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Articles

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2008 TRI Fellows in this Issue

Twenty-five TRI and three Compton Fellowships were awarded in 2008 to support research in tropical and subtropical areas around the world. Eleven fellows and their work are highlighted in this issue of the TRI Bulletin.

ARGENTINA. ***Tal Ilany*** is completing a Master of Forest Science degree at Yale's School of Forestry and Environmental Studies. Her focus is primarily on soil and forest ecology and agroforestry and plans to pursue a PhD in these subjects. Before coming to Yale, Tal worked on a project to improve environmental education curricula in higher education. She holds a BA from Carnegie Mellon University where she studied studio art.

Janet Lawson is a second–year Master of Environmental Science candidate at the Yale School of Forestry and Environmental Studies. Her research focuses on agricultural policy and development. Before coming to Yale, she served as an agricultural extension volunteer with the Peace Corps in Paraguay and worked in environmental education at the Chicago Botanic Garden. She holds a BS in Foreign Service from Georgetown University.

BRAZIL. ***Christopher Finney*** is a candidate for the Master of Environmental Management at the Yale University School of Forestry and Environmental Studies and the Certificate in Latin American Studies. He intends to pursue further study in Urban Planning or work in a related field.

Norio Takaki is a 2009 candidate for the degree of MEM from the Yale School of Forestry and Environmental Studies. He has a Bachelor's Degree in Japanese Language and Culture from the University of California, Berkeley. His personal and professional interests are centered around urban sustainability issues, with a focus on the integrated management of water resources. Norio's goal upon graduation is to employ the skills and knowledge he acquired at Yale to the task of improving potable water supply, sanitation, and aquatic ecosystems health in cities of the developing world.

FIJI. ***Rachael Teel*** holds a BA in environmental studies with a concentration in anthropology from Vassar College. Prior to her arrival at F&ES, Rachael spent four years working in the wildlife film industry. During this time she was employed by the Jackson Hole Wildlife Film Festival and by PBS's Nature series. She hopes to improve her Fijian and complete a longer ethnographic study on the islands in the near future.

HONDURAS AND NICARAGUA. ***Sara Enders*** graduated from Yale with a BS in Geology and Geophysics, where research on biogeochemical cycles and an internship at the International Rice Research Institute in the Philippines spurred her interests in environmental chemistry and sustainable development. Sara worked in the White Mountains for the Appalachian Mountain Club and as a Research Analyst for The Cadmus Group, Inc. before returning for a MESc from the Yale School of Forestry and Environmental Studies.

The 2008 TRI Fellows presented their research during the fall and spring semesters, sharing not only their findings, but also their insights on working in the field.

Jordan Macknick graduated from Hamline University with degrees in Mathematics and Environmental Studies. He worked for an organic food supply–chain company in the Netherlands and a non–profit wind energy company in Minnesota before starting a Master's of Environmental Science program at Yale's School of Forestry and Environmental Studies. At F&ES he has split his time analyzing world energy use trends and studying transboundary water management.

INDIA. ***Meghna Agarwala*** studied natural and environmental sciences at University of Pune and Jawaharlal Nehru University in India. She then worked for Wildlife Trust of India coordinating a small grants program and Nature Conservation Foundation studying snow leopard ecology, before enrolling in the Master's of Environmental Science program at Yale. After graduating from F&ES, Meghna plans to pursue a PhD at Columbia University, looking at possibilities for reconciling human–wildlife conflicts.

MADAGASCAR. ***Sarah Osterhoudt*** is a second year PhD student in the combined degree program between F&ES and Anthropology at Yale University. She is also a joint doctoral student with the New York Botanical Garden. Sarah is currently conducting research in Madagascar, where she and her husband were Peace Corps volunteers. Her research includes working with small–scale vanilla and clove farmers to investigate community change, global markets, knowledge production, and environmental identities. Sarah has also worked with agrarian communities in Bolivia, Nicaragua, Chile, and Peru.

Meg Selby earned a Bachelor of Liberal Arts with a concentration in Environmental Studies from the Wilkes Honors College. She has worked for in animal care and wildlife education with the Busch Wildlife Sanctuary, rehabilitating Florida native wildlife and teaching local communities about habitat and species conservation. Meg has also worked as a primate keeper at the Palm Beach Zoo, where exhibit development, animal care, and public programs led her to pursue an interest in wildlife conservation and community development at the Yale School of Forestry and Environmental Studies. Meg is working towards a Master of Environmental Science with a concentration in social ecology.

THE PHILIPPINES. ***Mark Evidente*** focused on environmental policy for land use and climate change, and on the interaction between business, government, civil society and communities to advance environmental goals while pursuing environmental management studies at Yale. He previously worked as Director for Legislative Affairs for Philippine Senator Richard J. Gordon, drafting legislation for tourism development that integrated environmental, cultural and economic perspectives into planning mandates. Prior to that, he was an Associate at the Philippine law firm SyCip, Salazar, Hernandez and Gatmaitan. He holds degrees in political science and law from the University of the Philippines.

The Future of Small Yerba Mate Farmers in Argentina:
An Opportunity for Agroforestry

Tal Ilany, MFS 2009 *and* Janet Lawson, MESc 2009

The legacy of Argentine agricultural policies has left an imprint on both the livelihoods and landscapes of yerba mate farmers in Misiones, Argentina, leading to a current state of land consolidation and degradation. Every year, 12,000 hectares of Atlantic Forest are cut down in Misiones Argentina, with only 44% of the original 2.7 million hectares of Atlantic Forest in Misiones remaining. Endemic deforestation in Misiones is a result of agricultural and economic policies that give rise to extreme forest exploitation and land conversion to monoculture plantations (Carrere, 2005).

One of the most widely planted agricultural species on small farms in Misiones is the native *yerba mate* (*Ilex paraguariensis* St. Hill), the leaves of which are steeped and served as a traditional beverage. Of the 19,000 yerba mate farmers in Misiones, over 80% are small farmers with less than 10 hectares (Vasquez, 2007). While the global trade of yerba mate is estimated at US $1 billion (Heck and Mejia, 2007), many small farmers struggle to make a profit from the crop due to low market prices and declining yields. This article explores how a combination of agroforestry management and agricultural policy can support farmers' livelihoods and maintain the quality of the land.

Regional Background

The Atlantic Forest extends throughout Brazil, Paraguay, and Argentina and is listed by Conservation International as one of the world's biodiversity hotspots, a fragile ecosystem with high levels of endemic flora and fauna. A major threat to this forest is exploitation from clear cutting to accommodate agriculture, livestock, and roads (Leal and Gusmão Câmara, 2003). Only 8% of the original Atlantic Forest remains and Misiones contains the largest continuous expanse (Figure 1; Holz, 2005). Using yerba mate agroforestry management in Misiones offers a way to strike a balance between preserving the forest while supporting farmers' livelihoods. Agroforestry increases nutrient cycling, soil organic matter and microbial populations reducing the need for farmers to clear forest for new fertile land.

Methods

During the summer of 2008 the authors worked in Misiones, Argentina in the department of Montecarlo, exploring the following questions:

1. How have government agricultural policies shaped the land use and agricultural practices of small and medium–sized yerba mate farmers over the past century?

2. Can burgeoning global niche markets create new opportunities that support both agricultural sustainability and the livelihoods of small and medium yerba mate farmers?

3. Which agricultural systems will provide farmers with the adequate crop yield while simultaneously ensuring long–term soil health?

To answer these questions, Tal implemented a study to explore soil fertility in yerba mate agroforestry systems, while Janet initiated research to explore the political ecology of land use changes for small yerba mate farmers. Tal sampled a total of twenty plantations, ten of which were monocultures of yerba mate and ten were agroforestry systems of yerba mate intercropped primarily with parana pine *(Araucaria angustifolia*). She sampled one forest site, with no recorded history of clearing, to provide a baseline control of soil nutrients typical to a regional secondary forest. She collected soil samples at two depths, measured diameter at root collar for yerba mate and diameter at breast height and live crown height for intercropped species. She is currently analyzing soil and root samples for nutrient content. Janet completed thirty semi–structured interviews with yerba mate farmers, agriculture extensionists, government officials, and university professors in

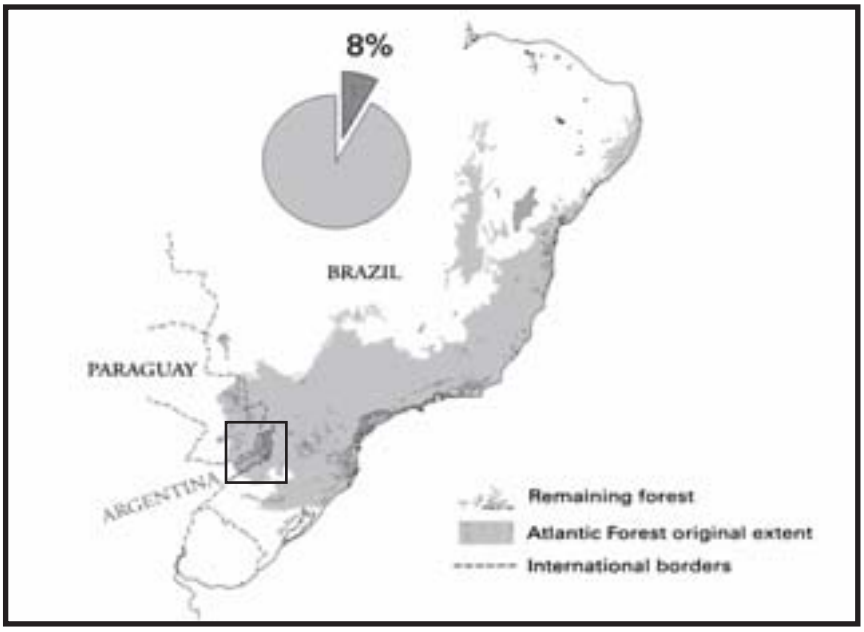

Figure 1. The province of Misiones, located in the square, contains the largest remaining continuous expanse of Atlantic Forest. Source: Leal 2003.

Argentina. She asked a series of questions to evaluate land–use history and allocation, the agricultural techniques employed, and the political economy of yerba mate production.

Yerba Mate and Agroforestry

Agroforestry is a management system that utilizes combinations of trees, crops, shrubs, grasses, and animals on the same piece of land. The combination of species increases nutrient cycling, provides optimal biological interactions between plants, lowers the risk of financial loss from crop failures, and yields multiple products (Parrotta et al., 1997; Workman et al., 2002). In Misiones, while yerba mate can be grown in agroforestry systems, it is more commonly planted in monocultures. From an environmental and economic standpoint, it is important to determine whether yerba mate grown in shade conditions affects productivity and soil fertility. This information can help improve management practices of the crop.

In Misiones, common timber tree species found intercropped with yerba mate include araucaria, eucalyptus (*Eucalyptus camaldulensis*), various types of pines (*Pinus taeda* and *P. elliottii*), and kiri (*Paulownia tomentosa*) (Figure 2). Of these, araucaria is the only one native to the region and is often found growing with yerba mate in the wild. While other studies look at a variety of native tree species intercropped with yerba mate, more research is required to fully understand the consequences of such systems (Eibl et al. 2000; Montagnini et al., 2006).

While there is minimal research on the specific growing requirements of yerba mate in agroforestry systems, we can look at species with similar growing attributes and examine both ecological and economic benefits of growing them in agroforestry systems. Two globally important products, coffee (*Coffea arabica*) and cacao (*Theobroma cacao*), are commonly managed using agroforestry throughout the tropics. In the natural forest setting, yerba mate, coffee, and cacao are intermediate trees and tolerate partial shade. However, when these species are cultivated on an industrial scale, they are often planted in full–sun monocultures. To determine what enhances both ecological and economic values of these crops, an exploration of light and nutrients interactions in agroforestry systems is necessary.

Nutrients

Maintaining soil nutrient levels in plantations can be challenging, especially on the low fertility and acidic soils of Misiones. Because the leaves of yerba mate are harvested annually, the plants are very demanding of soil nutrients and over time these plantations decrease in productivity. Mycorrhizae, a soil fungus that forms symbiotic relationships with plants, can be very important for nutrient and moisture sequestration, especially in low quality soils (Cardoso and Kuyper, 2006). Since systems with

more species diversity tend to promote more mycorrhizal associations, agroforestry may be an opportunity to encourage these relationships and maintain soil fertility over longer periods of time.

A study looking at coffee production examines mycorrhizal relationships with phosphorous and yield. Trees inoculated with mycorrhiza show increases in initial yield and growth when phosphorous is added in moderate amounts (Siqueira, 1998). While yerba mate is not known to form mycorrhizal relationships, some potential intercropping species like araucaria are known to do so. As araucaria is already generally well suited for the nutrient deficient soils of Misiones, it may be used to improve site conditions for yerba mate.

Light

Predictability and yield security are necessary for success in agricultural production. This success can only come from an understanding of how plants thrive within an environment. Light is a driving force of plant development and is integral to the formation of the nutrients and caffeine in yerba mate, coffee, and cacao. The tradeoffs between photosynthetic benefits and biotic factors must be carefully understood in order to fulfill production goals.

Recent evidence suggests that growing yerba mate in shaded conditions increases the amount of mineral material in the leaves, producing a higher–value product (Jaques et al., 2007). Yerba mate under a 75% shade tends to have higher amounts of caffeine and nutrients in leaves, woody stems, and fruits than when the tree is grown in full sunlight (Esmelindro et al., 2004; Jacques et al., 2007). In a study by Coelho et al. (2006), where yerba mate is grown under three different light levels (93%, 41% and 5%), caffeine and theobromine leaf concentrations increased with shade, while production rates were reduced by more than half. If leaf chemical concentration and yield are shared goals, then the intermediate shade conditions of an agroforestry system might provide ideal outcomes. Intercropping yerba mate with overtopping timber trees may therefore produce a higher quality product, but the amount of shade must be regulated in order to maintain desired production rates. Results from similar research with cacao and coffee reinforce the benefits of mixed systems for small farmers (Somarriba et al., 2001; Zheng and Ashihara, 2004; Zuidema et al., 2005).

Intercropping yerba mate with araucaria or other native species can provide increased soil organic matter and nutrient cycling, pest and weed control, and heightened levels of secondary com-

Figure 2. Yerba Mate intercropped with araucaria in Misiones.

pounds in the leaves. Small farmers in Misiones can use these agroforestry techniques to maintain soil fertility over the long–term. These techniques reduce the need to clear new land while providing another source of income from the harvestable timber. Overall, agroforestry systems appear to provide many ecological benefits and have the potential to generate economic opportunities for small farmers and the results of Tal's research can be used to weigh the benefits of using yerba mate agroforestry systems in place of monocultures in Misiones.

Policies and Profitability for the Small Farmer

During the past two decades, yerba mate farmers faced plummeting market prices that made it difficult to support themselves solely through yerba mate production. Following a large shift in economic policies in 1991, the yerba mate industry was deregulated and land was increasingly converted to high–density yerba mate plantations. This precipitated a steep decline in yerba mate prices, plummeting from 20 cents per kilo in 1991 to two cents in 2000 (Rosenfeld and Martinez, 2003). As a result, the National Institute of Yerba Mate (INYM)[1] was created in 2002 to set prices for the harvested green leaf (INYM, 2008). Although the price set by INYM in 2008 was 52 cents per kilo for the harvested green leaf, the ten largest firms that collectively control 80% of the market are able to drive down prices despite the rhetoric of the INYM. Farmers are often compelled to sign papers with the drying mills or cooperatives saying that they were paid the official price despite having in fact been paid much less.

In response to this price decline, some family farmers are now accessing new and growing markets, particularly those for organic and fair trade products from agroforestry systems. For these alternative markets to become viable in supporting yerba mate agroforestry as an agriculturally sustainable and economically stable option for small farmers, three important conditions must be met: (1) the creation of an effective government agricultural policy that supports small farmers in Argentina; (2) the development of institutional capacity to enable small farmers to access alternative markets; and (3) the increased diversification of crops and agricultural products produced on small farms.

Building an Argentine agricultural policy to support small farmers

In order to support the livelihoods of small farmers, the state must foster policies that create economic and social conditions that encourage a shift towards environmentally sustainable yerba mate production. Some recent initiatives are noteworthy. First, the Misiones provincial government created the Center for Yerba Mate Transactions (CTYM)[3] within the Ministry of Agriculture in order to develop accountability in the transactions between the farmer and the yerba mate drying, grinding, and packaging facilities (CTYM, 2008). While mechanisms for tracking these transactions are still being developed by CTYM, it will hopefully integrate transparency into yerba mate production and processing and ensure that farmers are paid the official price set by INYM. Second, while the National Institute of Agricultural Technology (INTA)[3] has been completing research on agricultural techniques to increase yields in yerba mate monoculture systems, it should also look at sustainable agroforestry techniques on small farm systems and determine which techniques are most suitable for small farmers. Third, INTA and INYM currently have fledgling programs for small farmers on soil conservation. These extension programs reach only a small audience and should be significantly broadened. All these initiatives involve instituting mechanisms for transparency in the yerba mate production chain and promoting research and agricultural field training for environmentally sustainable agroforestry techniques.

Developing institutional capacity for accessing new markets

Some larger family farmers — those that have both the capital to invest in agroforestry systems and the capacity to process, package, and export their yerba mate — have successfully tapped into niche markets for shade–grown and organic yerba mate in Misiones. Two of the larger family farms I visited this summer (each with more than 75 hectares of yerba mate) incorporated native trees in their yerba mate fields and exported certified organic yerba mate. However, these farmers have outside funding and support, as well as significantly more land and capital invested in their yerba mate plantations than the average small yerba mate farmer.

Given that small farmers often do not have the capital or the capacity to make costly investments in their agricultural systems, processing equipment, or marketing, how can the small farmer take advantage of a niche market that supports sustainable agroforestry? Cooperatives of small yerba mate farmers have had varied success in implementing sustainable agroforestry practices and accessing niche markets. The Cooperative Río Paraná based in Oberá, Misiones, was marketing their yerba mate nationally as fair trade and organic, but it has not been able to pay their farmers the official price set by INYM. The cooperative is paying back loans and lacks the capital to purchase drying and processing equipment and build storage facilities. While a cooperative structure can create a mechanism to obtain the capital for processing equipment, they also must have the institutional capacity to maintain relationships with foreign business partners that import shade–grown yerba mate. Government support is necessary to strengthen existing cooperatives. This support will give small farmers access to capital and training, allow them to invest in an agroforestry system, and take advantage of the opportunities provided by niche markets.

Diversification

The most important benefit of yerba mate agroforestry systems is its emphasis on diversity. With a variety of subsistence crops, gardens, fish farming, animal husbandry and alternative cash crops, small farmers will be better equipped to support themselves and their families despite market fluctuations. Combining coherent agrarian policies with agroforestry systems, will hopefully lead to a framework for economic justice and environmental sustainability within the yerba mate sector. These policies have the potential to promote the revitalization of yerba mate livelihoods and the conservation of Argentine landscapes.

Conclusion

Yerba mate production in agroforestry systems may be a profitable venture for small farmers. However, the long–term viability of this crop hinges on a combination of ecological and economic factors, specifically the maintenance of soil quality and the development of alternative markets and agricultural policies. Agroforestry systems may provide options for these farmers by diversifying the crops they produce, improving soil quality, and allowing access to alternative markets. Agroforestry can be ecologically beneficial, but requires farmers to follow certain management schemes to ensure profitability. Given the complexity of agroforestry management, educational programs must be available to small farmers whether they are offered through government extension, non–profit organizations, or private ventures. With supportive agricultural policies, agroforestry management can provide a future for small farmers in Misiones while sustaining the quality of the land.

Notes

[1] Instituto Nacional de la Yerba Mate
[2] Centro de Transacciones de la Yerba Mate
[3] Instituto Nacional de Tecnología Agropecuaria

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