Evaluation of rancher interest and on-farm performance of two indigenous tree species (Albizia guachapele and Samanea saman) in Guanacaste, Costa Rica

Robert W. Tawes
The University of Montana

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AN EVALUATION OF RANCHER INTEREST AND ON-FARM PERFORMANCE OF TWO INDIGENOUS TREE SPECIES
(ALBIZIA GUACHAPELE AND SAMANEA SAMAN)
IN GUANACASTE, COSTA RICA.

By
Robert W. Tawes
B.S. The University of Georgia, 1993

presented in partial fulfillment of the requirements
for the degree of

Master of Science

The University of Montana

1998

Approved by:
Chairperson

Dean, Graduate School

8/24/98
Throughout Latin America, cattle ranching has caused widespread deforestation and land degradation. Guanacaste, the Northwestern province of Costa Rica, is an extreme example of this. Cattle ranching, primarily for export to developed countries, has transformed Guanacaste, leaving it almost devoid of its original forest cover. Though most of the forest has been converted to pasture, ranchers still depend on trees for fence posts, building materials, and fuelwood. Trees also provide a host of ecological benefits.

This study, carried out in Colorado de Abangares, Guanacaste, involved a survey of local ranchers and on-farm trials of two indigenous tree species recommended by the ranchers for use in sylvopastoral systems: Guayaquil (Albizia guachapele) and Cenizaro (Samanea saman). The survey was administered to 33 local ranchers to gather information regarding their potential interest in incorporating trees within their pastures, their current use of trees and wood products, and any tree species of particular interest to them. Survey respondents indicated particular interest in A. guachapele and S. saman. Detailed studies on both species were then initiated, including seed germination trials; initial growth and survivorship in degraded pastures; and response to various fertilizer treatments.

Seeds of both species were collected, sown in a medium and maintained in a nursery. When the seedlings had reached approximately 30 cm height they were transferred to active pasture, where survivorship, growth and response to fertilizer were monitored for 5 months. A total of 90 individuals of each species were transplanted to pasture. Forty-five were planted in a livestock enclosure and 45 were planted in adjacent pasture using a randomized split plot design. Two fertilizer treatments were investigated: two applications of 10-30-10 fertilizer and two applications of chicken manure (plus a control - no fertilizer). A. guachapele performed especially well with rapid growth and high survivorship. Both species were palatable to cattle with 100% of the trees outside the enclosure grazed. Mortality of individuals outside the enclosure was 20% and 4% respectively, for S. saman and A. guachapele. Neither fertilizer treatment had significant effects (α = .05) on the growth of either species. This study suggests that A. guachapele may be of potential interest to ranchers throughout Guanacaste as a means to diversify and supplement their production.

Keywords: Albizia guachapele, Cattle, Costa Rica, Guanacaste, Nitrogen fixation, Rancher Survey, Samanea saman, Sylvopastoral systems.
ACKNOWLEDGEMENTS

This project would not have been possible without the support of COONAPROSAL R.L., particularly that of Ingenieros Franklin Castro, Osvaldo Rodriguez, and Asdrubal Venegas. I owe special thanks to Don Carlos Bonilla for donating part of his ranch for the growth and survivability trials. Gilberto Ugalde, Associate Peace Corps Costa Rica Director and head of the PC Natural Resource Management Program, was also especially helpful with his suggestions and assistance. Of course, the residents of Colorado de Abangares, particularly the ranchers interviewed, contributed a great deal to this project with their advice and good humor.

Classes with Steve Siebert and Jill Belsky at the University of Montana gave me a realistic overview of international development issues and associated natural resource problems. These classes played no small part in my idea for the following study. Finally, I would like to thank Steve Siebert for his insightful review of various drafts throughout the development of this project.
PREFACE

The following project was designed and implemented while I was a Peace Corps Volunteer in Costa Rica from 1995 to 1997. I entered the Peace Corps through the University of Montana's Masters International Program, and was given a position under PC Costa Rica's Natural Resource Management Project. The goal of the NRM project was to improve resource use and conservation among rural farmers and in small villages. After a training period of three months, I was assigned to work in Colorado de Abangares, Guanacaste, where I gave classes on environmental education and safe pesticide management, and worked with local stockgrowers to implement agroforestry systems.

Every volunteer is assigned to work with a host country, or counterpart, agency. I worked with the National Salt Producers Cooperative, or COONAPROSAL (Spanish acronym). COONAPROSAL came into existence in 1974 and is based in Colorado. To fuel the salt production and refining process, COONAPROSAL and its members use wood, most of which is taken from local pastures. The demand for this fuelwood, combined with clearing the landscape for cattle ranches, left much of Colorado deforested. Realizing the problems caused by deforestation, and seeking a sustainable source of fuelwood, COONAPROSAL, in 1988, purchased over 300 hectares of old pasture land and proceeded to reforest using both native and non-native tree species. I was assigned to work in the recently formed Agroforestry section of the cooperative, which dealt with the management of these lands.

Through visits to private farms and through my work with the cooperative, I began to realize that the lack of forest cover caused first by cattle ranching and later by both ranching and salt production combined was a serious environmental problem. After discussing the problem with host country counterparts and area ranchers, this project was planned and executed. The goal of the following research was not only to fulfill my Peace Corps and M.S. degree requirements, but, more importantly, to assist Guanacaste ranchers to incorporate trees into degraded pastures.
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INTRODUCTION

Tropical deforestation has been blamed for loss of biodiversity and environmental problems worldwide. Large areas of tropical forests have been converted to other uses and degraded. It is estimated that by the year 2,000, tropical deforestation rates could be as high as 20.4 million hectares per year (Panayotou and Ashton, 1992; WRI, 1990). Adverse effects associated with forest degradation include loss of soil fertility, increased atmospheric CO2 levels, and reduction of genetic diversity (Panayotou and Ashton, 1992).

Cattle ranching and the conversion of forests to pastures have been blamed for extensive deforestation, especially in Central and South America (Edelman, 1992; Parsons, 1988). Rising beef prices, coupled with government and international lending institution policies contributed in large part to the clearing of tropical forest land (Myers, 1981; Parsons, 1988). The once extensive Tropical Dry Forest along the Pacific in Central America, for instance, has been reduced to only 0.1% of its original size (Janzen, 1988).

Cultural factors can also contribute to deforestation. Cattle ranching is perceived as a prestigious activity in Latin America and ranchers are typically wealthy elite who admire the cowboy lifestyle (Edelman, 1992; Barnhorn, 1997). Cattle ranchers also have forceful lobbies and strong political leverage that enable them to affect government policies to their favor (Barnhorn, 1997; Edelman 1992; Myers 1981; Parsons, 1988). The ranching industry has been accused of environmental degradation, unemployment, and being extremely unproductive (Edelman, 1992; Parsons, 1988). The sale of low grade beef, primarily from Central American countries to developing countries, has been termed the
Many U.S. companies purchase beef from Central America (Parsons, 1988).

In Costa Rica, in general, and in the northwestern province of Guanacaste in particular, extreme examples of unemployment and environmental problems due to extensive cattle ranching exist. From the 1960s until recently, Costa Rica had extremely high rates of deforestation, between 30,000 and 50,000 ha/year, primarily due to the conversion of tropical dry and humid forests to cattle pasture (Thatcher et al., 1997; Segura, 1992). Guanacaste was originally covered primarily by tropical dry forest (Holdridge, 1956). These forests were cleared extensively after WWII because of high beef prices on the international market and government subsidies given to Costa Rican ranchers (Janzen, 1983; Edelman, 1992).

Costa Rica began to export beef in the 1940’s and 50’s, and the national cattle herd grew even though domestic beef consumption steadily declined (Barnhorn, 1997). By 1961, Guanacaste had lost the majority of its forest cover (Flores Rodas, 1985) (See Figure 1) and by 1963 Costa Rica had 2.3 million head of cattle, more than the national human population (Pérez, 1994). While beef prices have fallen and technologies exist to intensify beef production, Guanacaste remains largely in extensive cattle ranches, many of which contain degraded pasture.

In response to local and international concerns, and in an attempt to meet demand for wood products, Costa Rica began providing reforestation incentives to ranchers in 1989 (Barnhorn, 1997; Edelman; 1992; Thatcher et al.; 1997). There was also a call to intensify cattle ranching (Pérez, 1994; Combe, 1981). Many ranchers currently use highly productive imported African pasture grasses and have adopted rotational grazing, fencing
Figure 1: Dense Forest Cover (80% to 100%) in Costa Rica in 1950, 1961, and 1983

Source: Flores Rodas 1985, p 23 (Barnhorn 1997)
and improved breeding programs in an attempt to increase ranch productivity (Pérez, 1994; Urcuyo, 1995).

**Incorporating trees into Guanacaste pastures**

Agroforestry and sylvopastoral systems are another potential means by which cattle production could be intensified in Guanacaste. Trees could be advantageous to cattle ranchers for a number of reasons, including: provision of shade and wind protection for livestock as well as providing wood for fencing, fuelwood, and light construction.

Perhaps most importantly, the sale of timber, fruit, or other tree products could enable ranchers to diversify production and reduce dependence on the beef market (Gelfius, 1994; Russo, 1993). Indeed, planting trees has the potential to provide social benefits to area inhabitants as well. These benefits range from provision of fuelwood to new employment opportunities (Arnold & Falconer, 1989; Arnold, 1991). Additionally, fruit trees planted in pasture could improve nutritional intake of the landowner and in some instances that of the local population (Arnold, 1991).

Planted trees also provide valuable ecological benefits such as soil amelioration and wildlife habitat (Gelfius, 1994; Bazill et al., 1995). Finally, increased planting of trees in pastures could help Costa Rica meet its growing demand for wood products.

The incorporation of trees into Guanacaste pastures is not a panacea, however. Adverse effects of planting trees in pasture areas include competition of the trees with grasses for available light and increased soil compaction and root damage to the planted tree (due to increased use by cattle for shade) (Combe, 1981; Beer 1994; Russo, 1993). Table 1 illustrates both the advantages and disadvantages of planting trees in pasture.
**Table 1 Advantages and Disadvantages of Planting Trees in Pasture**

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shade for cattle/ ranch workers</td>
<td>Loss of pasture</td>
</tr>
<tr>
<td>Forage for cattle</td>
<td>Trees could compete with crops</td>
</tr>
<tr>
<td>Soil improvement</td>
<td>Bad tree form (due to light abundance)</td>
</tr>
<tr>
<td>Ranch beautification</td>
<td>Soil compaction &amp; root damage below tree</td>
</tr>
<tr>
<td>Fence post production</td>
<td>Increased insect damage to cattle</td>
</tr>
<tr>
<td>Wind breaks</td>
<td></td>
</tr>
<tr>
<td>Rapid growth (light abundance)</td>
<td></td>
</tr>
<tr>
<td>Wildlife habitat</td>
<td></td>
</tr>
<tr>
<td>Improved nutrition (fruit trees)</td>
<td></td>
</tr>
</tbody>
</table>


*A note on indigenous trees and indigenous knowledge*

Many forestry and agroforestry projects have come under attack in recent years for not taking into consideration the thoughts and needs of the local population (Arnold & Falconer, 1989; Arnold, 1991). Fairfax and Fortmann (1990) point out that many outside directed, "western" biased projects have resulted in unsuccessful development efforts. Blaikie (1995) advocates a more "interactionist" development approach. To enhance prospects for success, scientists and development specialists working in the tropics need to include local residents in the design and management of their development projects and concern themselves with local political and social realities (Blaikie, 1995). Land tenure, land accessibility, cultural issues, and local policy are particularly important to the development of successful agroforestry and sylvopastoral projects (Blaikie, 1995; Arnold & Falconer, 1989; Arnold, 1991; Fairfax & Fortmann, 1990). In Guanacaste, landowners, ranchers, and ranch managers have a wealth of knowledge about local tree species. One
of the main goals of this project was to involve ranchers and utilize their expertise in agroforestry to identify local multipurpose indigenous trees.

Trees native to Guanacaste were investigated in this study. Indigenous Guanacasteco tree species are well adapted to the harsh dry season, are familiar and available to local ranchers, and in some instances markets already exist for their timber or other products.

The incorporation of exotic tree species into a new area without fully considering environmental and economic factors is frequently problematic. Rocheleau and Ross (1995) found that an exotic species, *Acacia mangium*, caused household problems and led to increased deforestation in the Dominican Republic. In Colorado de Abangares, Costa Rica, the Indian tree species *Gmelina arborea*, was planted on a large scale in the late 1980s and is now maturing. According to local ranchers, cutting and transporting Melina costs more than the value of its timber (several ranchers, pers. comm.) Furthermore, Melina is not suitable for fenceposts or fuelwood (Asdrubal Venegas, Forester, 1997). Thus, ranchers who have planted Melina have no use or market for its wood.

OBJECTIVES

This study, carried out in the district of Colorado de Abangares, Guanacaste, investigated rancher interest, knowledge, and use of native tree species. This information was then used to identify two promising multipurpose trees for incorporation into local pastures. The specific research objectives were as follows:

1) Survey ranchers to determine their use of wood products, interest in planting trees in pastures, and to identify lesser-known multipurpose indigenous tree species of special interest/use to area ranchers.
2) Review the available scientific literature and collect seed germination rates and tree nursery data on rancher selected tree species.

3) Conduct on farm growth and survivability trials of selected species and investigate the effects of various fertilizer treatments on initial seedling growth; and

4) Disseminate information regarding promising species to ranchers interested in incorporating trees into their pastures, to government agencies, and to private organizations involved in reforestation and agroforestry efforts.

RESEARCH SITE AND STUDY METHODS

*Colorado de Abangares*

Colorado de Abangares is a town of approximately 3,000 people located in the southwestern part of Guanacaste, Costa Rica (Fig. 2). The town was founded in the late 1800s and its principal industries are ranching, fishing and salt production (Edelman, 1992) (Table 2). Because of its access to the sea, Colorado’s valuable hardwoods, such as Mahogany, (*Swietenia macrophylla*), were logged in the early 1900s (Edelman, 1992). The area was extensively deforested during the 1950s cattle boom as is evident through the observations of local ranchers.

> “Until 30 or 40 years ago, there were big trees and a lot of forest, the landowners first came and took out the big trees for wood and salt and then cut and burned everything for pasture”. (Luis Rojas, ranch hand, January 1997)

> “There is now some regeneration of vegetation on the surrounding hills. About 20 years ago there was nothing but pasture, as far as the eye can see”. (Phillipe Guitierrez, Rancher, February 1997)

Colorado also lost extensive forest cover due to salt production. Salt is extracted by forced evaporation through cooking. Until recently, the National Cooperative of Salt
Figure 2: Map of Colorado de Abangares and Guanacaste
Source: Edelman, 1992
Producers (COONAPROSAL), based in Colorado, used wood to fuel their salt refinery. They used an estimated 9,450 m³ of fuelwood per year until the refinery was permanently closed in 1997 (Noguera, 1995; Asdrubal Venegas, pers. comm., 1997). The combination of salt production and ranching left Colorado deforested.

<table>
<thead>
<tr>
<th>Table 2: General Data, Colorado de Abangares</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Population:</strong></td>
</tr>
<tr>
<td><strong>Annual rainfall</strong></td>
</tr>
<tr>
<td><strong>Holdridge Life Zone:</strong></td>
</tr>
<tr>
<td><strong>Major industries:</strong></td>
</tr>
<tr>
<td><strong>People/km² (cantón):</strong></td>
</tr>
<tr>
<td><strong>Average ambient T°C:</strong></td>
</tr>
</tbody>
</table>

Sources: ¹ Municipality of Colorado, ² Nuñez, 1988; ³ Ministry of Health.

Cattle ranches are large in Colorado. The average size is over 100 hectares (pers. obs.). Generally, ranch owners live in San José (or the elsewhere in the Central Valley) and visit their ranches once a month. Ranch management is left to an administrador or manager who lives on site. The administrador is in charge of pasture preparation, ranch maintenance, and all cattle activities. Land tenure and “tree tenure” have been identified as important factors in the decision of whether or not to plant trees (Bruce & Fortmann, 1992; Fortmann, 1985). Most, but not all, of the ranch managers in Colorado can plant trees without the owner’s permission and some derive some benefits from planted trees (e.g. fruit and sometimes timber).

While some areas are slowly returning to forest due to inaccessibility or because pasture maintenance is simply not feasible (e.g., steep sites), the region remains largely deforested. Not coincidentally, the trees that are most widely used for fence posts and for
timber are also the scarcest. Local landowners and *administradores* use wood for fence posts, corrals, houses, fuelwood, and for sale to timber mills and salt producers. At present, agroforestry practices such as live fences are less common here than in other parts of Guanacaste (pers.obs.).

*Rancher Survey*

A survey was developed and administered to 33 ranch owners and *administradores* in the district of Colorado. The survey gathered information regarding rancher opinions about trees and their incorporation into pastures, their knowledge of and potential interest in incorporating trees into existing cattle pastures, and recommendations regarding specific multipurpose tree species of particular interest (see Appendix I for survey instrument). The survey focused primarily on tree species native to Guanacaste. Native species are well adapted to the harsh Colorado dry season, are well known to area cattlemen, and their seeds are easily obtained. Ranchers that possessed between 10 and 500 hectares were interviewed for this study. While little data about the rancher population exists, there are approximately 100-120 ranchers in the Colorado district with landholdings of this size.

Using a combination of a personal list of ranchers and a partial list provided by the Ministry of Agriculture and Cattle, 33 ranchers were chosen for an interview. Fifteen of the ranchers were selected randomly from the combined list. The remainder were selected from the list because of their close proximity to Colorado or their accessibility. The interviews were conducted from October of 1996 through March of 1997 and each lasted approximately 40 minutes. Approximately half (48%) of the interviews were conducted with the landowner, while the remainder were carried out with on-site ranch managers.
All ranches were visited after the interview to check the veracity of the respondent’s statements regarding tree and grass species present, approximate ranch size, and types of cattle owned.

*Seed Germination Trials*

Survey respondents identified two indigenous tree species of particular interest: *Cenizaro (Samanea saman)* and *Tempisque (Sideroxilum capirie)*; a series of germination trials for both species were then developed.

First, excellent “parent” or “seed” trees were identified, specifically individuals that appeared healthy and well formed, and that produced large quantities of seeds (Gelfius, 1994). Seeds from these trees were collected, cleaned, and dried in the shade. The seeds were then treated and planted in 1 meter x 1 meter boxes.

For the *S. capirie* tests, there were five treatments with 13 seeds/treatment. The five treatments included: 1) seeds submerged in boiling water for 1 minute, 2) seeds submerged in boiling water for 2 minutes, 3) outer seed casing perforated with a knife, 4) seeds submerged for one minute in boiling water, then placed overnight in cold water, and 5) control (seeds not treated) (Gelfius, 1994; Rojas, 1994). The seeds were observed for 90 days to determine germination rates.

For the *S. saman* tests four treatments were employed, with 12 seeds/treatment. Treatments included: 1) seeds clipped with pliers, 2) seeds submerged in boiling water for 1 minute, 3) seeds submerged in boiling water for 2 minutes and 4) control (seeds not treated) (Gelfius 1994; Rojas, 1994). The seeds were observed for 14 days to determine germination rate.
Tree Nursery

Seeds were planted directly into 10 x 20 cm black plastic nursery bags in late February. The bags contained a clay loam soil similar to that found in the study site. A level, fenced area, with shade and water nearby was selected for a nursery site (Rojas, 1994; Gelfius, 1994). The seedlings were maintained in the nursery for four months where they were watered twice daily and treated with Mirex™ to combat Leaf Cutter Ants as needed.

Study of Growth and Survivorship of A. guachapele and S. Saman

A total of 90 seedlings of each species were transplanted to a homogenous block of open pasture after they attained a height of approximately 30 cm. The seedlings were transplanted in late June 1997, into 2 different environments (grazed and ungrazed) in separate populations (A. guachapele & S. saman) employing a split plot design. Thus, there were 4 plots (Figure 3), with each plot containing 45 seedlings. The plots were numbered as follows: 1) A. guachapele exposed to grazing, 2) S. saman exposed to grazing, 3) A. guachapele ungrazed and 4) S. saman ungrazed. The ungrazed plots were protected from cattle by fencing. Seedlings of both species were planted at 2 meter intervals.

All seedlings, both inside and outside the exclosure were then randomly selected for one of three treatments: 1) 2 treatments of 10-30-10 inorganic fertilizer, 2) 2 treatments of chicken manure (mixed with some soil and rice husks), and 3) control- no fertilizer. There were 15 seedlings in each treatment.
Figure 3: Growth and Survivability Study Design

C: Control seedlings (no treatment)
F: Seedlings treated with 10-30-10
M: Seedlings treated with chicken manure

A. *guachapele* exposed to grazing

| CFCMFCMCCCFFCM | FFCMFCMCCCFFCM |
| MMFCFCCMCMFCFCF | MMFCFCCMCMFCFCF |
| FFMCMCFMCMFFMM | FFMCMCFMCMFFMM |

A. *guachapele* ungrazed

| CFCFFFFCMFCFCMM | FCMFFFFCCCMFCCC |
| CMCCFCFFMMFFCM | MCMCMCCCMCMCFMF |
| CMFCMCMCMFFFM | MMFFMFCMCMCFMCF |

S. *saman* exposed to grazing

| FFCMFCMCCCFFCM | FCMFFFFCCCMFCCC |
| MMFCFCCMCMFCFCF | MCMCMCCCMCMCFMF |
| FFMCMCFMCMFFMM | MMFFMFCMCMCFMCF |

S. *saman* ungrazed
Study site

One of the ranchers interviewed during the survey expressed particular interest in *A. guachapele* and *S. saman* and donated a parcel of land for the pasture trials. The site was a level, open pasture on compacted clay-loam Inceptisol. The soil had a pH of 5.7, 4.29% organic matter, and is considered by many ranchers to be “excellent planting soil”. The study area was covered primarily by *Cynodon spp.*, known locally as “*estrella*” or star grass. *Estrella* was imported from Africa earlier this century to improve pasture productivity (Urcuyo, 1995) and is used by 47% of the ranchers interviewed. The site was at an elevation of 10-12 meters above mean sea level and located approximately 0.5 km from the Pacific Ocean. The site was under a system of rotational grazing on a ranch that encompasses 400 hectares and 250 head of cattle.

RESULTS AND DISCUSSION

Survey

Survey respondents expressed high regard for trees and interest in incorporating more trees into their pastures. Specifically, 88% of survey respondents were interested in planting trees on their land while 43% of the ranches had live fences (either from planting or natural regeneration or both). Twenty seven percent expressed concern about the loss of wildlife habitat caused by local deforestation. Only 9 % indicated that they have no interest in planting, primarily because they felt that trees only compete with grass. Table 3 lists some general ranch data acquired from the survey.

Almost all of the ranchers were quite knowledgeable of native trees. Furthermore, one of the respondents stated that ranchers are the true authorities on local trees, because they use and see them every day.
"The people that live and work with the trees are the ones who are knowledgeable. I know the trees that are good for cattle. Many times technical types come here and say they know what is good. How can they when they live in the Central Valley, where it is cold. One time a man wanted to reforest his land with Laurel (*Cordia alliodora*) and I told him and his forester that it wouldn’t work, that Laurel doesn’t grow well here. The forester cited some studies and proceeded to plant them anyway, thousands of them, I think there are maybe 5 alive today”. (J. Valverde, rancher, pers. comm, 1997).

<table>
<thead>
<tr>
<th>Table 3: Ranch Characteristics, Colorado de Abangares</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average size (ha):</td>
</tr>
<tr>
<td>No. workers/ ranch</td>
</tr>
<tr>
<td>(ha) of natural regeneration/ ranch</td>
</tr>
<tr>
<td>Head of cattle/ ranch</td>
</tr>
</tbody>
</table>

Ranchers expressed particular interest in several well-known fine wood tree species including *Cedrela odorata* and *Bombacopsis quinatum*. Field trials were not conducted on these species because a great deal is known about them both locally and in the scientific literature. Instead, fieldwork focused on two lesser-known multipurpose indigenous species that were also of interest to local ranchers, Guayaquil (*Albizia guachapele*) and Cenízaro (*Samanea saman*). General information on two other rancher recommended species, *Andira inermis* and *Sideroxilum capirie*, will also be included here because they warrant further investigation. However, growth and survivorship studies were not conducted on these species. Table 4 displays the tree species most frequently mentioned by Colorado ranchers.

*Albizia guachapele* (Kunth) Dugan

Guayaquil is a multi-purpose tree native to Guanacaste that was mentioned by over 50% of the ranchers surveyed. *A. guachapele* (synonym *Psuedosamanea guachapele*),
also known locally as Gavilán, has a natural range from Mexico to Colombia and is a nitrogen fixer of the family Fabacea (Rodriguez, 1995; Barneby & Grimes, 1996).

*-* guachapele is widely admired by ranchers for its fine furniture wood and, above all, for the length of time that its cut wood lasts in the ground as a fence post. According to local ranch workers, Teak (*Tectona grandis*) posts last only 10 years and several other species only last 5 years, while *-* guachapele* posts can last for 20 years or more (pers. comm.). Indeed, the beautiful red Guayaquil wood is both fungus and termite resistant (Nichols and Rodriguez, 1990).

**Table 4: Important Pasture Trees in Guanacaste**

*According to Rancher Survey, Colorado de Abangares*

<table>
<thead>
<tr>
<th>Species</th>
<th>Common name</th>
<th>Principal Use</th>
<th>Popularity*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <em>Albizia guachapele</em></td>
<td>Guayaquil</td>
<td>fenceposts</td>
<td>+</td>
</tr>
<tr>
<td>2. <em>Andira inermis</em></td>
<td>Almendro de Monte</td>
<td>shade</td>
<td></td>
</tr>
<tr>
<td>3. <em>Bombacopsis quinatum</em></td>
<td>Pochote</td>
<td>fine wood</td>
<td>+</td>
</tr>
<tr>
<td>4. <em>Brysonima crassifolia</em></td>
<td>Nance</td>
<td>fuelwood, fruit</td>
<td></td>
</tr>
<tr>
<td>5. <em>Cedrela odorata</em></td>
<td>Cedro Amargo</td>
<td>fine wood</td>
<td>+</td>
</tr>
<tr>
<td>6. <em>Diphysa robinoides</em></td>
<td>Guachipelin</td>
<td>fenceposts</td>
<td></td>
</tr>
<tr>
<td>7. <em>Enterolobium cyclocarpum</em></td>
<td>Guanacaste</td>
<td>fine wood</td>
<td></td>
</tr>
<tr>
<td>8. <em>Genipa americana</em></td>
<td>Guatil</td>
<td>wildlife</td>
<td></td>
</tr>
<tr>
<td>9. <em>Guazuma ulmifolia</em></td>
<td>Guácimo</td>
<td>fuelwood, forage</td>
<td>+</td>
</tr>
<tr>
<td>10. <em>Lysiloma seemanii</em></td>
<td>Quebracho</td>
<td>fuelwood, fenceposts</td>
<td></td>
</tr>
<tr>
<td>11. <em>Mangifera indica</em></td>
<td>Mango</td>
<td>fruit, shade</td>
<td></td>
</tr>
<tr>
<td>12. <em>Samanea saman</em></td>
<td>Cenizaro</td>
<td>fine wood</td>
<td></td>
</tr>
<tr>
<td>13. <em>Sideroxilum capirie</em></td>
<td>Tempisque</td>
<td>wildlife</td>
<td></td>
</tr>
<tr>
<td>14. <em>Spondias purpurea</em></td>
<td>Jocote</td>
<td>fruit, live fence</td>
<td></td>
</tr>
<tr>
<td>15. <em>Tectona grandis</em></td>
<td>Teca (Teak)</td>
<td>fine wood</td>
<td></td>
</tr>
</tbody>
</table>

Notes: * over 50% of ranchers surveyed mentioned this species

*A. guachapele* has a rapid growth rate (Rodriguez, 1995; Schroth et al., 1996 and Noguera, 1995) and high biomass production (Stewart & Dundson, 1994). It also has
dense wood and was one of the most sought after fuelwoods in the salt refining process. It appears to grow well in heavy clays (Nichols and Rodriguez, 1990) and denuded areas (pers. obs.). It is used by ranchers for fuelwood, fences, and because of its beauty.

Guayaquil flowers in a very rapid and spectacular fashion in January and February. The preferred seed treatment is to place the small seeds in boiling water for 1 minute and then leave them in cool water until they expand (Rodriguez, 1995; Adrubal Venegas, pers. comm.; pers. obs.).

Table 5: Summary Table of Four Important Native Trees in Guanacaste

<table>
<thead>
<tr>
<th>Species</th>
<th>Common Name</th>
<th>N2 fixer?</th>
<th>Usefulness to Rancher</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. guachapele</td>
<td>Guayaquil, Gavilán</td>
<td>yes</td>
<td>Fence posts, timber, soil enrichment, forage</td>
</tr>
<tr>
<td>A. inermis</td>
<td>Almendro de Monte</td>
<td>yes</td>
<td>Timber, shade, ranch beautification, soil enrichment.</td>
</tr>
<tr>
<td>S. capirie</td>
<td>Tempisque</td>
<td>no</td>
<td>Timber, wildlife habitat, aesthetics</td>
</tr>
<tr>
<td>S. saman</td>
<td>Cenizaro</td>
<td>yes</td>
<td>Forage, shade, timber, soil enrich.</td>
</tr>
</tbody>
</table>

**Andira inermis (Kunth)**

*Andira inermis* is an excellent shade tree that has durable, termite resistant wood with a specific weight of 0.63-0.88 (Benson & Blegen, 1994). One landowner demonstrated a few stout supports in his barn and proclaimed that they were constructed from Almendro wood 80 years ago by his grandfather. *A. inermis* is a large, leguminous, evergreen tree with a dense canopy that ranges from Southern Mexico to Peru, Bolivia and Brazil (Navarette, 1996). It prefers riparian areas and can attain a height of 27 meters (Benson & Blegen, 1994).
In Costa Rica, *A. inermis* appears to flower and produce fruit only every other year (Hartshorn, 1983). In Colorado, during the dry season of 1997, only 2 of 6 observed specimens flowered. In the wild, it is bat dispersed, particularly by the Jamaican Fruit Bat, *Artibeus jamaicensis* (Janzen, 1983). When seeds are collected, it is recommended to scarify the fruit endocarp or place them in boiling water. This species was not included in the study because of time constraints and the late (April & May) availability of seeds. Nevertheless, more research is warranted on the propagation of *A. inermis* and on its potential role in agroforestry systems because it is valuable as a shade producer and forage provider to wildlife. It is notable that ranchers leave this tree in pastures, not only because of its shade value, but also because of its appearance.

*Samanea saman* (Jacq. Merr.)

*S. saman* is a large tree with a wide spreading crown that is found throughout the tropics where it is prized as an ornamental and used for furniture (Raintree, 1987). It can reach a height of over 45 meters with a diameter of several meters. *S. saman* is a member of the Fabaceae family and is commonly referred to in the literature by its synonyms *Pithecellobium saman* and *Albizia saman*. The wood has a beautiful marble coloration and is highly sought after by Guanacaste sawmills. It has a specific weight of 0.44 (Benson & Blegen, 1994).

Ranchers retain *S. saman* in pastures not only because of the price it fetches at sawmills but also because of the shade it offers, its beauty, and the nitrogen rich seed pods that it produces every dry season, which cattle readily consume. Two possible disadvantages of this species are its slow growth (Stewart and Dundson, 1993; Akkasaeng, 1989) and the belief among many ranchers that it induces miscarriages in
cattle that feed on it. Forty percent of survey respondents reported that they had heard that ingestion of Cenizaro seeds caused abortion, but only 15% believed it. Seeds fall in March and April, the two harshest months of the dry season. It is possible that the seed fall coincides with a time that is notoriously high in cattle miscarriage.

**Tempisque (Sideroxilum capirie)**

*S. capirie* is a large tree, generally restricted to riparian areas or areas with subsurface irrigation. It is also known by its synonym, *Mastichendron capiri* and is a member of the Sapotaceae family. *S. capirie* grows to a height of 34 meters, is evergreen (although like *A. inermis*, it has a short leafless spell), and has rough, shaggy bark on a straight trunk. The wood is very tough, with a specific weight of 1.05 (Benson & Blegen, 1994).

*S. capirie* is of value to ranchers for its fine wood and importance to wildlife. In Colorado, hunters often wait beneath Tempisque trees, waiting for a chance to shoot Collared Peccaries or White Tailed Deer that feed on the fallen fruit. Janzen, (1983) noted that Coyote scat contained *S. capirie* seeds. Apparently, the seeds are dispersed by mammals, especially bats (several ranchers, pers. comm.). The seeds have low germination rates and take a very long time to germinate (Benson & Blegen, 1994)

**Seed germination trials**

*S. capirie* seeds took much longer than *S. saman* seeds to germinate (Figures 4 and 5). Clipping the outer seed coat of the *S. saman* seeds was the best treatment method. Clipped seeds experienced 100% germination after a 1-week period. 25% of the seeds that were placed in boiling water for 2 minutes germinated after 7 days.
Figure 4: Germination of S. saman Seeds After 1 Week (n=12)

T1: control, T2: clipped, T3: 1 min boiling water, T4: 2 min boiling water

S. capirie seeds exhibited a low germination rate. Only 12% of the seeds tested germinated after an 8 week period. Twenty three percent of the seeds submerged in boiling water for 2 minutes germinated.

Figure 5: Germination of S. capirie Seeds After 8 Weeks (n=13)

T1: 1 min boil H20, T2: 2 min boil. H20, T3: clipped, T4: 1 min boil. H20, 1 night cold H20, T5: Control
Results from growth and survivability trials of *A. guachapele* and *S. saman*.

Cattle ranged freely through the site at various times throughout the study period (Table 6). On two occasions horses were present as well. Although cattle were in the study area for only short periods, by mid November they had grazed 100% of the trees of both species planted outside the exclosure (Table 7). Despite the intense grazing pressure, 80% of the *S. saman* and 96% of the *A. guachapele* seedlings survived the 5 months following the transplant. Within the exclosure, 89% of the *S. saman* and 100% of the *A. guachapele* seedlings survived. The mortality rate of *S. saman* inside the exclosure resulted in part due to rabbits; rabbits grazed 6 *S. saman* individuals inside the exclosure, 3 of which died.

The 1997 rainy season was very dry due to a forceful El Niño (MINAE, 1997; pers. obs.). Consequently, cattle grazing pressure on the seedlings outside the exclosure could be higher than in wet years because the seedlings were the only green leaves in the otherwise desiccated environment. The trees inside the enclosure grew well, however. Their mean heights at the end of the rainy season are summarized in Table 8.

![Table 6: Summary of Cattle Presence in Study Area, 1997](image-url)
Table 7: Seedling Mortality Rates of *A. guachapele* and *S. saman* After 5 Months

<table>
<thead>
<tr>
<th>Species</th>
<th>Inside exclosure</th>
<th>Outside exclosure</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>A. guachapele</em></td>
<td>0%</td>
<td>4%</td>
</tr>
<tr>
<td><em>S. saman</em></td>
<td>11%</td>
<td>20%</td>
</tr>
</tbody>
</table>

The growth rates of control seedlings or those treated with organic or inorganic fertilizers were not significantly different (Table 8). This could be due to the lack of rainfall that may have affected fertilizer availability to the roots. *A. guachapele* grew more rapidly, and also resprouted faster than *S. saman* during the 5 month study period when it was grazed or damaged. Both species had nitrogen fixing *Rhizobium*

Table 8: Effects of Fertilizer Treatments on *A. guachapele* and *S. saman* Seedlings

<table>
<thead>
<tr>
<th>Species</th>
<th>Treatment</th>
<th>Mean Hgt. (cm)</th>
<th>St. dev. (cm)</th>
<th>*</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>A. guachapele</em></td>
<td>10-30-10</td>
<td>86.3</td>
<td>17.3</td>
<td></td>
</tr>
<tr>
<td><em>A. guachapele</em></td>
<td>Chicken man.</td>
<td>78.6</td>
<td>11.8</td>
<td></td>
</tr>
<tr>
<td><em>A. guachapele</em></td>
<td>Control</td>
<td>87.2</td>
<td>17.5</td>
<td></td>
</tr>
<tr>
<td><em>S. saman</em></td>
<td>10-30-10</td>
<td>64.6</td>
<td>16.4</td>
<td></td>
</tr>
<tr>
<td><em>S. saman</em></td>
<td>Chicken man.</td>
<td>64.2</td>
<td>13.0</td>
<td></td>
</tr>
<tr>
<td><em>S. saman</em></td>
<td>Control</td>
<td>59.3</td>
<td>9.60</td>
<td></td>
</tr>
</tbody>
</table>

* Differences significant at α=0.05
bacteria present when checked in the field. Figure 6 displays the wet season growth rates of both species.

![Figure 6: Wet Season Growth Rates of Enclosed Trees](image)

*Advantages and disadvantages of planting *A. guachapele* and *S. saman* in pasture.*

Establishment of *A. guachapele* or *S. saman* in pastures appears to require cattle exclosures, both to increase survivorship and growth rates, as well as to protect the form and thus future market value of the trees. Young trees may survive in active pasture but their form, after being grazed by cattle, will be severely affected. Starting a small tree plantation or line of trees (including nursery costs) on farm is inexpensive. Not including the price of tools (which most ranchers already have), the total cost of materials in this study cost approximately $62. In addition to capital expenses, labor is needed to maintain fencing and to prune and care for the trees.

A possible constraint to the incorporation of trees in pasture is the fact that trees will compete with grasses for sunlight. In addition, pasture inside a livestock exclosure is idle
and not available for grazing. Planting either of these two species could also increase mosquito and deer fly populations due to a reduction in wind velocity. Finally, soil beneath tree canopies could be compacted due to increased use by cattle for shade.

According to interviews with Colorado’s ranchers, in most instances, the advantages of incorporating trees into pastures appear to outweigh the disadvantages. Nevertheless, ranchers need to carefully evaluate the opportunities and constraints of planting trees in pasture before making an investment. One of the promising aspects of planting trees in pasture vs. trees in plantation is that while small landholders may not have sufficient space for a plantation, they often have the room and need for live fences or trees planted in pasture (Beer, 1994). Cameron, et al., (1991), suggest planting 500 trees per hectare in order to produce fenceposts or fuelwood concurrently with pasture or a stocking rate of 300 trees per hectare if the landowner is interested in producing timber.

RECOMMENDATIONS AND CONCLUSIONS

Perhaps the most important finding of this project is the importance ranchers ascribe to trees for timber, forage, shade, fenceposts, and many other uses. Ranchers were particularly interested in reforesting riparian areas and springs; 88% of those interviewed were interested in planting more trees. Clearly, these Guanacaste ranchers do not fit their “tree enemy” image (Bazill et al., 1995).

Rancher surveys are valuable tools and have been shown to be effective at determining rancher’s interests (Montagnini, 1992; Bazill et al., 1995). They allow researchers and development specialists to identify species actually used by landowners, and the reasons for their use. They are particularly valuable when they provide information regarding little known but highly valued indigenous tree species that are frequently overlooked in
reforestation efforts. In this study, ranchers were more familiar with and likely to use local species because they are adapted to local conditions. Furthermore, markets already exist for some local trees such as *A. guachapele* and *S. saman*.

Scientific research built upon local knowledge contributes to program success (Chambers, 1994). All too often building upon local knowledge is overlooked and species are introduced because of their financial value or because of good performance in site trials elsewhere. Valuable wood and nitrogen fixation, which are typically valued in reforestation projects, are important to ranchers, but so is the “look” of the tree as well as its growth rate, the habitat that it provides for wildlife, and shade that it provides to cattle. Rancher interviews to determine appropriate tree species for planting are applicable anywhere that agroforestry or sylvopastoral systems are implemented.

The four species reviewed in this study are important to cattle ranchers in Colorado de Abangares and certainly could be utilized elsewhere. *Albizia guachapele*, a native species of Costa Rica, is already grown in Africa and Asia, and is gaining notoriety for its fast growth rate (Stewart & Dundson, 1994). *Samanea saman* wood is prized by Malaysian foresters for its wood and it can be found as an ornamental tree well outside its native range (Raintree, 1987). *Sideroxylum capirie* is valuable for wildlife and its wood is exceptionally strong and durable. *Andira inermis* wood can be used for shade, to make corrals, and for heavy construction. Further studies of these four species are warranted to assess their suitability in agroforestry and sylvopastoral systems.

Of the two species recommended by ranchers and field tested, *A. guachapele* grew faster than *S. saman*. The fact that Guayaquil is locally scarce suggests its importance to the rancher. It is frequently cut for both fuelwood and fencing. While working for the
Peace Corps, I recommended that ranchers form woodlots or "bosquetes" of this species meet their future fuelwood and fence post needs. These trees can also be planted along fencelines where they protect against wind, provide shade, improve the soil and bring a host of ecological benefits (Beer, 1994; Gelfus, 1994). *A. guachapele* meets the requirements of a good "fence row" tree when analyzed using criteria outlined by CATIE (Beer 1994). It does not overly compete with pasture because of a sparse canopy (Schroth et al., 1996), it grows rapidly, it is leguminous, and is native to Guanacaste. Guayaquil's palatability to cattle and its ability to fix atmospheric nitrogen give it promise as a forage species. Of course, ranchers that plant this species along fences or between crops will have to use fencing for at least the first three years.

Combining trees with pasture is an obvious way to intensify ranch production, provide forage and shade to livestock and diversify ranch income. In Guanacaste, planting trees valued for timber and/or fuelwood offers advantages to area ranchers and could ameliorate some of the adverse environmental effects associated with decades of cattle ranching. Trees such as *A. guachapele* planted in small plantations, in open pasture, or along fences may improve not only soil characteristics and wildlife habitat, but also diversify cattle ranch production. Sylvopastoral systems such as these could also reduce timber pressure on remaining intact natural forest. In Colorado de Abangares, planting trees such as *A. guachapele* in pasture could satisfy local fuelwood and construction demands as well as bring myriad ecological benefits to area inhabitants.
APPENDIX I: Cattle Rancher Survey
Colorado de Abangares

Basic Data

1. Date:
2. Name of rancher
3. Ranch name:
4. Location:

Ranch Production

5. Ranch size:
6. Distribution of activities:

<table>
<thead>
<tr>
<th>Activity</th>
<th>ha</th>
<th>% of ranch</th>
</tr>
</thead>
</table>

Forestry and Agroforestry

7. How many cattle do you have?
8. What types and ages of cattle do you have?
9. What type of pasture grass do you have on the ranch?
10. How many full time workers do you employ?
11. Is there natural forest? How many hectares?
12. Do you have forestry plantations? How many hectares? What species?
13. Have you sold timber or fuelwood before? What species?
14. Which timber species are present in your ranch? Which fuelwood species?
15. When there is natural regeneration of forest, which species appear?
16. Are the timber trees that you have planted, from natural regeneration, or left from when the original was cleared?
17. Do you use live fences?
18. Do you have Cenizaro (Samanea saman) growing on your ranch? What is your opinion of it?
19. Which timber trees are your favorite and why?
20. Which trees are good for fenceposts?
21. Which trees are good for cattle (shade and forage).
22. Which trees grow well here in Colorado?
23. Which trees are good for wildlife.
24. Do trees affect pasture growth? How?
25. Would you be interested in planting more trees?
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