

**Spreading Agroforestry for Sustainability:
The Situation in Shandong and Sichuan Provinces**

By

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ABSTRACT

The 1998 flooding of the Yangtze River produced the commencement of the National Forest Protection Program and the Slope Land Conversion Program, policies intended to reforest the ecologically-damaged upper reaches of the river. These programs, however, wrought economic drain on Sichuan Province, with the removal of the booming logging business. Furthermore, a mass retirement of marginal slope land severely reduced the amount of cultivated land supporting the most populous province. In the wake of an ever-growing population, it is imperative that the farmers of Sichuan Province seek alternative land-use methods to optimize their yields. Agroforestry, the union of agriculture and forestry in one harmonious system, is one method verified to accent agricultural productivity and boost the environmental state of wellbeing. This study examines the incentives and initiatives supporting the existing agroforestry systems in Shandong Province and evaluates whether such motivations documented there would be successful in Sichuan Province.

Keywords: Agroforestry, Sichuan, Shandong, incentives

PREFACE

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TABLE OF CONTENTS

ABSTRACT

PREFACE

TABLE OF CONTENTS

INDEX OF FIGURES

I. INTRODUCTION	6
II. AGROFORESTRY AND THE CHINESE SITUATION	7
III. AN ACCOUNT OF SHANDONG PROVINCE	10
IV. CURRENT FOREST POLICY IN SICHUAN	17
V. COMPARATIVE STUDIES	22
VI. CONCLUSIONS	25
NOTES	27

INDEX OF FIGURES

Figure 1 Agroforestry yields on the North China Plain	10
Figure 2 Agroforestry rate for Yanzhou County, Shandong Province	12
Figure 3 Poplar shelterbelts in Yanzhou County, Shandong Province	12
Figure 4 Paulownia trees intercropped with winter wheat	13
Figure 5 Yearly Income and the Retirement of Cropland, Tianquan County, Sichuan Province	17

INTRODUCTION

China's network of agroforestry is riddled with contrast. Despite possessing one of the most highly established working agroforestry systems in the world, complete with major government-funded programming (Zhu et al. 1991), China's agroforestry network is best viewed as a continuum of development. On one end of the spectrum, agroforestry is an established and integral part to rural subsistence farming and ecological rehabilitation, whereas a lesser, perhaps underdeveloped, system approximates the opposing end of the gamut. Coastal Shandong Province and other vicinities belonging to the North China Plain abound with notable examples of thriving agroforestry systems; however, in Sichuan Province, the use of agroforestry systems as a remedy to environmental degradation has not been actively engaged.

Immediately following the devastating aftermath of the 1998 flooding of the Yangtze River, the central Chinese government implemented several campaign-style policies to address and ameliorate the wellbeing of the natural environment and its inhabitants. Sichuan Province found itself participating in such programs as the National Forest Protection Program (NFPP) and the Slope Land Conversion Program (SLCP). Although such policies focus on the desperate need for reforestation, no specific agroforestry initiatives have been implemented in the province.

With the implementation of the NFPP and the SLCP, the farmers of the mountainous Sichuan Province witnessed a large-scale reforestation operation at the expense of their traditional croplands. Croplands were already in ecologically poor condition, as cyclical slope land farming in marginal territories had accelerated the environmental degradation. As the onslaught of the new program policies reclaimed more farmland, the rural farmers'

economic woes increased. At present, a rapidly increasing population continues to place heavy strains on local farming operations, overburdened already long ago.

Now with less agricultural cropland than ever, Sichuanese farmers need to look towards harboring alternative agricultural methods in order to take full advantage of their reduced quantity of cropland and revitalize it, maximizing yields. This investigation explores the possible advantages of optimizing agricultural productivity in Sichuan Province by using the agroforestry experiences of Shandong Province as a tutorial and learning tool. In the following sections, this paper will examine the initiatives and incentives of agroforestry in Shandong Province and apply them to the situation of Sichuan Province, evaluating the rationality of introducing similar actions. Yanzhou County of Shandong Province and Tianquan County of Sichuan Province were visited and shall serve as representatives to their respective provinces.

AGROFORESTRY AND THE CHINESE SITUATION

Agroforestry is the unique combination of trees and crops and livestock in the agricultural landscape. An age-old practice, observed for thousands of years around the world, agroforestry is making a comeback in modern farming routines (Zhu 1991). In every corner of the globe, farmers are looking towards agroforestry: the Agricultural Research Service in the United States advocates agroforestry techniques to small farmers in an economic bind (Weaver 1997), the International Centre for Research in Agroforestry is aiding the African country of Malawi to engage in a major agroforestry initiative to help rejuvenate soils and battle severe food deficits (Bowers 2002) and in Brazil, the Projecto Abraco Verde, or Project Green Hug, is underway to provide training and assistance to formerly landless farmers, enabling them to reclaim fragile marginal forest lands that would otherwise be left

for ecological death (Fenimore and Cullen 2002). Combining the principles of forestry with agriculture, agroforestry plays an integral and vital role for more than one billion subsistence farmers who tend lands of a size of less than 1.2 hectares by increasing the profitability of their small tracts of land (Anonymous 2001). Certainly this figure shows no modesty, as the average land area available to the Chinese farmer is less than 0.1 hectares (Wu and Zhu 1997).

The environmental and economical benefits of agroforestry are diverse, vast and numerous. A study on the North China Plain revealed that agroforestry exhibits an advantage over monocropping in its natural ability to sequester carbon from the atmosphere at a yearly rate of about 1.23×10^6 tons of carbon (Wang and Feng 1994). Researchers in Indonesia's West Java have likened agroforests to behave more closely to forestland than cultivated land in the low level of erosivity they exhibit (Kusumandari and Mitchell 1997). Agroforestry systems promote the spread of biodiversity as monoculture cultivation plots are replaced with a multiple-specie arrangement, which deed also reduces the risk of devastating pest attacks (Noble 1997, Stoney and Bratamiharja 1990). Soil fertility, as well as moisture and increased organic matter, may be regained when species are planted in reciprocally beneficial combinations to draw nitrogen from the air and extract phosphates and potash from deep within the earth, making a self-sustaining system possible (Shepherd 2000, Zhu et al. 1991). Tall trees may act as wind blocks to shelter harvestable crops, reduce wind erosion and delay the attack of desertifying sands. Farmers can derive additional income from many tree byproducts, such as fodder, medicines, fruit, building materials, timber and fuelwood, as well as benefit from agroforestry's intangible results, such as an improved water catchment system and shade. In general, agroforests require very little investment in outside energy or

fertilizer (Noble 1997). By bettering the microclimate of the cultivated land and immediate environment, an increase in total agricultural productivity is the bottom line.

The term *agroforestry* encapsulates many different techniques of uniting forestry with agriculture. The most commonly used method in China is agrosilviculture or the silvable practice, which combines the growth of crops and trees into one harmonious system (Huang et al. 1997). Under the heading of agrosilviculture fall several distinct practices: alley cropping or intercropping, the planting of alternating rows of arable crops with trees; shelterbelt, the establishment of rows of trees with the express purpose of decelerating high winds to combat desertification and to shelter the crops beneath; four-sides, the practice of creating corridors or siding beside fields, roads, houses and waterways; forest farming, the cultivation of crops within existing forest environments; and forest gardening, the artificial simulation of a forest bionetwork (Huang et al. 1997, Shepherd 2000, Weaver 1997, Zhu 1991). Aside from agrosilviculture, agroforestry may refer to the integration of trees and crops with other agricultural systems. A tree, crop and fish partnership is labeled as aquaculture and the grouping of trees with livestock with or without crops is called silvopasture (Huang et al. 1997, Zhu 1991).

The modern sense of agroforestry—a land-use technique aimed at optimizing agricultural output—enters the stage at an opportune time. Consequences of man eking out his existence for thousands of years in China, adjusting the natural environment to suit his needs, are materializing with adverse ecological effects. The clearing of land by humans for agricultural purposes in China is deep-rooted in history and has had a substantial impact on the natural milieu (Blunden and Elvin 1998). Evidence of environmental degradation, such as soil erosion and infertility, deforestation, desertification and frequent natural disasters, is

blatantly visible and is a prime predicament in poor rural economies. Some of the most threatening problems that face the Chinese, as well as people in other parts of the world, include environmental degradation, rapid population growth and resource depletion (Wu and Zhu 1997).

The sheer size of China makes for its vast geographic expanse to be characterized by dozens of distinctive climates, soils, topographies and vegetation. The country is distinguished by a number of different environmental situations, unique to their own regions. The average conditions in southwest China's towering mountains are rather divorced from those of the eastern China floodplain. The complexity of Chinese geography and its entwined environmental issues are great and cannot be described in a few sentences.

Likewise, the agroforests of China are equally as variegated. Some species and techniques are better suited to different regions. For example, paulownia trees intercropped with winter wheat is a popular agroforestry system found on the North China Plain for its quick growth, microclimate control and windspeed reduction (Zhu 1991). Conversely, lacquer trees are preferred by the Lemo people in the southern province of Yunnan to help control soil erosion on the steep mountainsides that comprise their homelands (Long 2003).

While agroforestry systems of the North China Plain tend to be widely spread and incentive based, it is still important to note that southwestern China is not completely void of agroforestry operations. In fact, southwest China is the home to many minority groups who have traditionally practiced indigenous agroforestry techniques for centuries at a very localized level (Shi and Li 1999).

AN ACCOUNT OF SHANDONG PROVINCE

Shandong, a coastal province, comprises a part of the North China Plain that borders the Bohai and Yellow Seas between the latitudes of 34°25' and 38°23' North and the meridians 114°25' and 112°43' East. It serves as the home for over 1,000 rivers of varying sizes, including the Yellow River, which flows through the province to empty into the Bohai Sea. Accordingly, the province is characterized by flood plains, though it also boasts rolling hills and several mountains, from which it derives its name. Positioned in the warm temperate zone, the inhabitants of Shandong are accustomed to an annual mean temperature of 11° to 14° C, averaging 550 to 950 millimeters of precipitation per year (Shandong on Internet 2001).

In the subsequent paragraphs, the province of Shandong will be surveyed for its policies pertaining to agroforestry. A brief explanation of initiatives and incentives promoting agroforestry will be presented and an outline of how they function and why they work for the people of Shandong Province will then follow.

Not until the 1950s did the central Chinese government prepare for colossal policy reforms to remedy the ailing environmental condition of the country. China first implemented the Four Sides program to afforest the sides of fields, roads, houses and waterways in a first effort to combat environmental degradation. Nevertheless, the North China Plain reached levels of complete deforestation by the 1970s (Yin and Hyde 2000). Those agroforestry programs that existed during this time were managed by a trinity of supervisors: village cadres developed designs for agroforestry systems, technicians provided the procedural support and the villagers were left to tend the operations. Such administrative processes led to uniformity among and across systems that were all owned and operated by collectives (Wu

and Zhu 1997). By the late 1970s, agroforestry was “strongly recommended” as a means of flood control (Wang and Shogren 1992).

Under the commune-style agriculture policies, farmers were not permitted to grow any industrial crops for personal gain. Only food crops were allowed in the aim of maximum agriculture production, providing no external incentive for the planting of trees (Wang and Shogren 1992, Lee 1986). However, many policies overturned in 1978, paving the way for high density agroforestry in Shandong Province. Several of these policies were the Forest Responsibility System, the Household Responsibility System and various other government backed, extensive agroforestry projects. These policies, coupled with state investment in technical support and education in environmental issues, mark the departure from maximum agricultural output objectives towards optimizing land use methods (Wang and Shogren 1992).

The Forest Responsibility System established contract-bound household or team management of forested lands in 1978, which allowed the caretakers to directly profit from superfluous yields. The incentive of profit drove tree wardens to increase the standing stock (Lee 1986). Also beginning in the late 1970s were several sizeable agroforestry programs such as the Three North, or Green Great Wall, Coast Protection forests, Plains “Greenization” and Sand Controls. The Three North project is rumored to be the world’s largest agroforestry venture (Zhu et al. 1991). The Plains “Greenization” project, however, directly had an impact on Shandong Province. Beginning in the 1950s, trees were planted as windbreaks in the heavily deforested North China Plain and, more recently, an agroforestry network comprised of a combination of techniques has been established to avert natural disasters and increase land-use efficiency (Wu and Zhu 1997).

The Household Responsibility System converted the land tenure system from communes to individual households contracting land through the villages. For the first time, Chinese farmers were permitted to elect which crops to produce and how to sell the remaining harvest beyond the village quota (Wang and Shogren 1992, Wu and Zhu 1997, Yin and Hyde 2000, Yin 2004). The decentralization of the market system led to a milder economic climate and an overall friendlier atmosphere in the agricultural world, making it easier to earn a living as a farmer in Shandong Province (Wang and Shogren 1992, Yin 2004).

Empirical data from Yin and Hyde's (2000, 2004) research support the theory that the transition to the Household Responsibility System directly impacted the increase in agricultural productivity in Shandong Province. Furthermore, their studies indicate that agroforestry, especially the intercropping method, positively influences agricultural productivity, up to even ten percent. Certainly, the length of the contract with the village sanctions an enduring investment in agroforestry, allowing great returns for the farmer who has invested. Additionally, subsidies are available for farmers planting paulownia saplings (Wang and Shogren 1992), making agroforestry on the cultivation plot a more lucrative undertaking.

With agroforestry, not only does the agricultural output increase, but the farmer's extra wages begin to rise. In Yin and He's (1997) study, combined data in paulownia-wheat intercropping systems with corn, beans and cotton suggest an average yearly income increase of 650.51 USD when the paulownia trees are planted in a five by twenty meter spatial arrangement in the North China Plain.¹ From the same dataset, a graph (See Figure 1) can be drawn to display the yearly crop yields and timber volume in the various paulownia intercropping systems. As the trees mature and the timber volume expands, agricultural

output decreases; however, the selling price for paulownia timber, at least at the time of this study, is remarkably higher than that for the produce and can fetch reasonably high returns for the farmer who cultivates paulownia on his land. The numbers at the top of the graph for each year represent the total value of crop yields and timber volume by the 1983 market price standards.

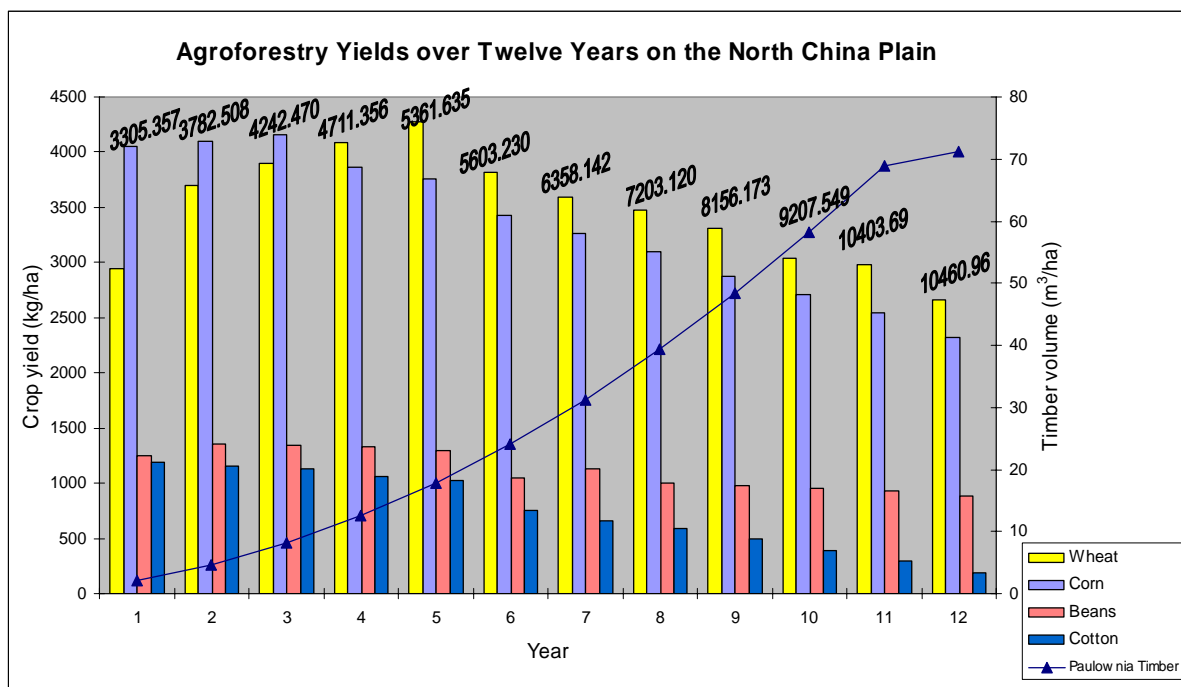


Figure 1. Agroforestry Yields on the North China Plain – a longitudinal study over 12 years. Paulownia trees are planted in a five by twenty meter spatial arrangement. Numbers at the top of each year indicate the total value for crops and timber combined.

It is evident how agroforestry grew to become a success in Shandong Province. Arboreal plantings and the shift in tenure from commune-structured agriculture to the Household Responsibility System provided proper incentives for the farmers to invest in trees and essentially buy into the agroforestry system. With the novel ability to vend their surplus harvests as they desired, this served as an enticement to develop agroforestry systems on household plots to optimize their household agricultural output. Agroforestry, as a multiple

land-use technique, thus rapidly gained heavy support in Shandong Province. Moreover, confidence in their own tree planting is augmented by an increase in total agricultural productivity and an increase in extra income, a direct result of increased environmental conditions brought about by the introduction of new trees to the area (Yin 2004).

In Shandong Province, Yanzhou County serves as an experimental model with concentrated agroforestry techniques in place. Currently, the World Bank has invested 4,000,000 RMB yuan in 1,000 hectares for three years to conduct developmental research in the field of agroforestry.² So successful is the agroforestry in Yanzhou County, that upon visiting in 1983, former political leader to the Peoples Republic of China Deng Xiaoping heralded the paulownia intercropping he saw there and encouraged the establishment of subsequent agroforests in Shandong to mirror those in Yanzhou (Wu and Shepard).

The agroforestry rate in Jining City of Yanzhou County has shown a steady increase in overall participation in the agroforestry network and an increase in overall agricultural productivity. Presently the agroforestry rate approximates 100% (See Figure 2). The county Forestry Bureau nursery, established in 1968, is now responsible for the selection and breeding of seedlings of over one hundred species to be incorporated in agroforestry systems. The nursery also provides technical services and demonstrations for farmers. Figures 3 and 4 provide examples of agroforestry techniques in Yanzhou County today.

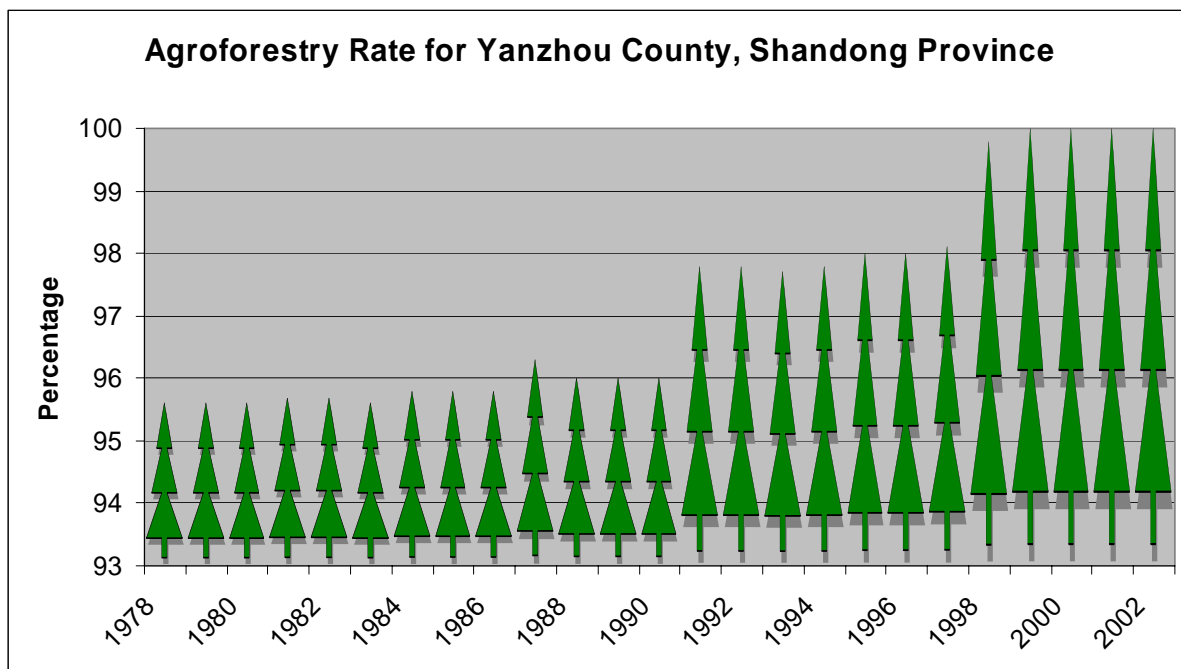


Figure 2. Agroforestry rate for Jining City, Yanzhou County, Shandong Province.³



Figure 3. Poplar shelterbelts in Yanzhou County, Shandong Province.



Figure 4. Paulownia trees intercropped with winter wheat (Cai and Zheng 1991).

CURRENT FOREST POLICY IN SICHUAN

Sichuan Province possesses the mighty Yangtze River and five of its major tributaries. The eastern part of Sichuan Province lies in the Red Basin, containing plains and undulating hills, while the western part of the province occupies the Western Sichuan Plateau, dappled with lofty mountains. The climate of Sichuan Province divides itself among its geographic bodies: humid sub-tropical in the basin and varying intensities of temperate zones in the plateau regions. The average temperature is 16.5°C and precipitation amounts to 1000 millimeters yearly. Sichuan Province is also the most populous in all of China (China Internet Information Center).

Filson (2001) acknowledges the contemporary environmental situation in western China as being among one of the worst in the world. In Sichuan Province, the environment is plagued

with maladies and the possibility of natural disaster occurrences are steeply augmented with soil and water erosion problems. Hydraulic erosion accounts for the loss of 2.4 billion tons of soil loss per year in the Yangtze River Basin (Department of Water and Soil Conservation and Ministry of Water Resources 1999). Unbounded population and economic growth is creating a growing burden to support the influx of people and businesses. Already by 1995, there was only 0.83 hectare of arable land available per capita in Sichuan Province.⁴ This space crunch is sending farmers to gobble up any possible marginal slope land for use in the agriculture sector, hence radically promoting the erosion of soil (Shi and Li 1999).

Coupled with soil erosion and the depletion of soil fertility, deforestation has posed an environmental threat for many years in Sichuan. Birdlife International (2003) cites severe and speedy depletion of forest cover in Sichuan Province having taken place particularly since the 1960s. Already by 1988, forest cover only accounted for 12.6% of total land coverage in Sichuan Province, down by over 6% of the total from thirty years before. As natural resources are used up and biodiversity wanes, the fragile Sichuanese environment moves closer and closer to a state of unsustainability (International Centre for Research in Agroforestry, Shi and Li 1999).

Nevertheless, reforestation policies following the 1998 Yangtze River floods are now overseeing a slight reversal in this trend. In Tianquan County of Sichuan Province, for example, a county in western Sichuan Province, forest coverage totaled 50.23% of the county's 2394 square kilometers before 1998. Following intensive afforestation crusades, the 2003 forest coverage rate ranked at 59.5% of the total land coverage, for a 9.27 percentage point increase, gaining approximately 222 square kilometers of newly forested land in the county (Li 2004).⁵ The forest coverage rate for the whole of Sichuan Province in

2003 had risen to 39.7%, of which, 61% comprises afforested lands (Sichuan Statistical Bureau 2003).

These afforestation policies are strategies of the central Chinese government to correct some of the negative environmental factors present at the upper reaches of the Yangtze River prior to the 1998 floods. Namely, the government implemented two obligatory programs: the National Forest Protection Program (NFPP) and the Slope Land Conversion Program (SLCP). In introducing the NFPP, over 60 million hectares of natural forest in southwest China are slated for protection, which includes the implementation of logging bans and afforestation aspirations of 8.6 million hectares yearly. Additionally, to help alleviate stresses that accompany the newly defunct logging business, there are plans to found commercial timber plantations and relocate laid-off laborers. The SLCP aimed to convert cropland sitting on hillside slopes of twenty-five degrees or greater into forest land or grassland (International Centre for Research in Agroforestry, Wang 2002). No specific agroforestry projects were proposed.

Loyal to their intentions, these programs figure into the successful reforestation equation of Sichuan Province. Nonetheless, these programs prove to be a bit sloppy in their planning. The curriculum has clearly outlined the promotion of environmental rehabilitation, but the size of the task is daunting and many of the program leaders are highly unqualified for their positions, due to a lack of trained workforce. Also, proper methods in which to deal with the devastating effects on local economies that previously relied on logging, in particular, are not apparent (International Centre for Research in Agroforestry).

Not surprisingly, many disincentives to tree planting in Sichuan Province exist. Unemployment resulting from the enactment of the NFPP has spurred disenchantment.

Those indirectly affected by the ban, such as truck drivers, were not at all compensated for their losses, resulting in a lack of any financial base that could be invested in agroforestry systems. The state-owned forests do not harbor personal gains and therefore, do not make for very good tree-planting incentives (Wang 2002). In fact, they may be the motive behind a scuttle of illegal logging activity over the Myanmar border, as seen from satellite imagery. The longevity of investment also poses a threat of uncertainty for future yields when survival in the present is so critical. Those who are retiring slope land will not continue to receive subsidies all the way up until their tree stocks have fully matured for harvesting (International Centre for Research in Agroforestry). The bottom line is that there are no new sources of income emerging and there is very little faith in planning for the long-term.

Right away, economic losses in the agriculture sector fell harshly upon the Sichuanese after the implementation of the new forest policies. In 1999, immediately following the initiation of the arboreal programs, the Food and Agriculture Organization recorded that Sichuan Province's annual revenues plummeted 680 million RMB yuan (Heimo 2000). In a case study where local households were interviewed in Tianquan County,⁶ a best-fit regression on the data collected reveals that for every mu (a Chinese measurement equivalent to approximately 0.07 hectares) of cropland retired after 1998, a loss of 297 RMB yuan amassed (See Figure 5).

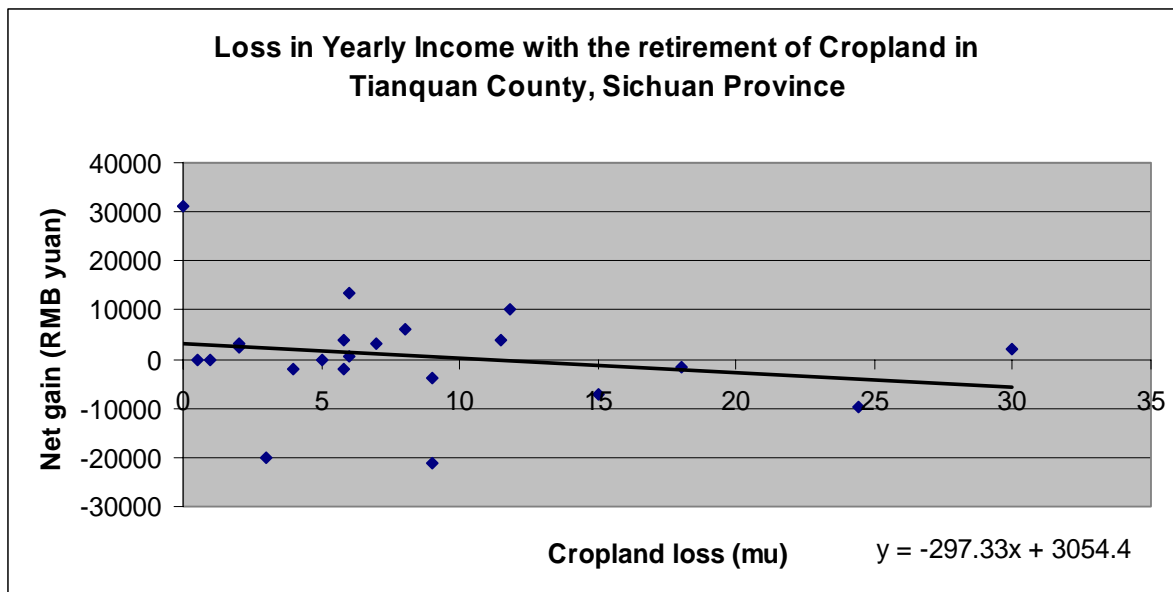


Figure 5. This graph depicts the loss of yearly income as the number of retired cropland increases.

Agroforestry does exist on the small-scale in Sichuan Province. Southwest China, which includes the provinces of Sichuan, Yunnan and Guizhou, is home to approximately forty minority ethnic groups who have engaged in indigenous agroforestry, or ethnoagroforestry, for thousands of years on their autochthonous territories. Methods are diverse, as are the living conditions and traditions are particular to different minority groups. In addition to ethnoagroforestry systems, other more widely-recognized systems are in place, such as the four-sides arrangement with mulberry trees, which are conducive for the accommodation of economic insects, are growing in the western part of the province, hedgerows are used on some slope land to prevent further soil loss and some aquaculture systems, incorporating fish, silkworms and mulberry trees, are in operation in the Sichuan Basin today (Shi and Li 1999).

A Canadian team of scientists recognize the critical need for sustainable farming practices in western China and have pledged their help in bringing agroforestry systems to this part of China as a means to slow environmental degradation, educate farmers on better land-use techniques and encourage gender equity. The Agroforestry Capacity Building program, still

in its infancy, has established several demonstration sites around western China, in the watershed basins of the upper reaches of the Yellow and Yangtze Rivers including one in Sichuan Province, in Yufeng. The scientists are evaluating each demonstration site for ways to improve cropping techniques and to disseminate this information to the rural population so that they may most optimally utilize the natural environment in friendlier ways. The Canadians are establishing a peer-to-peer education system on the benefits of agroforestry, meant to be taught by farmers for farmers, thus evading the foreboding top-down hierarchy in policy reform (Filson 2001).

COMPARATIVE STUDIES

Noting the long success of agroforestry systems in Shandong Province, would it be possible to take lessons learned there and transplant them west, to Sichuan Province? Is it possible to create incentives in Sichuan Province that mirror those found in Shandong Province, that would foster the establishment of more widely-spread agroforestry systems as a tool to optimize land-use practices and rehabilitate the decaying environment?

First of all, it is necessary to admit enormous differences in the climates, soils, vegetation, physical geography and ethnic compositions of Sichuan and Shandong Provinces. A glance at a map of Chinese climate zones reveals vastly different characteristics between the two provinces. It would be virtually impossible to replicate and transmit the successes—species types, agroforestry techniques and incentives—of Shandong Province to Sichuan by virtue of their drastically innate differences. Instead, it is important to scrutinize the accomplishments of Shandong Province and glean from them the principles of realization, so as to tailor incentives for agroforestry specific to Sichuan's economic and environmental situation.

Both Sichuan and Shandong Provinces are heavily populated. Sichuan is the most populous with a total of 114,190,000 inhabitants in 2000.⁷ In a test of significance performed between the rural arable land to agricultural labor per capita in the two provinces, results show that the null hypothesis of there being no difference between the provinces must be rejected at the 95% confidence level ($p = 0.05$).⁸ This makes the per capita variable of arable land for agricultural labor significantly different between the two provinces, meaning that the land crunch in Sichuan Province is significantly worse than in Shandong Province. Therefore, the argument for enhanced land-use techniques to optimize agricultural operations is imperative. Enter agroforestry.

The boom of agroforestry in Shandong Province was a direct result of a change in the land tenure system, switching to the Household Responsibility System. Such a swap occurred in Sichuan Province as well, but in Sichuan, the new system left farmers with fragmented plots of land (Shi and Li 1999), making widely spread agroforestry operations, such as those functioning in Shandong Province, nearly unfeasible if not impractical. Uniformity in agroforestry systems began during the commune tenure system on the North China Plain and the trend remained in existence through the policy change. Sichuan lacked this evenness from the start; mountain systems crisscross the province, making adjacency farming complicated.

If Sichuan Province can not directly retrace the steps Shandong Province took to flourish into a haven of agroforests, one idea it can mimic is the private sector-public sector joint partnerships. XueHong Wang (2002) advocates for such business enterprises in Sichuan Province to promote the cultivation of trees on household plots by guaranteeing a market for the harvest. Shandong Province is a forerunner in such agrobusiness ventures, as China

opens her doors to a free market economy. A prime example of this exists is the Shandong Sunpaper Industry Joint Stock Co., Ltd., based out of Yanzhou County.⁹ The paper company encourages genetic breeding and research and draws a large percentage of its wood fiber pulp from local agroforestry plots. Such a partnership supports agroforestry as a reliable source of income, while giving back to the environment all of the positive assets agroforestry has to offer.

Looking towards Sichuan Province's unique situation, it would be wise to embrace the ethnic diversity and dip into the knowledge pool of indigenous agricultural expertise. This could offer insight to a widened variety of agroforestry systems and they are especially useful because they are already known to be fruitful in the Sichuanese environment. A fusion of ethnoagroforestry and modern methods may reveal some very attractive results and an increase in productivity. Research should continue in this field to discover the most favorable systems in combination.

Most importantly, it is vital that incentives for agroforestry are created in Sichuan Province. Communication with the rural people to create a mutual understanding between those who develop policies and those who feel the brunt of them is crucial. Community involvement and integration will generate interest in agroforestry when concerns are addressed in a more amicable bottom-up fashion. Policies created in crisis, such as the spawning of the NFPP and SLCP, do not always yield the expected results, as reflected in the case the economic downwards spiral in Sichuan. Therefore, continual policy evaluation is the secret to true development.

Education on the fragile state of the environment is fundamental in bringing sustainability to any region. Researchers should work hard to assure that their findings reach the

knowledge of farmers and that new techniques are instituted properly with an acute sensitivity to the fragile ecosystems, in which they exist. Also, the introduction of new tree species to household plots may help to make profits attainable at more regular intervals, compared to only at harvesting times. The integration of several species in multi-purpose agroforests will increase biodiversity as well as alternate the gestation times on a given plot, permitting multiple harvests and, thus, extra income.

Perhaps the best advice is to preach flexibility, with diversified species on the plot, a farmer can learn to follow market trends and plant new species as he sees fit. From year to year, a farmer can change the composition of crops to meet demands of world markets. For example, there is a growing demand for organic crops grown in China that are then exported to other parts of the world. A farmer can even soar ahead with a thirty to fifty percent higher profit in the wake of the organic food fever (Nakanishi 2003).

CONCLUSIONS

It is clear that Sichuanese farmers must select only the most advantageous methods of cultivating their modest amounts of arable land. Recent reductions in cropland availability to the farmers of Sichuan Province require a more serious vision towards sustainability if the region is to support its rapidly growing population in future years. At present, Sichuan Province is overrun with ecological ruin, but several government-induced policies have been implemented to rehabilitate the environmental state at the upper reaches of the Yangtze River. However, the NFPP and SLCP were not thoroughly planned for the benefit of everyone. Many disincentives exist for farmers not to plant trees and help in the reforestation efforts.

The situation in Shandong Province is quite the opposite. Large scale programs instituted by the central Chinese government have provoked the wide use of agroforestry systems. Today an enormous network of agroforestry exists in this peninsular province. Perhaps most importantly, agroforestry has been proven to increase agricultural productivity. Species in the system work to mutually benefit each other's growth, requiring very little external inputs. Lessons from Shandong's successes may be garnered to help establish a thriving agroforestry network in Sichuan Province and begin the long road to ecological restoration.

Indeed the physical differences between Sichuan Province and Shandong Province are immense. It would be out of the question to simply transplant the initiatives set forth in Shandong Province in Sichuan Province. The path to success in agroforestry in Shandong Province has been gradual and not without the help of government-sponsored tree planting campaigns. Features of Shandong's successes, such as private-public sector relationships, sapling subsidies and developmental studies, may and should be imitated in Sichuan Province. The hope would be to create a larger network of agroforests, ultimately to claim the environmental and economical benefits they have to offer.

In the end, it is necessary to incorporate some of Sichuan's unique features into the planning of agroforestry expansion. Existing ethnoagroforestry techniques should be taken into consideration, as they have already shown to be successful for many years. Continual forestry policy re-evaluation ought to become a standard procedure and community involvement should increase. Education and responsiveness to new technological developments in the field of agroforestry are key to optimizing agricultural in the delicate Sichuanese conundrum. A blend of accomplishments from Shandong Province with local

flair, sensitive to native matters s bound to make for a more sustainable pattern of land use in Sichuan Province.

NOTES

1. Below is the data from Yin and He's (1997) twelve year study on paulownia intercropping in northern China. The output price value for crops and timber reflect the 1983 standards (Wheat is 0.213 USD, corn 0.128 USD, beans 0.298 USD, cotton 1.276 USD and timber 127.603 USD). From this data, the combined total yearly value is calculated by adding the year's wheat, corn, bean, cotton and timber values. Then, the yearly increase is calculated by subtracting the previous year's values.

Year	Wheat (Kg/ha)	Corn (Kg/ha)	Bean (Kg/ha)	Cotton (Kg/ha)	Timber (m ³ /ha)	wheat value (USD \$)	Corn value (USD \$)	Bean value (USD \$)	Cotton value (USD \$)	Timber value (USD \$)	Yearly total (USD \$)	Yearly increase (USD \$)
1	2945	4049	1253	1190	2.1	627.285	518.272	373.394	1518.44	267.9663	3305.357	---
2	3704	4103	1355	1158	4.6	788.952	525.184	403.79	1477.608	586.9738	3782.508	477.1505
3	3896	4155	1343	1134	8.1	829.848	531.84	400.214	1446.984	1033.5843	4242.47	459.9625
4	4088	3858	1331	1062	12.5	870.744	493.824	396.638	1355.112	1595.0375	4711.356	468.8852
5	4274	3761	1298	1028	17.8	910.362	481.408	386.804	1311.728	2271.3334	5361.635	650.2799
6	3816	3426	1047	756	24.1	812.808	438.528	312.006	964.656	3075.2323	5603.23	241.5949
7	3588	3260	1134	662	31.3	764.244	417.28	337.932	844.712	3993.9739	6358.142	754.9116
8	3470	3093	1004	591	39.3	739.11	395.904	299.192	754.116	5014.7979	7203.12	844.978
9	3312	2877	978	492	48.3	705.456	368.256	291.444	627.792	6163.2249	8156.173	953.053
10	3042	2709	956	393	58.2	647.946	346.752	284.888	501.468	7426.4946	9207.549	1051.3757
11	2981	2543	927	294	68.9	634.953	325.504	276.246	375.144	8791.8467	10403.69	1196.1451
12	2658	2325	887	194	71.2	566.154	297.6	264.326	247.544	9085.3336	10460.96	57.2639

2. Statistics supplied by Yanzhou Forestry Bureau during an informational session and informal interview on May 31, 2004, Yanzhou County, Shandong Province.

3. Statistics obtained from Dr. Can Liu of the China National Forestry Economics and Development Research Centre and the State Forestry Administration.

4. Statistics gathered and compiled by the International Food Policy Research Institute (IFPRI) from *China Rural Statistical Yearbook* and *China Statistical Yearbook*.

5. Data obtained from Weiyu Li, Commissioner of Tianquan County, Sichuan Province during an informational session and informal interview on June 14, 2004, Tianquan County, Sichuan Province.

6. It must be dually noted, however, that the sample size of the household interviews used to run this regression contains only 22 samples of data, likely influenced by skewing. But as an observational value, generally the households that rely primarily on subsistence farming without off-farm jobs suffer the consequences of lost wages as a direct result of the land retirement programs. The Pearson's coefficient r has a value equal to -0.22, suggesting a weak negative correlation between μ of cropland retired and total household income.

To gather data in Tianquan County, Sichuan Province, a survey form was devised to probe for basic demographic household information as well as a pool of other data relating to household and local economics, environment and policy. Over a period of five days, thirty-one rural households in several villages were interviewed. The interviews lasted approximately two hours each and were conducted by Chinese-speaking individuals, who translated the interview questions from English to

Chinese to the interviewees and, without delay, translated the replies back into English to be recorded by the accompanying group of two to four students. Results from all of the translator-student paired groups were then compiled into a master dataset.

Tianquan County was selected out of all the counties in Sichuan Province because it serves as a pilot demonstration county under the auspices of the Slope Land Conversion Program. Selection of the households to be interviewed varied by township. In the first few townships that housed interviews, such as Liang Lu and Zishi, we arrived to the villages, were greeted by locals and led to households that had agreed to be interviewed. In other townships, such as Shijing, local officials intentionally led us to party leaders' homes to conduct the interviews.

7. Statistics gathered and compiled by IFPRI from *China Statistical Yearbook*. The dataset includes the demographic information for Chongqing City (now an autonomous municipality) with that of Sichuan Province's, as it is an extensive dataset over 49 years.

8. Statistics gathered and compiled by IFPRI from *China Rural Statistical Yearbook*, years 1970 to 2000.

9. Information provided by Shandong Sunpaper Industry Joint Stock Co., Ltd. during an informational session and informal interview on May 31, 2004, Yanzhou County, Shandong Province.

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