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UPROOTING DIVERSITY?

PEASANT FARMERS' MARKET ENGAGEMENTS AND THE ON-FARM CONSERVATION OF CROP GENETIC RESOURCES IN THE GUATEMALAN HIGHLANDS

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The long-term security of the global food supply is contingent upon the on-farm conservation of crop genetic diversity. Without it, food crops lack the ability to evolve in the face of new pests, emerging plant diseases, and changing environmental conditions. The genetic diversity of many of humankind's major food crops is cultivated in the field, primarily by peasant farmers of the Global South. As the widening of global markets affects the lives of these farmers in new ways, the future provisioning of crop genetic resources and, ultimately, the security of the global food supply is in doubt. In this paper I investigate how the participation of Guatemalan peasants in the market economy is related to the on-farm conservation of crop genetic diversity in three crops: maize, legumes, and squash. I find that participation in markets is not inherently detrimental to the provisioning of crop genetic resources but that without the proper protections in place market participation may unleash processes that contribute to genetic erosion over time. I conclude by sketching seven policy prescriptions that would encourage the on-farm conservation of crop genetic diversity in a way that is consistent with peasant farmers' development objectives.

Keywords: Crop Genetic Resources; Natural Assets; Food Security; Peasant Agriculture

JEL Classification: O13, Q2, N56

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Introduction

As it embarks upon a new millennium, the global community is slowly awakening to the potential of a historic yet heretofore largely unheralded environmental crisis: the erosion of genetic diversity in humankind's major food crops. The ramifications of this crisis are far-reaching. The genetic diversity in crops provides the raw material that allows our staple foods to evolve with changing environmental conditions; without it our food crops are dangerously susceptible to new pests, emerging plant diseases, and climate change.

Ironically, peasant farmers from the Global South are responsible for cultivating the vast majority of crop genetic diversity. Long characterized as 'backward' and an impediment to 'development,' subsistence-oriented farmers in many areas of the developing world are, in fact, the providers of an invaluable ecological service. As their economic lives become increasingly integrated into global markets, however, the future of peasant farmers – and, ultimately, global food security – are thought to be in jeopardy.

The concern that market development will undermine the conservation of crop genetic resources is rooted in the belief that subsistence-oriented agricultural practices are an inferior means of fulfilling economic needs. If given a choice, the theory continues, peasants will inevitably reorient all aspects of their economic life – both production and consumption – to the market economy. In their self-interested rush to maximize their personal welfare, it is assumed that peasants will abandon traditional agriculture and, ultimately, the practices that guarantee the long-term evolutionary capabilities of humankind's principal food crops. The paradoxical implication is that the welfare of peasant farmers can only be improved at the risk of destabilizing a cornerstone of global food security.

Drawing upon my field research conducted in the highlands of western Guatemala, this essay contributes to the unraveling of the paradox. I find that the impact of market activities upon the on-farm conservation of crop genetic resources is contingent upon the broader social framework that governs market outcomes. If creatively implemented, markets can, in fact, play a positive role in helping farmers' to achieve their development goals in a way that is consistent with the *in-situ* conservation of crop genetic diversity.

1. Crop Genetic Resources in Guatemala

Guatemala's peasant farmers play a crucial, but seldom recognized, role in safeguarding global food security. Along with neighboring southern and central Mexico, Guatemala is known by ecologists as a 'megacenter of diversity' (Perales, *et al*. 2005). The region is the historic center of origin and the modern center of diversity for a number of crops, including the common bean, squash, chilies, avocados, and, most importantly, maize (Wilkes, 2004). Some 6,000 years ago, Mayan farmers in this Mesoamerican region domesticated what is now, along with rice and wheat, one of the world's three staple cereal crops (Pingali and Smale, 2000). Over the millennia, the descendants of these Mayan farmers have developed a rich diversity of maize, yielding several thousand varieties adapted to a wide range of environmental microhabitats.

As they have done for thousands of years, Guatemala's peasant farmers practice a poly-cropping system known as *milpa*, where maize is intercropped with beans, squash, chilies, and other useful plants. While one might suspect such a time-honored practice as making *milpa* to be stagnant, it is anything but. On the contrary, it is a highly dynamic system producing a constant flow of new maize varieties (Maxted *et al*, 1997, Louette, 1999). Via the practice of diversity management, peasant communities plant many different varieties of maize, adapted to diverse local environmental conditions such as soil type and climate, and to desired traits such as reliability, time of harvest, and taste (Bellon, 1996). The proximity of domesticated maize varieties to their wild and weedy relatives allows introgression—the back-and-forth hybridization between related species—that along with natural mutation brings new raw material into the crop's genetic profile. Farmers identify desirable traits and encourage their development via selective breeding, seed exchange, and manipulation of the local environment. Under the combined pressures of human and natural selection in the face of new pests, emerging plant diseases, and changes in the climate, these 'evolutionary gardens' (Wilkes, 1992) of *milpa* agriculture provide a steady flow of new maize varieties.

In contrast to the rich genetic diversity found in Guatemala's evolutionary gardens, 'modern' agriculture as practiced in the United States and other industrialized countries is characterized by a high degree of varietal uniformity. While this uniformity serves the objective of short-run profit maximization, it renders the crop vulnerable to insect and disease epidemics. This risk was dramatically illustrated in 1970 when a leaf blight destroyed one-fifth of the U.S. maize harvest (National Academy of Sciences, 1972). More recently, though on a much less dramatic scale in terms of its immediate impact, once robust potato fields in the Peruvian Andes were decimated after the farmers there adopted a genetically uniform package that was encouraged by national development policies (Ortega, 1997). To combat this vulnerability, plant breeders must release a constant stream of new varieties that incorporate genes for resistance to emerging pests and pathogens. Commercial seed varieties generally must be replaced every 5-10 years; indeed, some released varieties become obsolete in the very year that they are released (Wilkes, 1992). By providing the genetic raw material for this relay race between plant breeders and nature, traditional agriculture provides the ultimate foundation of the global food supply (Pingali and Smale, 2000).

Recognition of the economic value of crop genetic diversity is relatively recent. As Brush (2004) recounts, it was not until the 1960s that the erosion of crop genetic resources sparked serious concern among scientists and policy makers. Since then, the main policy response has been increased *ex situ*—or "off site"—preservation of crop germplasm in seed banks, as opposed to *in situ*—or "on site"—conservation in the field. While *ex situ* collections provide plant breeders with convenient access to crop germplasm, and offer some insurance against losses of *in situ* diversity, they do not provide an adequate substitute for on-site conservation.

As a number of crop scientists (*e.g.* Brown, 1999; Maxted *et al*, 1997; Wilkes, 1992) have begun to stress, there are distinct advantages to *in situ* conservation. There are at least three reasons that *ex situ* seed collections are an inadequate substitute for the continual cultivation of crop genetic resources in the field. Perhaps the most important is that on-farm conservation is a *dynamic* process. The ongoing process of evolution cannot be stored in a gene bank, it can only take place in the field. A second advantage is that *in situ* conservation is less vulnerable to human error, the likelihood of which is compounded by the chronic underfunding of gene banks (Wilkes, 1992). This danger was brought home to Guatemala in 1985, when it was discovered that roughly one-fourth of its national collection of maize varieties had been inadvertently destroyed (Fuentes, 1999). Still another limitation of *ex situ* collections is that they isolate seeds from the farmers who cultivate them. In order to be useful, crop genetic resources must be coupled with the knowledge of their agronomic attributes. The farmers who cultivate crop varieties know a great deal about their resistance to pests and diseases, their ability to grow in different soils and climates, their water requirements, and so on. In contrast, the records in gene banks merely record when and where the variety was collected. For these three reasons seeds "in the bank" must be complemented by seeds in the field.

2. Market Development and Genetic Erosion

Concern about the spread of markets into centers of genetic diversity can be traced, in part, to a series of theoretical models developed by agricultural economists in the 1990s. The motivating question of these models was why farmers (who were assumed to be rational, utility-maximizing agents) cultivated a mix of traditional and modern Green Revolution crop varieties rather than completely adopting the newer seeds, which were assumed *a priori* to be superior.[1] In a particularly influential piece, de Janvry *et al*. (1991) attributed the 'partial adoption' of improved seeds to the high costs of conducting transactions in imperfect markets. They maintained that so long as farmers remained isolated from markets they would be discouraged from allocating certain choice variables – particularly labor and food – to market production and that "successful agrarian development" was contingent upon policies that facilitated market integration. In a similar model, Fafchamps (1992) suggested that as rural communities became more integrated into the market economy, farmers would shift from cultivating multiple crop varieties for household consumption to the production of a single crop variety that could be sold in the market. Goeschl and Swanson (2000) were among the first to model the effects that market integration would have upon the cultivation of crop genetic diversity *per se*. Not surprisingly, their model provided a similar conclusion as its predecessors: as isolated farmers gained greater access to the market economy, they would reallocate their resources from the cultivation of crop genetic diversity to more lucrative and less risky opportunities in the labor and financial markets.

Although the early studies were mostly theoretical exercises, they have helped to establish the notion that the spread of markets necessarily contributes to the erosion of crop genetic resources. Several researchers have attempted to test the premise empirically by using distance from market centers as a proxy for market isolation and the costs of engaging in market transactions. Many studies have supported the hypothesis that market isolation is associated with higher levels of crop diversity (Van Dusen and Taylor, 2005; Winters *et al*., 2006). Some (Aguirre- Gómez *et al*., 2000) have found that market isolation may be positively associated with some measures of crop genetic diversity while negatively associated with others. Still other studies have provided

[1] These studies, in turn, were the progeny of earlier models that addressed the same question. In one of the earliest analyses, Hiebert (1974) concluded that the 'partial adoption' of Green Revolution seeds was a rational response to learning under uncertainty. Later studies (*e.g*. Feder, 1980; Hammer, 1986) attributed the practice to rational yet risk-averse farmers.

evidence that challenges the predominate hypothesis (Perales *et al*., 2003), finding that farmers cultivating in close proximity to major market centers maintain relatively high levels of crop diversity. For the most part, the empirical studies suggest that market isolation – or at least distance from market centers – is associated with higher levels of crop diversity, but the relationship is not as straightforward as earlier theoretical models have suggested (Smale, 2006).

Addressing the question from another angle, several researchers have investigated how the development of grain markets affects the level of diversity cultivated on the farm. Although maize farmers in Guanajuato, Mexico have been found to be more interested in the consumption attributes of their crops than their commercial qualities (Smale *et al*. 2001), market prices for agricultural output have been shown to affect the levels of crop diversity in many other regions of the world. For example, Steinberg (1999) found that the Mopan Maya have stopped cultivating colored varieties of maize because they cannot be marketed while Meng *et al*. (1998) found that wheat farmers in relatively isolated regions of Turkey are less responsive to grain prices than farmers who cultivate near market centers. Similarly, in a study of four maize farming communities in central Mexico, farmers told Perales (1998) that market factors such as high prices and strong demand were among their main reasons for cultivating certain varieties of maize; Perales also found that traditional maize varieties are more dominant in communities that sell a greater proportion of their maize output. As these studies suggest, agricultural markets can play an important role in shaping the *in situ* conservation of crop genetic resources. Whether or not they actually encourage farmers to cultivate diversity is contingent upon the level of demand and the relative prices of different crop varieties.

While the existing research has provided valuable insights into the relationship between agricultural markets and the on-farm conservation of crop genetic diversity, it has largely ignored the impact of farmers' participation in other types of markets. Farmers from low-income countries have long relied upon wage labor and small-scale non-agricultural commodity production to supplement their agricultural production; along with the recent growth of transnational migration, these non-agricultural market activities are playing an increasingly important role in rural livelihood strategies (Reardon and German Escobar, 2001; Bebbington, 1999; Deere, 2004). Despite farmers' widespread participation in non-agricultural markets, very little research has been conducted on the impact of the phenomenon on the cultivation of crop genetic resources. In one notable exception, Fitting (2006) explains how the growing prevalence of transnational migration is undermining the institutions that support the cultivation of maize genetic diversity in Mexico, a finding that Van Dusen and Taylor (2005) support with statistical evidence. Van Dusen and Taylor (2005) also found that households located in communities where a greater percentage of agricultural tasks are performed by hired labor tend to plant fewer crop varieties; they interpret this to mean that more fully developed labor markets are associated with lower levels of diversity.

In the following sections I investigate how different forms of market participation are related to the on-farm conservation of crop genetic resources in the context of two villages located in the Guatemalan highlands. I examine two forms of market engagements: (1) the allocation of productive resources to agricultural and non-agricultural production for the market, and (2) expenditures in the market. In so doing, I shed light on Goeschl and Swanson's (2000) hypothesis. Are higher levels of market participation associated with lower levels of crop genetic diversity? Do peasants substitute one realm of their economic life for the other, or are the two realms complementary?

3. Site Description

The data for this study were collected from Nimasac and Xeul – two villages located in the heart of Guatemala's western highlands. Nimasac is a hamlet in the Municipality of Totonicapán in the Department of Totonicapán; Xeul is a hamlet in the Municipality of Cantel, Department of Quetzaltenango. Both villages are predominantly K'iche' Mayan[2] and situated in what economic geographer Carol Smith (1989) identified as the "core" of northwestern Guatemala's regional market system. Indeed, located within 20 miles of Guatemala's second largest city, Quetzaltenango, both communities are relatively well integrated into the market economy. Table 1 describes the prevalence and earnings from the five principal economic activities in the communities: wage labor, in-home non-agricultural commodity production and merchant activities, *milpa* agriculture for household consumption, remittances from transnational migration, and agricultural sales.

Nimasac is located in a wide mountain valley just outside the town of Totonicapán. In K'iche' Mayan, Nimasac means "Big Field." Locals distinguish three areas of the community: (1) the wide valley floor where villagers reside and cultivate *milpa*; (2) the steep mountainside, which is a mosaic of privately owned and community managed forest; and (3) the plateau-like mountaintop known as "Alaska" where community members cultivate additional *milpa* plots. Altitudes in the village range from 8,000 to 10,000 feet above sea level.

The people of Nimasac are renowned for their strong indigenous culture and their merchant activities. As shown in Table 1, however, households in the community participate in a variety of economic activities. Nearly two-thirds of all households have at least one community member who is engaged in wage labor; more than a quarter of households have at least one family

Table 1: Economic Activities

Activity	Nimasac			Xeul		
	% of HHs Engaged in Activity	Average per HH ($US)	% of Total HH Income	% of HHs Engaged in Activity	Average per HH ($US)	% of Total HH Income
Non-farm Employment	62.7	1,155.79	38.32	81.7	1,951.54	69.23
Commodity Production/Merchant Activities	91.5	990.86	32.85	78.3	711.74	25.25
Milpa Agriculture*	100	374.48	12.41	93.3	96.79	3.43
Remittances	27.1	336.59	11.16	0.05	26.66	0.95
Agricultural Sales	42.4	158.68	5.26	33.3	32.26	1.14
Total		**3,016.40**	**100**		**2,818.98**	**100**

* Value is imputed from the market value of the agricultural products

[2] Within the 119 households surveyed, 99.4% of the inhabitants of Nimasac and 97% of the inhabitants of Xeul were self-identified as indigenous.

member who is engaged in transnational migration. Since the Ministry of Agriculture established a small irrigation system in the village in the early 1980s, many farmers have received technical assistance from agricultural extension agents who have encouraged them to cultivate snow peas, broccoli and other "non-traditional" crops for export. The crops have not faired well in Nimasac's harsh environment, however, and after several bouts with failure – and the withdrawal of the foreign non-governmental agencies that supported the project – the majority of the participants in the program have reverted back to growing *milpa* on their land.

As its K'iche' name signifies, Xeul is located "beneath the mountain" (or at least at the foot of one) some 10 miles outside of Quetzaltenago. Its growing environment is not as varied as the environment in Nimasac, but altitudes range from 7,500 to 9,000 feet above sea level. Like Nimasac, the residents of Xeul are very active participants in the market economy. As chronicled in Manning Nash's *Machine Age Maya* (1958), the people of Xeul have a long history of labor market participation: a cotton textile mill that began operating in 1876 has been a major employer in the area for over a century. In-home non-agricultural commodity production is another important activity in the community. More than one-quarter of households earn income from weaving the colorful wraps that are worn by many of Guatemala's indigenous women; another 20 *percent* of households have members who earn income from embroidering indigenous blouses and western-style clothing for export and domestic consumption.

This study is based upon data that I have gathered from the two communities over the past five years. The most important stages of the fieldwork included participant observation and open-ended interviews (January – July, 2002); a representative sample survey of 120 households (February – April, 2003); semi-structured and open-ended interviews (September – December, 2003); and focus group exercises (July – August, 2006).

4. Legumes and Squash: The Diversity of Two Minor *Milpa* Crops

In keeping with the region's reputation as a 'megacenter of diversity,' the *milpa* plots of Nimasac and Xeul are often rich in crop diversity. While the *milpa* is usually understood to be a cornfield, it is often – though not always – much more than maize. In addition to having maize as its centerpiece, it is not uncommon for *milpa* plots to be interspersed with beans, squash, fruit trees, leafy greens, herbs, and medicinal plants. Given that multiple varieties of most of these plants are cultivated within a community, the landscape of the highlands is renowned for its rich inter- and intra-crop diversity.

In this essay I focus upon the diversity of the three major *milpa* crops – legumes, squash, and, especially maize.[3] As described in Table 2, the farmers of Nimasac and Xeul plant many different types legumes and squash and, as will be discussed in the following section, an even

[3] Nonetheless, it is important to remember that a number of other plants are often present in Guatemalans' *milpa* plots. As a result, the numbers that I use here tend to understate the level of intra-crop diversity. For example, *milpa* plots are often shaded by one or more fruit trees. Totonicapán has a regional reputation for its apples, which along with plums, cherries, quince, and apricots, are widely grown in both communities. A leafy green locally known as *nabo culix* is common, as are cilantro, epazote, and other herbs. Wild plants that occur among the *milpa* are also utilized, including amaranth greens and bittersweet, which is used as a sedative and to treat skin ailments.

Table 2: Legume and Squash Species Cultivated (common Spanish names in italics)

Legume Species Cultivated	***Cucurbita* Species Cultivated**
• *Alfalfa* - Alfalfa • *Arveja* - Peas • *Arveja China* – Sugar Snap Peas • *Frijol Negro* - Black Beans • *Garbanzo* – Chick Peas • *Haba* – Broad Beans • *Piloy* – Scarlet Runner Beans	• *Ayote* – Winter Crookneck Squash • *Chilacayote* – Fig Leaf Squash • *Güicoy* – Summer Squash • *Güisquil* – Chayote/Mirliton

Table 3: Crop Diversity in *Milpa* Plots

	Nimasac (n = 59)	**Xeul** (n = 60)	**Total Sample** (n = 119)
Number of *Milpa* Seed Lots per HH			
Mean	4.55	3.58	4.06
Standard Deviation	1.99	1.82	1.98
Minimum	1	0	0
Maximum	9	7	9
Number of Maize Varieties per HH			
Mean	2.38	2.4	2.39
Standard Deviation	0.80	1.23	1.04
Minimum	1	0	0
Maximum	5	5	5
Number of Legume Species per HH			
Mean	1.47	0.96	1.21
Standard Deviation	1.05	0.78	0.45
Minimum	0	0	0
Maximum	3	3	3
Number of Squash Species per HH			
Mean	0.69	0.21	0.45
Standard Deviation	0.98	0.55	0.83
Minimum	0	0	0
Maximum	3	3	3

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greater number of maize varieties. At the community level, broad beans (fava beans), peas, and scarlet runner beans are the most widely cultivated legumes; the four varieties of squash are equally prevalent. Despite the contribution of beans and squash to crop diversity in the highlands, they play a relatively minor role in the overall level of *milpa* diversity cultivated by rural households. The number of maize varieties cultivated by the average farmer tends to be twice as large as the number of squash and bean species combined (Table 3).

While the overall landscape of the Guatemalan highlands is rich in crop diversity, not all *milpa* crops are equally diverse. Whereas many households manage multiple varieties of maize and other crops, a handful of households (7% of those surveyed) only cultivate maize in their *milpas*. Whether or not a household augments its *milpa* with other plants could be driven by any number of factors, including the characteristics of the land, the availability of labor, the gender of the household member who manages the plot, and the perceived advantages and disadvantages of intercropping minor *milpa* crops with maize.

During focus group discussions, highland farmers identified a variety of advantages and disadvantages associated with cultivating minor crops in the *milpa*. Among the many advantages discussed were the pleasure that farmers derive from growing multiple crops and the environmental benefits of intercropping. But for the majority of farmers, the advantages of intercropping were related to its ability to help fulfill their family's consumption needs. Perhaps the most widely mentioned advantage of cultivating minor crops were that they complemented maize in the family diet and ensured that basic nutritional needs would be met. As one female participant explained, "When I grow beans I know that my family will eat, even if we don't have meat." Other farmers noted that they could sell the crops in the market for a cash income. They did not perceive the selling of *milpa* crops as a profitable activity, but rather as an *intercambio*, or exchange that allowed them to obtain goods like sugar and coffee that they could not produce at home.

Focus group participants also identified several drawbacks associated with intercropping. Several male participants complained that cultivating beans, squash, and other plants in the *milpa* complicates weeding and other agricultural tasks and is, ultimately, more labor intensive. Another common complaint was that intercropping lowers maize yields. The beans that grow up the cornstalks tend to weigh the maize plants down, making them more susceptible to lodging[4]; the roots of squash plants "disturb" the roots of the maize plants; and a popular leafy green known as *nabo culix* has a reputation for consuming too much moisture and drying up the soil.

Relative attitudes about the advantages and disadvantages of intercropping differ among men and women. In general, women tend to have a more favorable impression of intercropping, while men tend to recognize more of the disadvantages. When questioned about this, a group of female participants explained that men simply evaluate *milpa* by the tortillas on their plate and that they fail to acknowledge the role that the minor crops play in sustaining their families.[5]

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[4] Lodging occurs when a plant falls to the ground. It is typically due to high winds and/or the inability of crops to support their seed.

[5] Indeed, several of the advantages discussed relate to important contribution of beans and squash to the family's food security. One might counter that men perform the majority of agricultural work and are more familiar with the drawbacks of intercropping, which largely occur in the field. Yet a survey of focus group participants and my field observations field suggest that men and women are equally active in tending to their *milpas*. The relationship of gender and crop diversity, however, is unclear and deserving of future research.

5. Maize: The Diversity of the Principal *Milpa* Crop

Maize Classification

While Guatemala is renowned as a center of maize genetic diversity, the peasant farmers who cultivate that diversity do not conceptualize it at the molecular or genetic level. Instead, they understand maize diversity in terms of "seed lots." Seed lots are groupings of kernels that are unique to a given farmer; they refer to each type of seed that the farmer distinguishes when planting (Louette, 1999). At the community level, diversity is understood in terms of "varieties" or the set of seed lots that share common characteristics and often share a common name. Varieties, in turn, are usually distinguished as either "landraces" that have been selected and managed by farmers over time or "improved varieties" that have been scientifically developed by crop breeders.

Guatemalan farmers typically distinguish maize types according to a handful of physically observable plant characteristics. Classification by grain color is the primary means for differentiating maize types. However, since multiple types of a given color are common (*e.g.* two types of white maize), additional criteria are often applied. Common criteria for differentiating varieties of the same color include the length and thickness of cobs and the size and shape of kernels. A farmer wishing to differentiate between two seed lots of the same color may also do so according their growing environments, distinguishing, for example, between "yellow maize for the mountaintop" and "yellow maize for the village."

A Description of Maize Diversity in the Guatemalan Highlands

Rural Guatemalans classify their maize into four different color groups: yellow, white, black, and red. In addition to their solidly colored maize varieties, some farmers plant varieties known as *pinto*, or "spotted," whose individual cobs are a mix of grain colors. Table 4 summarizes the prevalence of each color of maize and the attributes that farmers associate with them.

As is typical in all of Guatemala's highland communities (INE, 2004: 29), yellow and white maize are the most widely cultivated colors of maize in Nimasac and Xeul. The widespread cultivation of yellow is largely attributable to its versatility and its reputation for higher yields. It can be grown in all microclimates and all but the poorest of soils. White maize, in contrast, is a more demanding color of maize. Farmers say that it doesn't produce well at the highest elevations and, since it tends to have the tallest plants, it cannot be grown in windy environments where it is more susceptible to lodging. Moreover, it has a reputation for requiring more fertilizer than the other colors of maize, having the slowest time to maturation, and as being the least nutritious. Despite these many drawbacks, white maize is widely regarded as the tastiest color of maize and it is customary to serve it for weddings, baptisms, and other celebratory occasions.

Black maize is not nearly as prevalent as its yellow and white counterparts. While many of the surveyed households cultivate black maize, they tend to allocate less area to it than their other varieties. This phenomenon is particularly evident in Xeul where half of the surveyed households cultivated black maize, yet it only accounted for 15% of all maize acreage. Black

Table 4: The Prevalence of Maize Colors and Their Perceived Attributes

Color	Proportion of Households who Cultivate		Proportion of Maize Area		Perceived Qualities
	Nimasac	Xeul	Nimasac	Xeul	
Yellow	100.0	85.7	54.8	40.3	• Highest yielding color • Environmentally versatile: can be grown in a variety of environments • More calories and vitamins than white maize, less than black • More resistant to pests than white • Matures more quickly than white, but not as quickly as black • Tortillas do not go hard as quickly as white tortillas
White	90.0	87.5	31.6	44.2	• Plants grow very tall, rendering them susceptible to lodging • Does not grow well at the highest elevations • Requires more fertilizer than other colors • Believed to contain fewer calories and vitamins than other colors • Matures more slowly than yellow and black • Widely touted as the tastiest color • Used for celebrations (*e.g.* weddings, Christmas, birthdays) • Primary ingredient for specialty dishes like *chuchitos*, *paches*, and *talluyos*
Black	35.0	50.0	12.5	15.0	• Most environmentally versatile: said to grow in any environment, including those with poor soils • Requires the least amount of fertilizer • Most resistant to rot • Matures more quickly than yellow and white • Believed to have more calories and vitamins than yellow and white • Many note claim that it has the best aroma and makes smooth tortillas • Many claim that they do not like the taste of black maize and that it upsets their stomachs • Used to make *atoles* and for medicinal purposes (*e.g.* treating measles)

					• Requires the greatest quantity of lime to remove the pericparp during the nixtamalization process. • Difficult to sell surplus in the market • Must use the *masa* (dough) the day that it is milled, otherwise it goes bad • Owners of electric mills are reluctant to process black nixtamal since the dough discolors the lighter colors of maize • A preferred color of Mayan priests
Red	1.7	0.0	1.2	0.0	• Not typically cultivated as it is said to appear spontaneously, usually among yellow maize • Appearance is said to be a "work of God," symbolizes birth • Makes tasty, smooth tortillas • Used for medicinal purposes • A preferred color of Mayan priests
Pinto	0.0	3.6	0.0	0.6	• Typically a mix of black and white kernels

maize is the most maligned color. Many Guatemalans say that they don't like the taste; others say that it upsets their stomachs. It is supposedly more difficult to sell black maize in the market and operators of electric mills have been known to scold clients who bring black maize that will discolor the maize dough (*masa*) of other clients. Nonetheless, black maize has many qualities to commend it. It is the most environmentally versatile color, requires the least amount of fertilizer, and is the most resistant to rot. Moreover, it is believed to be the most nutritious color of maize and many maintain that it has the best aroma and makes smooth tortillas.[6]

Regardless of color, most of the maize varieties cultivated in the highlands are local landraces. There is, however, a significant minority of farmers who cultivate with improved seed varieties. Improved maize varieties were introduced to the Guatemalan highlands in the late 1970s. While it is possible to purchase a pound of certified seed for about $0.46 (US) from agricultural supply stores, most of the highland farmers who use improved maize varieties acquired them for free from governmental and non-governmental aid workers. All of the improved varieties that I encountered during my fieldwork were developed by the Guatemalan Institute for Science and Agricultural Technology (ICTA) as part of its "Dynamic System for Maize Improvement" (Fuentes, n.d.). According to the farmers who use them, there are definite advantages associated with the use of improved varieties, most notably higher yields that are due to bigger ears and stronger stalks that are resistant to lodging. However, there are also significant drawbacks with

[6] Some women say that black maize feels under-appreciated and that it "cries." Its "tears" contribute to its rich aroma and smooth texture.

improved maize varieties. Farmers note that they do not produce well in poor soils, require large quantities of fertilizer, and do not perform well after 3-4 years in the field, requiring that the seed be replaced.[7]

Most farmers are unable to distinguish their seed lots by a common name. Among the 293 seed lots identified in the household survey, respondents were only able to assign a common name to 38% of their maize seeds; 10% of the named seed lots were improved varieties. Without specific names, farmers revert to the aforementioned taxonomy, relying upon color and the growing environment or the physical characteristics of the cob and grain. When asked, most maintain that their seeds do indeed have a name but that they have either forgotten it or that they never knew. Their forgetfulness is not surprising given that most families inherit their seeds from their parents and have grown the same types of maize since the formation of their household: 82% of the seed lots cultivated were acquired from extended family members (usually the husband's parents) and the typical seed lot has been cultivated for more than ten years. In general, men tend to be more familiar with the names of the seed varieties, while women are more likely to describe varieties by their attributes and are more familiar with their culinary qualities.

Table 5 lists that maize varieties that were assigned common names in the household survey and the qualities associated with them. However, given that respondents were unable to assign a name to nearly two-thirds of their seed lots, it is quite likely that other varieties are grown and that the list is incomplete. It is also impossible to determine the exact prevalence of each variety. Nonetheless, my overall fieldwork experience suggests that the most common named varieties grown in Nimasac and Xeul are *Obispo*, *Salpor* (or *Saqpor*), *Toto Amarillo*, and *Chivarreto*.

Perhaps the most widely grown variety is a landrace commonly referred to as *Obispo*, or "Bishop." *Obispo* typically has white or yellow kernels, but two survey respondents in Nimasac also reported growing black versions of the variety. Farmers identify *Obispo* firstly by its thin cob and then by its average sized kernels that are often pointed at the tip. According to a favorite anecdote, previous generations called the variety *Avispa*, or "wasp," since the pointed grain is shaped like a wasp's body. There are no references to either name in the botanical literature, however, its physical characteristics are similar to a "primitive" variety known as *Imbricado* that Wellhausen *et al*. (1957: 45) report was grown in the departments of Totonicapán and Quetzaltenango in the 1950s.

The most celebrated variety of maize grown in the highlands is the landrace *Salpor*. Also known as *Saqpor* in Totonicapán – a K'iche' name that describes its large, white, rounded kernels – it is renowned for its flavor. As a farmer from Xeul explained, "We use *Salpor* for fiestas. It represents exquisiteness; it's giving the best." Indeed, *Salpor* is the preferred variety for preparing the specialty dishes like *talluyos*, *chuchitos*, and *paches*[8] that are typically served for Christmas, weddings, baptisms, and other celebratory occasions. Despite its culinary acclaim,

[7] The Mayan Mam have had a similar experience with improved maize varieties in Quetzaltenango (Hostnig *et al*., 1998).

[8] All three are different takes on what Americans refer to as "tamales." A *tulluyo* is a large corn tamale with broad beans intermixed throughout the corn dough. *Chuchitos* and *paches* are both corn tamales with a piece of meat and relish in the middle. The difference is that *chuchtios* are savory while *paches* are sweet.

Table 5: Maize Varieties and their Perceived Qualities

Variety Name	Color(s)	Improved/ Landrace	Grown in… Nimasac	Grown in… Xeul	Qualities
Chivarreto	Yellow	Improved	Y		• Improved variety that was introduced to Nimasac 15 years ago • Low-statured plant that is resistant to lodging • Produces at higher altitudes where other varieties are unable • Can be grown in lower altitudes, but has smaller cobs/lower yields than other yellow varieties • Developed by ICTA with genetic material from the neighboring municipality of San Francisco el Alto, Department of Totonicapán • Certified seed costs $0.46/lb.
Compuesto Blanco		Improved		Y	• Developed using genetic material from Chimaltenango (Fuentes, n.d.: Table 2) • Better adapted to lower altitudes than other improved varieties • Certified seed costs $0.46/lb.
Cuarenteño	Yellow/ White	Landrace	Y		• Shorter growing cycle than most varieties (cultivated in May instead of March)
Obispo	Yellow, White, Black	Landrace	Y	Y	• Thin cob with pointed grains • Difficult to shell • Possibly a hybridization of the landrace *Imbricado* (see Wellhausen *et al.*, 1957: 45) • Predominantly yellow, but white and black versions are also cultivated
Salpor/Saqpor	White	Landrace	Y	Y	• Known as salpor in Xeul and saqpor in Nimasac. • Saqpor is K'iche' for "big white" • Kernels are large and rounded • Floury variety • Tall plants and large cobs render the plant susceptible to lodging • Requires relatively large quantities of fertilizer • Grain costs 25% more than other white landraces in local markets

					• Widely regarded as the tastiest variety • Used for *paches*, *talluyos*, and other celebratory dishes • Grains are toasted to make *pinole*, a type of meal that is often mixed with sugar and cinnomon. • Dough swells when cooked
San Marceño	Yellow/ White	Both	Y	Y	• ICTA developed an improved variety of San Marceño with genetic material from a landrace of the same name • Does not produce as well as local landraces in Totonicapán
Saqxol	Pinto	Landrace?		Y	• Mix of black and white kernels
Semilla de Mayo	Yellow	?	Y		• Shorter growing cycle than most varieties (cultivated in May instead of March)
Toto Amarillo	Yellow	Improved	Y		• Has thick cobs and large kernels • Requires more fertilizer than other yellow varieties • Created by ICTA from a local criollo variety after it was determined that San Marceño does not produce well in Totonicapán • Certified seed costs $0.46/lb.
Xilom	Pinto	Landrace?		Y	

Salpor is one of the least hardy varieties of maize grown in the highlands. It requires large amounts of fertilizer and its tall plants and thick cobs render it particularly susceptible to lodging.

A yellow maize known as *Toto Amarillo* was the most prevalent improved variety that I encountered during my fieldwork. Using genetic material acquired from Totonicapán, ICTA developed the variety in the 1970s after it determined that its other improved seeds performed poorer than local varieties in Totonicapán (Fuentes, n.d.) According to ICTA, the improved variety now has yields that are 8% greater than local varieties, a statistic that is corroborated by local farmers who maintain that Toto Amarillo's large kernels have increased their yields. They also note the limitations of Toto Amarillo, specifically that it demands more fertilizer than other yellow varieties and that its cobs are relatively thick.

Chivarreto is another widely grown improved variety. Like *Toto Amarillo*, *Chivarreto* is a yellow variety of maize that was created by ICTA in the 1970s. The improved seed was developed using the genetic material from a landrace grown in a nearby hamlet of San Francisco el Alto, Department of Totonicapán. *Chivarreto* is widely appreciated in Nimasac for its low stature and ability to grow on the 10,000-foot high mountaintop – known as Alaska since it is cold and windy – where many farmers own land.[9] *Chivarreto* has proven to be a remarkably versatile variety as many farmers also use it to seed their land in the village, some 2,000 feet lower in elevation.

Evolving Maize Varieties

Although maize varieties are frequently classified as *Chivarreto*, *Salpor*, or by some other name, it is important to note that the actual boundaries that are used to distinguish varieties are fluid and non-stationary. Consider, for example, the agricultural practices of 'Emilia.' A couple of years back, an agricultural extension agent gave Emilia one pound of *Toto Amarillo* seed. Given that the seed was insufficient to cultivate an entire plot of land,[10] Emilia planted part of the plot with her newly acquired improved seed and part of it with yellow *Obispo*. Like all of ICTA's

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[9] The cultivation of maize on the mountaintop is a relatively recent phenomenon. As several informants explained, it is a practice that was established during the early 1990s. Prior to the 1990s, most farmers cultivated *wheat* – not maize – in Alaska. In part, this was due to their inability to grow maize on the mountain since local seed varieties were not suited to the cold and the wind. Wheat, on the other hand, performed much better in the high elevation and could be sold to buyers. The wheat was not generally consumed in the community. Instead, returns from its sale were typically allocated to the purchase of maize, since it was the grain of choice. During the early '90s, however, there was a dramatic drop in the price of wheat and the buyers became more critical of the quality of the wheat that was cultivated on the mountaintop, a transformation that could very well be linked to the dramatic influx of low-priced wheat from the United States that began entering Guatemala in the late 1980s under PL480 (see Garst, 1992). The lower prices combined with more finicky buyers undermined the profitability of growing wheat; in time, farmers ceased its cultivation. Fortunately, most families were not severely affected by the changes in the wheat market. At roughly the same time that Nimasac was losing its wheat market, farmers discovered that they could, in fact, grow maize in Alaska. Using *Chivaretto* or seeds that they acquired from the neighboring municipality of Nahualá, and fertilizing the plants with chicken manure that "warmed the soil," farmers were able to make a relatively seamless transition from the cultivation of wheat to the cultivation of *milpa* on the mountaintop. One farmer was still ecstatic about the discovery, noting that since they are less affected by price fluctuations in the markets for maize and wheat, many families in Nimasac now enjoy a greater sense of food security.

[10] Two pounds of seed are typically required to cultivate the standard 1-*cuerda* plot (1 *cuerda* = 0.118 *hectares*).

improved varieties, *Toto Amarillo* is an open-pollinated variety, so it is likely that the two varieties cross-pollinated. When selecting seed the following year, Emilia was not concerned about propagating the archetypical *Toto Amarillo* nor the archetypical *Obispo*. Instead, she wanted seed cobs with the qualities that fit a particular ideal.[11] Like most *campesinos*[12], Emilia selected ears with narrow cobs (a quality associated with *Obispo*) and full, rounded kernels (a quality associated with *Toto Amarillo*). Emilia is no longer able to distinguish between the two varieties; now she simply cultivates "yellow" maize.[13]

Maize is a dynamic crop, particularly when it is shaped by the constant pressures of human and natural selection as it is in rural Guatemalans' *milpa* plots. As Morris and Lopez-Pereira (1999) have noted, this dynamic nature makes classifying maize varieties into distinct and well-defined categories a difficult and somewhat arbitrary process. Indeed, many farmers talk about how their seed lots have evolved over time. The result, as illustrated in Appendix 1, is that the seed lots from distinct households may be dramatically different, even if they share the same name.

Motivations and Constraints for Cultivating Maize Diversity

Like their counterparts in Mexico (Bellon, 1996), Guatemala's peasant farmers mention several reasons for maintaining maize diversity. They also recognize multiple constraints. Economic, environmental, and cultural processes all play an important role in shaping the overall level of diversity managed by a given household. This section provides a brief discussion of the processes that peasants identify as encouraging and constraining the cultivation of maize diversity within their households.

Perhaps the most commonly cited reason for growing multiple varieties of maize is *gusto*, or "pleasure." Peasant farmers note that they enjoy cultivating different varieties of maize; it makes them happy to harvest multiple colors of grain. They also enjoy eating it, as consuming multiple colors of maize is a means of varying an otherwise monotonous diet. As an older peasant from Xeul explained, "We grow many classes of maize because we like colors. Not everyone wants to eat black maize everyday. Guatemalans are people of maize. We eat tortillas all day long, tortillas with chilies. We grow different colors of maize so that we don't get bored with our tortillas."

Culinary purposes provide another motivation for cultivating maize diversity. In addition to tortillas and tamales, which are a staple at every meal, Guatemalans consume a variety of maize-based products. Certain types of maize are better suited for preparing certain types of foods. For example, recipes that have sauces and relishes enveloped in corn dough are made with white maize since, as one *campesina* explained, "The white maize acts like a sponge and absorbs the flavor." All colors of maize are used to make *atoles* (or hot, maize-based drinks), though their tastes and uses are varied: black and yellow *atoles* are salty and consumed on a regular basis,

[11] Via an econometric model, Smale *et al*. (2001) came to a similar conclusion about maize farmers in Mexico, noting that they are not as concerned with actual varieties of maize as they are with particular attributes.
[12] *Campesino* is the Spanish word for "peasant."
[13] This process of *creolization* is said to be especially beneficial to small-scale subsistence farmers since it allows them to integrate desirable new traits into their agricultural portfolios (Bellon *et al*., 2006).

while white *atole* is typically sweetened with cinnamon and sugar and served for celebratory occasions. Similarly, all colors of maize can be used to make tortillas and tamales, though it is said that yellow and white maize are for preparing tortillas while black maize is used to make tamales.

In addition to utilitarian reasons, there are also environmental motives for cultivating multiple maize varieties. In a landscape as varied and heterogeneous as the Guatemalan highlands peasants usually cultivate in a variety of growing environments. "Each place has its own seed," a young *campesino* told me. For example, black maize is said to grow relatively better in poor soils whereas white maize, especially *Salpor*, is typically grown close to home where it can receive more care.

Growing multiple varieties is also a means for managing risk. As a relatively affluent peasant explained, "Some years yellow maize grows well, some years white grows well; that's why I plant both." Nature is unpredictable in the highlands; by growing multiple seed lots that have varying levels of resiliency to environmental threats (*e.g.* pests, pathogens, weather), a household is able to minimize the probability that environmental conditions will destroy its entire harvest. In the language of economics, farmers stabilize their yields by maintaining a portfolio of maize varieties.

There are also strong cultural motivations for cultivating multiple varieties of maize. When asked why they cultivate so many varieties of maize, many focus group participants simply stated that it was their tradition to do so; "It's what we Mayans do." Some suggested that the practice is rooted in the Mayan cosmology where the universe is conceptualized as having four corners, each represented by one of the four colors of maize. Balancing all four colors is reflective of the Mayan value of complementarity. For example, red corresponds with the rising sun and symbolizes the beginning of life while black corresponds with the setting sun and represents peacefulness and death. Similarly, white symbolizes forces that are invisible to the human eye such as the wind and spirits while yellow is symbolic of material things that can be touched and seen.

Despite the importance of balance in Mayan spirituality, many rural Guatemalans note a reduction in the number of farmers cultivating red and black maize. A Mayan priest attributed this to the government and aid agencies' focus on yields, continuing with, "Everything has God in it and those objects should not be sacrificed in the name of production." Indeed, as the priest noted, technical assistance in the Guatemalan highlands has been strongly biased against minority grain colors. In its campaign to develop higher yielding seed varieties, for example, ICTA has focused exclusively on yellow and white varieties; none of its improved varieties are black or red. Agricultural extension agents have further entrenched ICTA's bias by encouraging farmers to replace their local landraces (black, red, or otherwise) with the higher yielding improved varieties.

The most widely mentioned constraint to cultivating maize diversity is insufficient land. Indeed, Guatemala's concentrated agrarian structure and insufficient landholdings for the vast majority of farmers have limited the economic opportunities of the country's peasant farmers in a variety of ways (Barry, 1987; Handy, 1984; World Bank, 1996). Their inability to cultivate more varieties of maize is yet another. Among the households surveyed, the typical family controlled less than 0.5 hectares of arable land. Limited landholdings have discouraged farmers from planting black maize (since it is not widely liked and its culinary qualities are less versatile) and *Salpor* (since it is more susceptible to environmental conditions and, hence riskier to grow).

A final limitation to cultivating maize diversity is the limited ability of some *campesinos* to acquire new seed varieties. Several peasants mentioned a desire to cultivate commonly grown varieties of maize, but maintained that they did not know where to obtain the seed. Nearly two-thirds of survey respondents reported that they engaged in seed exchange, but 92% of it occurred within families. This suggests that the types of seed available to households are typically confined to family networks.

In sum, peasants identify multiple forces that foster the diversification of their household's maize portfolio. The pleasure of cultivating multiple varieties, the enjoyment that comes from diversifying one's diet, distinct culinary qualities associated with different varieties, the necessity of matching seeds with diverse environmental conditions, a desire to hedge against environmental uncertainty, tradition and a respect for their Mayan heritage are all motivating factors for peasant households to cultivate maize diversity. At the same time, however, they note that there are social forces working to constrain their management of maize diversity. In addition to pressures from agricultural extension agents to abandon their more colorful varieties, peasants find their cultivation of maize diversity constrained by insufficient landholdings and limited access to seed varieties that are not cultivated by family members.

Among the many processes that peasants identify as affecting their cultivation of maize diversity, one set of forces is conspicuously absent, namely market engagements. The peasants of Nimasac and Xeul make no mention of a relationship between their market participation and their management of maize diversity. Does this mean that the dire predictions of Goschel and Swanson (2000) were wrong and that market engagements do not affect the level of intra-crop diversity cultivated by peasant households? The following section provides an econometric analysis of the question.

6. The Impact of Market Participation on Maize Diversity - An Econometric Approach

Measuring Diversity

While the notion of diversity may seem fairly simple and intuitive, there is no obvious means for measuring it. As ecologists studying species diversity have noted, diversity is a two-dimensional concept (Magurran, 1988). Perhaps the most obvious dimension of diversity is "richness," or the number of species present in a given area. The second and usually less apparent dimension is "evenness," or the relative abundance of species within a given area.[14] Some measures of

[14] Consider, for example, two farmers, each cultivating two varieties of maize on a one-*cuerda* plot of land. Assume that Farmer A allocates ½ *cuerda* to each variety of maize while Farmer B allocates 0.99 *cuerdas* to variety 1 and 0.01 *cuerdas* to variety 2. Although both fields are equally rich in diversity (they each contain two varieties per *cuerda*), Farmer A's field would be considered more diverse overall since it has a more even distribution of varieties.

Table 6: Measures of Crop Diversity at the Farm Level

Index	Concept	Construction	Explanation
Count	Richness	$D = S$	S = Number of farmer-managed units of diversity
Margalef	Richness	$D = (S-1)/\ln A$ $D \geq 0$	A = Total arable landholdings controlled by household
Shannon	Proportional abundance, equitability	$D = -\Sigma\alpha_i \ln\alpha_i$ $D \geq 0$	α_i = Area share occupied by *i*th variety managed by household
Simpson	Proportional abundance, dominance	$D = 1 - \Sigma\alpha_i^2$ $1 \geq D \geq 0$	α_i = Area share occupied by *i*th variety managed by household

Adapted from Smale, 2006: Table 1.2

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diversity only capture one of the dimensions while others collapse both dimensions into a single value. While the first type fails to express the complexity of diversity, the later tends to confound the relative importance of each dimension. Thus, no single measure of diversity is ideal.

As has become standard in the literature on crop diversity (Smale 2006; Aguirre Gomez *et al*, 2000, Meng *et al*., 1998), I use several measures of diversity in this essay. Table 6 summarizes the four diversity indices that I use and defines their construction. Two of the diversity indices emphasize richness while the other two are measures of proportional abundance. The indices based on proportional abundance are also known as heterogeneity indices since they account for both richness and evenness (Magurran, 1988). By comparing and contrasting these four indices, it is possible to achieve a more nuanced understanding of diversity than if one were to rely upon a single measure alone.

One approach for measuring richness is a simple count of seed lots. I use this approach for measuring the intra-crop richness of each of the three principal types of *milpa* crops – maize, beans, and squash – as well as the overall infra-crop richness of a household's *milpa* (*i.e*. a summation of the number of varieties of maize, and the number of species of beans, and squash).[15] There are two disadvantages of using counts to measure diversity: (1) they are not adjusted for the area cultivated; and (2) they have no means of capturing the evenness of a distribution. They do, however, allow for at least a basic measure of diversity in situations where it is difficult to calculate the area share for a given seed lot, as is the case with minor *milpa* crops like beans and squash that are sporadically interspersed within the more methodically cultivated maize plants.

[15] Instead of beans, the category is technically legumes, since it includes peas and alfalfa.

Table 7: Diversity Indices

Diversity Measure	**Mean**	**SD**	**Minimum***	**Maximum**
Count *Milpa* Seed Lots	4.209	1.861	1	9
Count Maize Seed Lots	2.478	0.958	1	5
Count Legume Species	1.260	0.946	0	3
Count Squash Species	0.469	0.841	0	3
Margalef Index (Maize)	0.316	0.201	0	0.935
Shannon Index (Maize)	0.739	0.418	0	1.609
Simpson Index (Maize)	0.457	0.238	0	0.800

* The Margalef, Shannon, and Simpson Indices all have a lower limit of zero if only one variety is cultivated.

The Margalef index is another means for measuring richness. By dividing the number of seed lots by the natural log of the amount of arable land controlled by a household, the Margalef index improves upon the counting approach. However, given the difficulty in measuring the amount of land allocated to secondary *milpa* crops like beans and squash, I only use the index to measure the varietal diversity of maize.

As indicators of richness, neither the count nor the Margalef indices account for the evenness of crop diversity. Thus, two measures of proportional abundance – the Shannon index and the Simpson index – are included in the study. Derived from information theory, the Shannon index takes into account the evenness of the abundance of varieties. The Simpson index is a measure of dominance; it is more heavily weighted towards the most abundant seed lot grown by a household and is less sensitive to intra-crop richness (Magurran, 1988). In other words, the Shannon index is more weighted towards uncommon species (and hence, richness) while the Simpson index is more weighted towards abundant species (and hence, dominance). Since both the Shannon and Simpson indices are based upon the area allocated to a given crop and the survey instrument did not capture the area cultivated with minor *milpa* crops, the indices are only used to measure the proportional abundance of maize varieties.

Table 7 presents descriptive statistics for these diversity measures, calculated from the household survey data.[16] The count of *milpa* seed lots measures the richness of infra-crop diversity; the remaining six indices provide measures of intra-crop diversity for maize, legumes, and squash.

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[16] Four households that do not own arable land and, hence, do not cultivate *milpa* were not included in the regression analysis. Thus, the sample includes 59 households from Nimasac and 56 from Xeul, for a total of 115 households.

The Model

Having developed quantitative measures of crop diversity, it is possible to estimate the relative effects that different forms of market participation and other potentially relevant forces have upon the on-farm conservation of crop diversity. To do so, the following model was estimated:

$$D_i = \beta_0 + \beta_1 C_i + \beta_2 H_i + \beta_3 S_i + \beta_4 N_i + \beta_5 P_i + \beta_6 E_i + \varepsilon_i$$

where: D_i = measure of crop diversity of household *i*;
C_i = household characteristics of household *i*;
H_i = human capital variables of household *i*;
S_i = social capital variables of household *i*;
N_i = natural capital variables of household *i*;
P_i = market production of household *i*;
E_i = market expenditures of household *i*; and
ε_i = error term

In other words, five sets of explanatory variables are tested for their influence upon the level of crop genetic diversity that is maintained at the household level: household characteristics, human capital, social capital, natural capital, and market engagements. Table 8 summarizes each set of the explanatory variables and their hypothesized effects.

The set of household characteristics consists of two explanatory variables: age of household heads and wealth. The age of household heads is included to test whether older farmers have a higher propensity to conserve crop genetic diversity due to traditional practices and taste preferences. Since both men and women play important roles in maintaining crop diversity, the average age of both household heads is used. Age is hypothesized to be positively correlated with crop diversity since older households are expected to value tradition more than younger households.

A measure of wealth is included to investigate the potential effects of economic security upon the on-farm level of crop diversity. Given that wealth has multiple dimensions whose individual linear regression coefficients are unlikely to infer the impact of an overall change in wealth (Filmer and Pritchett, 2001), an index was created using principal components analysis. The index is derived from the size of household dwellings, the area of forested land controlled, a wealth ranking estimated by the interviewer at the time of the survey, and a proxy for household expenditures.

Measures of human capital are included to test the hypothesis that the quantity and quality of a household's labor power affect the level of diversity maintained on the farm. Household labor is simply a count of the number of household members who are fourteen years of age or older. Since managing a diverse *milpa* is assumed to be more labor intensive than a mono-cropped *milpa*, the sign for household labor is expected to be positive. Education is measured as the average years of education per adult household member. Since the educational system in Guatemala tends to teach 'modern' values and the opportunity cost of working in the *milpa* increases with education, the sign of this variable is expected to be negative. Technical

Table 8: Definitions of Explanatory Variables and Hypothesized Effects on Diversity

Category	Variables	Description	Mean	Hypoth Effect
Household Characteristics	Age of HH Heads	Average age of the head of household and the head's spouse	41.13	+
	Wealth	Measure created using principal components analysis	0.00	-
Human Capital	Household Labor	Number of household members 14 years of age and older	4.13	+
	Education	Years of education per adult household member	4.36	-
	Technical Assistance	Household members have received agricultural training (dummy)	0.10	-
Social Capital	Community	Household is in Nimasac (dummy)	0.51	?
	Religion	Proportion of evangelical household members	0.36	-
	Seed Exchange	Household has received seed from outside extended family (dummy)	0.23	+
Natural Capital	Arable Landholdings	Area of arable landholdings (*cuerdas**)	6.46	+
	Arable Landholdings Squared	Area of arable landholdings squared (*cuerdas*)	102.16	-
	Distinct Plots	Number of arable plots that differ in terms of their fertility, climate, and/or slope	1.70	+
Market Production	Labor Market Participation	Weekly hours of wage labor per adult household member	12.10	-
	In-home Commodity Production and Merchant Activity	Proportion of household income earned from in-home commodity production and merchant activity	0.38	?
	Commercial Agriculture	Value of agricultural output sold per *cuerda* of land (quetzales**)	6.51	-
	Transnational Labor	Proportion of adult household members working abroad	0.05	-
Market Expenditures	Consumer Goods	Monthly expenditures per adult equivalent unit on a basket of consumer goods	10.78	-
	Hired Labor	Number of field hand days hired per year	19.89	?

* 1 *cuerda* = 0.118 hectares
** 7.6 quetzales ≅ $1.00 (US)

assistance is a dummy variable indicating whether the household has received agricultural training from governmental and non-governmental agencies. Since agricultural extension agents usually encourage farmers to adopt improved seeds that are able to cover broad growing environments, it is hypothesized to have a negative effect on measures of genetic richness.

Three measures of social capital are tested; each is hypothesized to affect crop diversity differently. As discussed in Section 5, some peasants maintain that limited access to seed has prevented them from cultivating more varieties of maize. Thus, a dummy variable indicating households that obtained seed from outside the family is hypothesized to have a positive effect on maize diversity. It has also been suggested that a declining reverence for Mayan cosmology has reduced interest in cultivating diversity. Protestant religions – whose practitioners are referred to as “evangelicals” in Guatemala – are widely known for their condemnation of Mayan spirituality and have been aligned with fostering “anti-*milpa*” attitudes (Annis, 1987), thus a variable representing the proportion of household members who identify as evangelicals is hypothesized to have a negative affect. A dummy variable that indicates whether a household resides in Nimasac or Xeul is also included and has no expected sign.

Agro-ecological characteristics that are believed to influence the household management of crop diversity are included in a set of natural capital variables. The area of arable land maintained by a household has been said to permit the cultivation of more maize varieties and is expected to have a positive sign. A quadratic of arable land is also included; its sign is expected to be negative, on the standard assumption that diversity is concave with respect to area. Another agro-ecological variable, distinct plot types, is included to measure the variability among a given household’s agricultural land. It is calculated as the number of non-contiguous plots controlled by the family that (subjectively) differ in regards to at least one of the following environmental qualities: climate, fertility, and slope. The number of distinct plot types serves as a proxy for the incentive to match different seeds with different agro-climatic niches; it is hypothesized to have a positive effect on the level of on-farm diversity.

The final set of variables, market participation, is included to test the hypothesis that engagements in the market economy create a disincentive to maintain crop diversity on the farm. Six distinct types of market engagement are included: four relate to the household’s allocation of resources, two to the household’s expenditures.

The value of agricultural output per unit of arable land is a proxy for the allocation of land resources to market activities. Since nearly all land is cultivated, households either allocate their arable land to the cultivation of cash crops that are mostly sold and command high market prices or to *milpa* crops that are typically consumed within the household and fetch relatively lower prices in the market. It follows that households with more agricultural sales per unit of cultivable land are hypothesized to allocate less land to *milpa* agriculture and, therefore, have lower measures of maize and *milpa* diversity.

The model also includes three variables to capture how households allocate their labor power: (1) the number of adult hours allocated to wage labor during an average week, (2) the proportion of adult family members engaged in transnational migration and working abroad, and (3) the share of household income earned from in-home non-agricultural commodity production and independent merchant activities. Theoretically, all three activities divert family labor away from the cultivation of *milpa*. They might also decrease the economic relevance of subsistence agriculture since income earned in the marketplace could be used to purchase substitutes for homegrown crops. Thus, one might expect allocated labor to the three forms of market engagement would be associated with a reduction in crop diversity. But, given that in-home commodity production and merchant activities tend to be a relatively flexible use of labor power that would allow farmers to attend to their fields when they desire, their hypothesized effect on crop diversity could be weak.

The final two market variables are included to test the impact of household expenditures on crop diversity. It has been hypothesized that as households earn more income they will substitute commodities purchased in the market for food crops grown in their fields (de Janvry et al., 1991). An index that measures a household's expenditures (in Quetzales) per adult equivalent unit on a select basket of consumption goods is employed to test this hypothesis. The impact of hired labor on crop diversity is also tested. On the one hand, hired labor might allow for households to practice labor-intensive diversity management, even if they suffer from a shortage of labor power or its members are otherwise employed. But, given that cultivating a diverse *milpa* requires an intimate knowledge of agricultural inputs (*e.g.* the knowledge of how a given seed performs in a given environment), it might be that be that hired labor represents a "mass production" mentality for *milpa* cultivation and are associated with lower levels of crop diversity.

7. Econometric Findings

Four sets of regression results are presented in Table 9, in which the dependent variables are measures of infra- and intra-crop diversity. Specifically, they are simple counts of *milpa* diversity, maize varieties, legume species, and squash species respectively. To account for the discrete count nature of the dependent variables, Poisson regressions were used to estimate each model.

Table 10 presents three additional sets of regression results. The dependent variables are the Margalef index, the Shannon index, and the Simpson index. As discussed in Section 6, these indices differ from one another in the weight that they accord to the richness and evenness dimensions of maize diversity. The Margalef index is the most heavily weighted towards richness; the Simpson index accords it the least amount of importance. Tobit models were used to estimate the models since all three have limited dependent variables.

Among the household characteristics, only wealth is statistically significant in explaining the level of maize diversity cultivated. In general, higher levels of wealth are associated with lower levels of infra- and intra-crop diversity. As indicated by the relatively strong statistical significance of wealth in the Margalef, Shannon, and Simpson models, this finding is particularly reliable as it relates to the richness and proportional abundance of maize diversity.

Table 9: Factors Influencing *Milpa* Diversity - Poisson Results

		Total *Milpa* Varieties (Infra-crop diversity) (n = 115)		**Maize Varieties** (Intra-crop diversity) (n = 115)		**Legume Varieties** (Intra-crop diversity) (n = 115)		**Squash Varieties** (Intra-crop diversity) (n = 115)	
		Coeff.	t-ratio	Coeff.	t-ratio	Coeff.	t-ratio	Coeff.	t-ratio
	Constant	0.9034***	2.84	0.4709	1.20	-0.3361	-0.57	-2.1032*	-1.92
HH Characteristics	Age of HH heads	-0.007	-0.18	0.0038	0.69	-0.0089	-1.11	-0.0037	-0.26
	Wealth	-0.0581	-0.98	-0.0620	-0.82	-0.0295	-0.27	-0.059	-0.32
Human Capital	Household labor	0.0234	0.81	0.0005	0.01	0.0615	1.16	0.0402	0.43
	Education	0.0009	0.04	0.0063	0.20	-0.0291	-0.61	0.0737	0.93
	Tech. assistance	0.0014	0.01	-0.0404	-0.15	0.2721	0.80	-0.6203	-0.88
Social Capital	Community	0.1899	1.68	-0.0264	-0.18	0.3605*	1.72	1.3021***	3.32
	Religion	-0.2053*	-1.75	-0.1040	-0.70	-0.5765**	-2.51	0.1302	0.36
	Seed exchange	0.1632	1.35	0.0325	0.20	0.2740	1.24	0.5498*	1.60
Natural Capital	Arable land	0.0420***	2.60	0.0361*	1.68	0.052*	1.80	0.0470	0.89
	Arable land sqrd.	-0.0006**	-2.21	-0.0005	-1.39	-0.0009*	-1.82	-0.003	-0.33
	Distinct plots	0.0280	0.43	0.0651	0.79	-0.0021	-0.02	0.1689	0.78
Market Engagements	Labor market	0.0081	1.20	0.0003	0.05	0.0214*	1.74	0.0001	0.01
	In-home CD/merchant	0.1348	0.68	-0.0727	-0.29	0.1938	0.53	0.3646	0.54
	Commercial Agriculture	0.0017	0.60	0.0018	0.50	-0.0033	-0.63	0.113	1.40
	Migrant labor	0.2687	0.59	-0.0806	-0.13	0.7587	0.95	-0.7931	-0.54
	Consumer goods	-0.0001	-0.01	0.0027	0.25	0.0091	0.56	-0.0568*	-1.60
	Field hands	-0.0029**	-2.26	-0.0020	-1.27	-0.0017	-0.78	-0.0154	-1.78
	Deviance R-Squared	0.07		0.03		0.08		0.17	

*** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

Table 10: Factors Influencing Maize Diversity - Tobit Results

		Margalef Index (Richness) (n = 115)		Shannon Index (Proportional abundance) (n = 115)		Simpson Index (Proportional abundance) (n = 115)	
	Variable	**Coeff.**	**t-ratio**	**Coeff.**	**t-ratio**	**Coeff.**	**t-ratio**
	Constant	0.048	0.35	0.0780	0.28	0.0726	0.46
HH Characteristics	Age of HH heads	0.0027	1.45	0.0052	1.34	0.0027	1.24
	Wealth	-0.0650***	-2.47	-0.1289**	-2.42	-0.0782***	-2.58
Human Capital	Household labor	0.0071	0.54	0.0180	0.68	0.0142	0.94
	Education	0.0059	0.54	0.0177	0.80	0.0111	0.88
	Tech. assistance	-0.4179	-0.43	-0.1291	-0.66	-0.0849	-0.76
Social Capital	Community	-0.1964	-0.39	-0.0346	-0.34	-0.0017	-0.03
	Religion	-0.0579	-1.16	-0.1143	-1.12	-0.0601	-1.04
	Seed exchange	0.0301	0.55	-0.0377	-0.34	-0.0410	-0.65
Natural Capital	Arable land	0.0083	1.12	0.0349**	2.30	0.0186**	2.15
	Arable land sqrd.	-0.0001	-0.74	-0.0004*	-1.81	-0.0002*	-1.63
	Distinct plots	0.0010	0.03	0.0027	0.04	-0.0064	-0.19
Market Engagements	Labor market	0.0015	0.53	0.0055	0.92	0.0030	0.88
	In-home CD/merchant	0.0065	0.08	0.0994	0.57	0.0628	0.63
	Commercial agriculture	0.0013	0.93	0.0024	0.87	0.0014	0.89
	Migrant labor	0.1369	0.67	0.5351	1.29	0.4059*	1.73
	Consumer goods	0.0047	1.28	0.0065	0.86	0.0044	1.04
	Field hands	-0.0012**	-2.23	-0.0029***	-2.61	-0.0017***	-2.80
	Deviance R-Squared	0.57		0.14		0.36	

*** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

The negative relationship between wealth and maize diversity is consistent with two hypotheses. First, it is consistent with the notion that households cultivate a diversity of maize varieties as a means for managing risk. Since wealthier households control more assets, they may be able to manage environmental risks that might affect maize production in other ways than diversifying their seed lots. The negative relationship of wealth and maize diversity might also be explained by the qualitative observation that wealth is associated with previous – as opposed to current – transnational migration. Elizabeth Fitting (2006) found that transnational migration has changed farmers' attitudes about maintaining crop diversity in Mexico. A similar process may be unfolding in Guatemala and is worthy of further research.

None of the human capital variables are statistically significant. Although positive, the statistical insignificance of household labor – combined with its relatively small marginal effects – suggests that greater availability of household labor does not have a notable impact on the levels of infra- or intra-crop diversity cultivated on the farm. For the same reasons, higher levels of education do not necessarily translate into less diversity managed on the farm. The negative and relatively large coefficients for the technical assistance variable suggest that, as predicted, training from agricultural extension agents tends to lower the richness and evenness of maize genetic diversity. This finding is not particularly reliable, however, since large standard errors have rendered it statistically insignificant.

All three of the social capital variables play a role in explaining the richness of diversity in farmers' *milpa* plots. As predicted, households with a greater affiliation for evangelical Christianity tend to maintain plots that are less rich in overall infra-crop *milpa* diversity and grow fewer species of legumes. Surprisingly, acquiring maize seeds from someone outside of the family is statistically associated with planting more squash types, but not – as some farmers claimed – with the diversity of maize. Perhaps the initiative to seek seed outside normal networks is indicative of a broader interest in agricultural diversity. Also, households residing in Nimasac are more likely to cultivate a larger number of legume and squash species than their counterparts in Xeul.

Among the natural capital variables, the amount of arable land controlled by households is significantly and positively associated with most measures of crop diversity. In general, the null hypothesis that the level of crop diversity managed by a household is positively associated with the size of its arable landholdings cannot be rejected. As the amount of arable land controlled by a household increases, it is more likely to maintain an overall richer *milpa*, particularly with respect to maize and legumes. It is also more likely to provide the additional maize varieties that it cultivates with a share of land that is relatively equal with existing varieties. Nonetheless, the increased richness and evenness that is associated with the expansion of a household's arable landholdings is likely to increase at a decreasing rate, as indicated by the negative and statistically significant sign of the square of land owned variable.

Surprisingly, the number of distinct plots was not found to have a substantive or statistically significant effect on any of the measures of crop diversity. This finding may be attributable to the low levels of environmental heterogeneity (subjectively) reported by survey respondents; the survey may have failed to capture the extent to which farmers match seeds to environmental conditions. It might also suggest that the availability of *Chivarreto* and other environmentally versatile maize varieties may reduce the need for farmers to use different seeds in distinct environmental niches, at least within a given community.

A primary objective of this paper is to examine the relationship between different forms of market engagement – especially the allocation of household resources to market production – and the level of on-farm crop diversity. In general, the allocation of household resources to market-oriented activities like wage labor, non-agricultural commodity production and merchant activities, cash cropping, and transnational migration do not play a statistically significant role in explaining crop diversity on the farm. Thus, the reliability of the estimations is questionable. Nonetheless, it is worth noting that the coefficients for most of this subset of market engagement variables are not negative – as predicted – but *positive*. Rather than contributing to the loss of crop genetic resources, allocating productive resources to market activities is potentially associated with a rise in levels of infra- and intra-crop diversity. This relationship is particularly evident with the statistically significant (Simpson model) and substantively positive (Shannon and Simpson models) association of transnational migration with higher measures for the proportional abundance of maize diversity.

Even as allocating productive resources to market activities is generally associated with higher levels of on-farm crop diversity among the sample, household expenditures in the marketplace are shown to have a negative relationship with cultivation of crop genetic resources. As hypothesized, households that spend more on consumer goods tend to maintain lower levels of squash diversity. The marginal impact of consumption expenditures on this minor *milpa* crop is relatively small, however, and the variable has an indeterminate effect on the other measures of crop diversity. Thus, the notion that farmers will substitute purchased food for self-cultivated crops is only weakly supported by the regression results. The negative relationship between market expenditures and the on-farm conservation of crop genetic resources is more convincingly demonstrated by the effects of employing field hands to assist with agricultural labor.

The hiring of field hands is shown to be negatively associated with four different measures of crop diversity. As more days of field labor are employed, a household is likely to plant fewer *milpa* crops. Moreover, it is likely to plant a *milpa* that is less rich in maize diversity (Margalef Index) where a small number of maize varieties are dominant (Shannon Index, Simpson Index). The negative relationship between hired labor and crop diversity might be attributable to field hands' limited ability to match seeds with a given plot of land. Diversity management requires an intimate knowledge of seed qualities and the environmental characteristics of each plot of land. Since households that rely upon hired labor may be less likely to have such knowledge – or unable or unwilling to convey that knowledge to the workers that they hire – they might be more likely to plant a "generalist *milpa*" that performs well enough rather than a "specialized *milpa*" that conforms to the particular qualities of the land and tastes of household members.

8. Discussion: The Impact of Market Engagements

The econometric results identify three key variables that can be reliably associated with lower levels of crop diversity at the household level: (1) the small size of arable landholdings that constrain farmers from planting more crop varieties and limits the area that they allocate to minority varieties; (2) higher levels of wealth; and (3) greater use of hired field hands. These findings are consistent with investigations conducted by other researchers in the field (Van Dusen and Taylor, 2005; Winters *et al*., 2006) and carry important policy implications, as will be discussed in the following section. One of the more noteworthy results of the regressions, however, is the statistical insignificance of several market variables, namely the hours of wage labor per adult household member, the value of agricultural sales per unit of land, the income share of in-home commodity production and merchant activities, and the proportion of adult household members engaged in transnational migration. The limited explanatory power of these variables suggests that, contrary to conventional economic wisdom, allocating productive resources to market activities is not associated with a reduction in the level of crop genetic diversity on the farm. Indeed, the signs on these variables, albeit statistically insignificant, are generally positive.

There are at least four possible explanations for the positive and statistical insignificance of the market production coefficients. One reason is the relative balance of factor endowments in the Guatemalan highlands. In relation to their typically meager landholdings, most peasant households have a relative abundance of labor. Excluding one notable outlier, the average family in Nimasac and Xeul controls approximately six *cuerdas* (or two-thirds of a hectare) of arable land. Given that it is possible to adequately cultivate a *cuerda* of maize with seven full days of labor, the average family would only need to allocate some 42 person-days of labor to maize agriculture in order to produce an acceptable harvest in a given year. Additional time in the fields allows peasants to attend to minor *milpa* crops and to improve maize yields. Nonetheless, given that the average household has four adults of working age, most families incur a "surplus of labor" to the extent that attending to their *milpa* requires only a small percentage of their available labor supply.

Another possible explanation is market segmentation. While maize is always readily available in the numerous local markets of the highlands, the preferred maize varieties are not. Marketed maize is categorized as either coastal maize or highland maize; highland maize, in turn, is subdivided into white maize, yellow maize, black maize, and *Salpor*. As its name implies, coastal maize is grown on Guatemala's western coast and piedmont; usually it is the product of modern agricultural practices. Coastal maize is available year-round in highland markets and is relatively cheap, costing about 20% less than yellow, white, and black maize from the highlands and 35% less than *Salpor*. But, highland peasants have a strong preference for their local maize varieties. Most are willing to pay the price premium for highland maize that they maintain is more aromatic and produces tortillas that are "smooth like bread" in comparison to the notoriously hard tortillas made from coastal maize. Maize from the highlands is not always available in local markets, however; at least 8% of all maize consumed must come from sources outside the communities. Thus, while coastal maize is an inferior substitute, households that rely upon markets for their maize may have no choice but to purchase it. The limited availability of preferred maize varieties in local markets may help to discourage the substitution of market activities for traditional agricultural practices.

A third possible explanation for the insignificance of market variables might be the unique role that maize plays in the social lives of rural Guatemalans. Most of the literature on crop genetic diversity conceptualizes the agricultural output of peasant farmers as a mere commodity whose value can be imputed and measured in market prices. For many Guatemalan peasants, however, maize is no ordinary good. Although it has many characteristics of a commodity – it is bought and sold in markets and sometimes even discussed about in terms of its profitability – maize also generates a number of non-market entailments for Guatemalan farmers. For example, many farmers mentioned that the enjoyment that came from working the land was just as important to them as the food that they produced. Growing maize is also understood as an expression of cultural identity. It is a commonality shared by all households. Working the land and cultivating *milpa* is associated with a sense of community; donating maize to community celebrations or to families in need helps to fortify social networks. Growing maize also allows the predominantly K'iche' Mayan farmers to relate to their creation myth, the *Pop Wuj*, which explains how *Ixmucane*, the Grandmother of Day, created humans from the four colors of maize; in reference to this, Guatemalan highlanders will frequently note, *Somos hombres de maíz*, "We are people of corn." In general, growing *milpa* and participating in the market are viewed as equally important but distinct aspects of rural Guatemalan's economic lives. As a male participant in one focus group explained, "A person may have a job – he might work in construction or make shoes in his home – but that is to earn money. One grows maize to sustain the family with food." The women from another focus group concurred, "They are different types of activities, different aspects of our lives." The fact that maize is conceived as such may account for the limited impact of market engagements upon the level of crop diversity that is cultivated on the farm.

Finally, the statistical insignificance of the market participation variables in the regression results may be attributable to the absence of longitudinal data. The models only measured how market engagements related to crop diversity for a given year; a lack of suitable data precluded a statistical examination of how market engagements affect the conservation of crop genetic resources over time. This is a key limitation of the study. Qualitative observation suggests, however, that at least one form of market engagement is likely to have contributed to the erosion of crop genetic resources over time: the growing prevalence of transnational migration.

The practice of migrating and working abroad has become increasingly prevalent in Guatemala over the past ten years (OIM, 2002); it has dramatically transformed the rural landscape. Migrants often choose to flaunt their new wealth by building large cinderblock homes that dwarf the adobe homes of their non-migrant neighbors. In doing so, they tend to take already scarce land out of agricultural production and put pressure upon other families who are "trying to keep up with the Rosales" to do the same. Should this loss of habitat continue, it could lead to significant losses of crop genetic resources (Wilkes, 1992: 13). Moreover, as Fitting (2006) has observed in Mexico, the practice of transnational migration has the potential to transform intergenerational attitudes toward maize agriculture such that young people lose interest in maize agriculture and discontinue its practice. This, of course, returns us to our original question: is it possible to achieve rural development in a way that fortifies – rather than threatens – the on-farm conservation of crop genetic resources?

9. Development Goals and Policy Implications

Economic theorists have hypothesized that economic development in centers of crop genetic diversity will inevitably undermine the institutions that support the cultivation of crop genetic resources, thereby contributing to the process of genetic erosion. The theory carries the paradoxical implication that the economic lives of peasant farmers can be improved only at the risk of destabilizing a cornerstone of global food security. If so, the only way to conserve crop genetic resources, it would seem, is to stymie the development ambitions of small-scale farmers in centers of genetic diversity.

This essay has contributed to an unraveling of the paradox. The theoretical models positing that the process of development will contribute to the loss of crop genetic resources have, in fact, conflated "development" with "market integration" and market integration with the displacement of subsistence production. Yet, the findings reported here suggest that rural development goals are not necessarily synonymous with market subsumption. The rural residents of Nimasac and Xeul have expressed an interest in broader social initiatives, including improved infrastructure, empowerment of women, and better educational opportunities. They are not opposed to markets *per se*, but their interests are more focused on the creation of new *forms* of market engagement that allow them to earn a cash income and attend to valued household (re)productive activities like child care and *milpa* agriculture, particularly more flexible employment opportunities. In other words, they engage with the market not to substitute for subsistence-oriented agriculture, but to complement it. Cultivating maize and other crops for household consumption is a not only a relatively secure means for farmers to acquire preferred foodstuffs, it also generates important cultural and social entailments. Meanwhile, allocating resources to market production is relatively risky, but it provides income to supplement what would be an otherwise meager – if not perniciously insufficient – livelihood if peasants were to rely solely upon subsistence agriculture.

The econometric analysis presented in this essay suggests that the allocation of household resources to market activities is associated with higher levels of infra- and intra-crop diversity on the farm, at least among the sample of households surveyed. Though statistically insignificant, the results challenge the standard argument that the expansion of the market economy will inevitably contribute to the erosion of crop genetic resources. Instead, the key variables associated with the on-farm conservation of crop genetic resources are the size of a household's arable landholdings, its level of wealth, and the use of hired field hands. The limited area of cultivable land was found to be the principal constraint to maintaining crop diversity while higher levels of wealth and greater reliance upon hired field hands are associated with lower levels of diversity on the farm.

Although the allocation of productive resources to market production was not found to have a statistical relationship with the conservation of crop genetic resources in the year that the survey was undertaken, this does not necessarily mean that such forms of market engagement are irrelevant. Since time series data are not yet available, the statistical analysis was unable to capture the dynamic implications of market production. Allocating resources to market production may unleash processes that contribute to the loss of crop genetic resources over time. The specter that current economic activities may contribute to the displacement of *milpa* agriculture in the future – even though it is an activity valued by peasant farmers and a cornerstone of global food security – would imply that the current development trajectory in the Guatemalan highlands has the potential to produce a socially undesirable outcome.

The challenge in Guatemala is to create the means by which rural communities can achieve their development objectives in a way that is consistent with the *in-situ* conservation of crop genetic resources. Strategies that reward and empower the farmers who cultivate crop diversity would help to realize both sets of objectives. As the literature on "natural assets" demonstrates, conservation of natural resources and rural development can, in fact, go hand-in-hand (Boyce and Shelley, 2003; Rosa *et al*. 2003). The following is a brief outline of seven policies and institutions that would contribute to both the realization of rural development objectives and the on-farm conservation of crop genetic diversity.

1. <u>Participatory Plant Breeding</u>: Focus group participants expressed a desire for improved agricultural technology, particularly technologies that offer better harvests and a diversity of tastes and textures. A strategy known as participatory plant breeding (PPB) would allow farmers to achieve this goal in a way that is consistent with the on-farm conservation of crop genetic resources. PPB offers an alternative to conventional plant breeding strategies where crop scientists create broadly adapted seeds with no input from farmers and little concern for conserving genetic resources (Brush, 2004).[17] The participatory approach, by contrast, is a collaborative process where farmers and plant breeders work together and use local plant materials to develop seeds that are well-suited to local environmental conditions and manifest qualities desired by farmers. This approach could be especially useful in improving an array of seeds that fill farmers' various use needs.

2. <u>Regional Seed Fairs</u>: Despite an interest in cultivating diversity, most farmers have little access to seeds outside their family networks. Less than a quarter of survey respondents reported receiving seed from a non-family member. Yet, as Louette (1999) explains, the introduction of new plant material plays an important role in the evolution and conservation of crop genetic resources. Regional seed fairs where farmers can display crop varieties that they are particularly proud of and engage in seed exchange have been shown to facilitate farmers' access to new genetic material and to enhance the prestige of agricultural activities (Gonzales, 1999).

3. <u>Agricultural Trusts</u>: Although rural Guatemalans would like for *milpa* agriculture to remain a defining characteristic of their local landscape, they are concerned about the pressures that residential construction and population growth are putting upon their limited agricultural land. As biologist Garrison Wilkes (2006) has noted, the loss of agricultural habitat is one of the greatest threats to crop genetic resources. Agricultural

[17] With its focus on yields and seeds that conform across a variety of environments (Fuentes, n.d.), the Guatemalan Institute of Agricultural Science and Technology's maize improvement program is no exception. Like most improved seeds, ICTA's varieties require relatively large amounts of fertilizer that, as the farmers explain, "burns" minor *milpa* crops like legumes and squash.

easements could contribute to the slowing of this trend. Easements could be sold by communities or individual farmers who would forgo the development rights to their land and promise to continue practicing *milpa* agriculture. As a similar scheme in the United States has shown, the returns from selling easements could provide farmers with the financial resources that would enable them to continue cultivating their land in a way that is personally enjoyable and culturally meaningful while improving their economic well-being and ensuring the continued provisioning of ecological services (Isakson, 2002). Guatemalan communities that conserve crop genetic resources could use the returns from such easements to finance public goods like potable water projects, schools, and community health care centers.

4. Land Redistribution: Guatemalan peasants often lament the small area of their agricultural landholdings. Indeed, most farmers expressed a desire to expand their arable land. Their want is not due to lack of land in the country as a whole, but to its inequitable distribution. Guatemala has one of the most concentrated agrarian structures in the world, and holds the dubious distinction of having the second most unequal distribution of arable land in Latin America (World Bank, 1995). The country's current agrarian strategy of market-assisted land reform is woefully insufficient to change this pattern (CONGCOOP, 2001; CAR, 2006) and essentially requires that recipients cultivate cash crops instead of growing maize and other crops for household consumption. An alternative approach that redistributes unproductive plantation land to peasants who want to cultivate *milpa* would facilitate the cultivation of crop genetic resources in two ways: (1) by opening up new land for maize agriculture, and (2) slowing the fragmentation of existing plots with each successive generation, a process that the econometric results suggest is associated with lower levels of crop diversity.

5. Empowerment of Women: While the empowerment of women is an inherently worthwhile development goal, it also offers the positive entailment of facilitating the on-farm conservation of crop genetic resources. Among their objectives, women expressed a strong desire for greater control over the reproductive aspects of their lives; expanding their reproductive rights could help to slow population growth and, thereby, the loss of agricultural land. Women also expressed a desire for greater educational opportunities, an improvement that is often associated with higher levels of crop diversity (Smale *et al.*, 2006). Finally, Guatemalan women prefer the quality and diversity of tastes offered by landrace maize (FAO, 2002). Providing them with a greater voice in household decision-making would help to ensure that improved varieties do not displace landrace varieties.

6. Flexible Employment: Rural Guatemalans would like better jobs. Specifically, they would like jobs with higher wages and greater flexibility. While the labor market in the highlands is flexible – workers are hired and fired at the whim of employers – the workday is not. Many highlanders expressed frustration that their long work weeks and inflexible work schedules prohibited them from attending to household duties like childcare, food preparation, and cultivating crops for household consumption. Policies that generate part-time employment off the farm could facilitate the cultivation of crop genetic resources on it (Boyce, 2006).

7. Niche Markets: Guatemala is a tourist mecca. Visitors from around the world come to experience its natural beauty and unique Mayan culture. Most, however, leave without experiencing the high-quality landrace maize varieties that are the hallmark of traditional Mayan cuisine. Unless they have the opportunity to eat in the homes of peasant farmers, most visitors assume that Guatemala's staple is a tasteless, stale tortilla made from modern hybrid maize varieties, or worse, instant corn dough. Restaurants that showcase the high quality and culinary diversity of Guatemala's landrace maize varieties and minor *milpa* crops could be very successful in the country's urban and tourist regions. The restaurants could raise awareness about the importance of crop genetic diversity and the fundamental role that Guatemalan *campesinos* play in securing global food security, thereby enhancing the prestige associated with *milpa* cultivation. Moreover, the restaurants could assist farmers economically by paying them a price premium for traditional crop varieties.

The policies sketched above point to the possibility of a rural development strategy that is consistent with the on-farm conservation of crop genetic resources. Improving the welfare of peasant farmers need not be synonymous with a reduction in long-term food security. Moreover – as the proposed policies of niche markets, flexible employment, and agricultural easements suggest – selectively instituted markets can play an important role in fulfilling these dual objectives.

The relationship between markets and the conservation of crop genetic diversity is complex. As the econometric analysis in this study has shown, higher rates of market participation are not necessarily associated with a loss of crop genetic resources and may, in fact, facilitate their on-going conservation. Yet, as the qualitative analysis suggests, market engagements have the potential to unleash forces that contribute to genetic erosion over time. Whether or not market engagements actually undermine this cornerstone of global food security will be contingent upon the broader social framework in which they are nested. Without the appropriate protections in place, self-interested actions in the marketplace in the end may produce the unwanted result of displacing *milpa* agriculture. Alternatively, the creation of markets and other institutions that reward farmers for provisioning crop genetic resources would empower them to achieve their development objectives and, ultimately, help to guarantee a resilient food supply for generations to come.

Appendix 1: Seed lots of yellow *Obispo* from three different households in Nimasac

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