in northern Australia (Middleton et al., 1995).

Exotic species can have significant effects on associated ecosystem species. In Puerto Rico, understory native and naturalized trees and shrubs have been regenerated under exotic tree species (*Casuarina equisetifolia*, *Eucalyptus robusta* and *Leucaena leucocephala*) (Parrotta, 1995). In South Africa, however, invasive exotic plants such as *Acacia*...
and are only now undergoing preliminary domestication to extend their utilization (Nouaille, 1992).

It is likely that the most appropriate path is judicious use of both native and exotic species. For example, in the Kenyan highlands, under greatly increased population pressure, intensively managed exotic leguminous trees have become common for fodder and green manure production. They are being combined with the traditional species, filling complementary roles in the resulting forest mosaic.

Weediness

A number of introduced tree legumes have become serious weed pests. For example, *Acacia nilotica* was introduced to provide shade and fodder for sheep in western Queensland but now infests 6 million hectares of *Astrebla* grasslands (Carter, 1994). Over the past 80 to 100 years, mesquite (*Prosopis* spp.) has become an aggressive invader of desert grasslands in the southwestern United States (Ibrahim, 1992). Movement of *Leucaena leucocephala* subsp. *leucocephala* around the world since the 1600s has led to this inferior but seedy variety becoming a weed in many tropical environments (Hughes, 1994). Natural hybridization occurring when related taxa are planted in close proximity, which is facilitated by free movement of seed in international R & D activities, may increase weed risk (Hughes, 1998; Nouaille, 1992). Species may also become a weed in their own environment. *Albizia tomentosa* is a weed in disturbed areas in Mexico (Hughes and Pottinger, 1997) and *Acacia aneura* is often weedy in southwest Queensland, Australia when poorly managed (Beale, 1994).

Perhaps the most important step in avoiding weed risk is to ensure that the rural community adopting new species has the knowledge and tools to make full use of multipurpose tree species. Tree legumes should not be introduced where risk is high, or where nearby disturbed vegetation might be ecologically threatened.
multiple uses including forage are too numerous to list. Outstanding examples are *Leucaena leucocephala* in Australia (Middleton et al., 1995) and Asia (Moog, Bezkorowajnyj and Nitis, 1998), *Gliricidia sepium* in Southeast Asia (Stewart, 1996), *Sesbania grandiflora* in Indonesia (Gutteridge, 1994), *Calliandra calothyrsus* in Indonesia (Palmer, Macqueen and Gutteridge, 1994) and *Acacia* spp. in Africa (Wickens et al., 1995).

Nevertheless, despite high levels of promotion, farmer uptake has been lower than anticipated. Many recent attempts to achieve adoption of new varieties and agroforestry packages have been unsuccessful or only partially successful. Difficulties in achieving high levels of adoption for *Leucaena* are reported for Africa (Dzwowela et al., 1998), South America (Argel and Lascano, 1998) and Asia (Moog, Bezkorowajnyj and Nitis, 1998).

**Improving farmer uptake**

To improve farmer uptake, development efforts must include an understanding of farmers' choice of species and agroforestry system, which is determined by their specific needs and resource constraints. On-farm testing of new varieties and systems could bring farmers more directly into the decision-making process and address their social constraints (risks, relevance, labour, environment) and economic constraints (incentives, markets and returns).

Communication, training, extension and research networks and adequate training of specialists and technicians are needed in all aspects of the management and use of tree legumes. A collaborative approach is needed among scientists, agroforesters, foresters, extension workers and farmers.

Community-based supply mechanisms for delivery of seed post project are often lacking. Moreover, since farmers can use existing material at no cost, it is important to ensure that high-quality seed is readily available through traditional channels at a reasonable price. Perhaps smallholder seed production schemes could be promoted to provide income for farmers and local availability of seed. These enterprises can also be used to create incentive to conserve the native range of threatened species, although quality control may be a problem.

The superiority of germplasm and substantial advantage in woody and leaf biomass yields must be demonstrated in order to interest farmers in new varieties. Farmers will plant new varieties if they recognize key benefits.

**CONCLUSIONS**

Forage tree legumes are already major contributors to farming systems. They have the potential to become even more important in livestock industries, thus enhancing the quality of life of rural communities.

Many benefits are claimed for forage tree legumes. Apart from their value for livestock, they are recognized for their contributions to farming systems, the welfare of rural populations, and protection of the environment. There are now many species and varieties available for farm use with a wide range of ecological adaptation. However, no single species delivers all stated benefits, and there is no single species suited to the entire range of conditions.
While forage is just one of the many uses of tree legumes, forage use often provides the best opportunity for commercial enterprise, provided livestock markets exist. Most other uses are semi-subistence or have an environmental focus, thus limiting economic opportunity. It is significant that both small- and large-scale operators are finding relevant applications for tree legumes. However, it is imperative to pursue development objectives in an environmentally responsible manner. The key focus, thus limiting economic opportunity. It is significant that both small- and large-scale operators are finding relevant applications for tree legumes.

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**Kaitho, R.J.** 1997. Nutritive value of browses as protein supplement(s) to poor quality roughages. Wageningen Agricultural University, the Netherlands. (Ph.D. thesis)


