Institutional support and in situ conservation in Mexico: biases against small-scale maize farmers in post-NAFTA agricultural policy

Keleman, Alder

Agric Hum Values (2010) 27:13–28
DOI 10.1007/s10460-009-9192-y

Institutional support and in situ conservation in Mexico: biases against small-scale maize farmers in post-NAFTA agricultural policy

Alder Keleman

Accepted: 22 October 2008 / Published online: 3 February 2009

Abstract One of the major adjustments brought on by the North American Free Trade Agreement (NAFTA) was a change in the relationship between Mexican agricultural support institutions and the small-scale agricultural sector. Post-NAFTA restructuring programs sought to correct previous inefficiencies in this sector, but they have also had the effect of marginalizing the producers who steward and manage the country's reserve of maize (*Zea mays*) genetic diversity. Framed by research suggesting that certain maize varieties in a rain-fed farming region in southern Sonora are in danger of loss due chiefly to long-term drought, this article explores the ramifications of post-NAFTA agricultural policies for in situ maize diversity conservation. Qualitative methods, including semi-structured interviews with agricultural support institutions and participant observation with farmers, were used to gather data on dryland farmers' access to research and extension, as well as possibilities for collective action. In southern Sonora, agricultural support is oriented primarily toward high-tech production, and there are structural barriers to small-scale farmers' access to research and extension institutions. Further, collective action around agriculture is limited. These circumstances represent significant limitations to farmers' options for accessing new techniques which might help maintain maize diversity in the context of economic and environmental change.

A. Keleman (✉)
Fox International Fellowship, Yale University,
c/o Food and Agriculture Organization, Agricultural
Development Economics Division, Room C309,
Viale delle Terme di Caracalla, 00153 Rome, Italy
e-mail: alder.keleman@gmail.com

Keywords Agrobiodiversity · Mexican agricultural policy · In situ conservation · Maize · *Zea mays* · Mexico · NAFTA · Neoliberal restructuring

Abbreviations

BANRURAL	*Banco Nacional de Crédito Rural* (National Rural Credit Bank)
CIANO	*Centro de Investigaciónes Agrícolas del Noroeste* (Agricultural Research Center of the Northwest)
CIMMYT	*Centro Internacional para el Mejoramiento del Maíz y el Trigo* (International Maize and Wheat Improvement Center
CONASUPO	*Compañía Nacional de Subsistencias Populares* (National Company for Popular Subsistence)
FAO	Food and Agriculture Organization of the United Nations
FERTIMEX	*Industria Mexicana de Fertilizantes* (Mexican Fertilizer Industry)
INIFAP	*Instituto Nacional de Investigaciones Forestales, Agrícolas, y Pecuarias* (National Institute for Forestry, Agricultural, and Livestock Research)
NAFTA	North American Free Trade Agreement
PAPIR	*Programa de Apoyos a Proyectos de Inversión Rural* (Support Program for Rural Investment Projects)
PIEAES	*Patronato para la Investigación y Experimentación Agrícola del Estado de Sonora* (Agricultural Research and Experimentation Board of the State of Sonora)

PROCAMPO *Programa de Apoyos Directos al Campo* (Program of Direct Support to the Countryside)
PRODESCA *Programa de Desarrollo de Capacidades en el Medio Rural* (Program for Rural Capacity Building)
PRONASE *Programa Nacional de Semillas* (National Seed Program)
SAGARPA *Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca, and Alimentación* (Secretary of Agriculture, Livestock, Rural Development, Fisheries, and Nutrition)
SDR *Secretaría de Desarrollo Rural* (Secretary of Rural Development)
SINACATRI *Sistema Nacional de Capacitación y Asistencia Técnica Rural Integral* (Nacional System for Integrated Rural Capacity Building and Technical Assistance)

Introduction

The potential negative impacts of agricultural trade liberalization on the genetic diversity of maize may be the most pressing issue facing Mexico in the post-NAFTA context (Nadal and Wise 2004, p. 1). Mexico is the center of origin of maize, and diverse varieties traditionally maintained by farmers continue to hold nutritional and cultural importance throughout the country (Barkin 2003; Ortega Paczka 2003). Although much of this diversity is conserved ex situ in gene banks, in situ conservation in farmers' fields provides benefits that gene banks are unable to duplicate (e.g., Brush 2000).

Researchers discussing many regions of Mexico have identified trends toward the decreased use of local maize landraces in recent years, especially in areas where maize agriculture is highly commercial (cf., Brush and Perales 2007; Chambers et al. 2007; CIMMYT 2006; Nadal and Rañó 2006; Ortega Paczka 2003). This finding was paralleled in my research in the state of Sonora. In the municipality of Alamos, Sonora, evidence suggests that the number of varieties of maize planted by dryland farmers has decreased in recent years, with a 10-year period of severe drought reported by farmers as an acute factor leading to these losses (Keleman 2008). Changes in Mexico's agricultural policy following neoliberal economic restructuring provide an important context for these disappearances.

Based on field research and a review of the literature, this article examines changes in the relationships between small-scale Sonoran farmers and agricultural support institutions, focusing on a key question: Given current institutional and environmental conditions, what options do farmers have for maintaining local maize varieties (landraces)? This article describes the ways in which farmers' relationships to research and extension institutions operating in southern Sonora have changed following neoliberal restructuring, demonstrating that under current circumstances these institutions provide few options for farmers who would wish to maintain local maize production. I also discuss collective action around maize in Alamos, which exhibits similarly limited potential for providing options for maintaining local maize production and diversity.

These factors are important for in situ conservation because the range of available options shapes farmers' choices about maize production. Observing historical changes in agricultural systems in the United States, Hendrickson and James (2005) point out that agricultural production has increasingly become influenced by requirements and standards stipulated by a concentrated market of purchasers, processors, and retailers. This highly concentrated group of businesses dominates the market not only in the United States, but also internationally. The range of farm-management choices left to farmers (i.e., for managing production processes) is often constrained by the need to live up to these businesses' specific standards, taking the locus of decision-making off of the farm. Farmers may consequently find themselves obligated to make choices that lead to the loss of knowledge, skills, or on-farm genetic diversity (Hendrickson and James 2005, pp. 278–281).

Large-scale agribusiness shapes Mexican agricultural markets as well. One of the key goals of Mexican agricultural policy since the late 1980s has been to facilitate Mexican farmers' entry into national and international production chains, an aspiration which has influenced the restructuring of national government institutions. Hence, although the maize farmers discussed in this article are not currently selling maize on the international commodity market, the programs offered to them by agricultural support institutions, as well as the parameters for accessing these programs, are shaped by the over-arching objective of integrating farmers into such markets. This article explores these changed relationships between farmers and agricultural support institutions via both a literature review and a case-study from a rain-fed farming region of southern Sonora. As these explorations demonstrate, farmers' options for accessing support that might help conserve maize landraces in situ have been constrained in the post-NAFTA context.

Case study: maize diversity in Alamos, Sonora

Study site

The municipality of Alamos is located in the southeast corner of Sonora, bordering with Sinaloa and Chihuahua (Fig. 1).

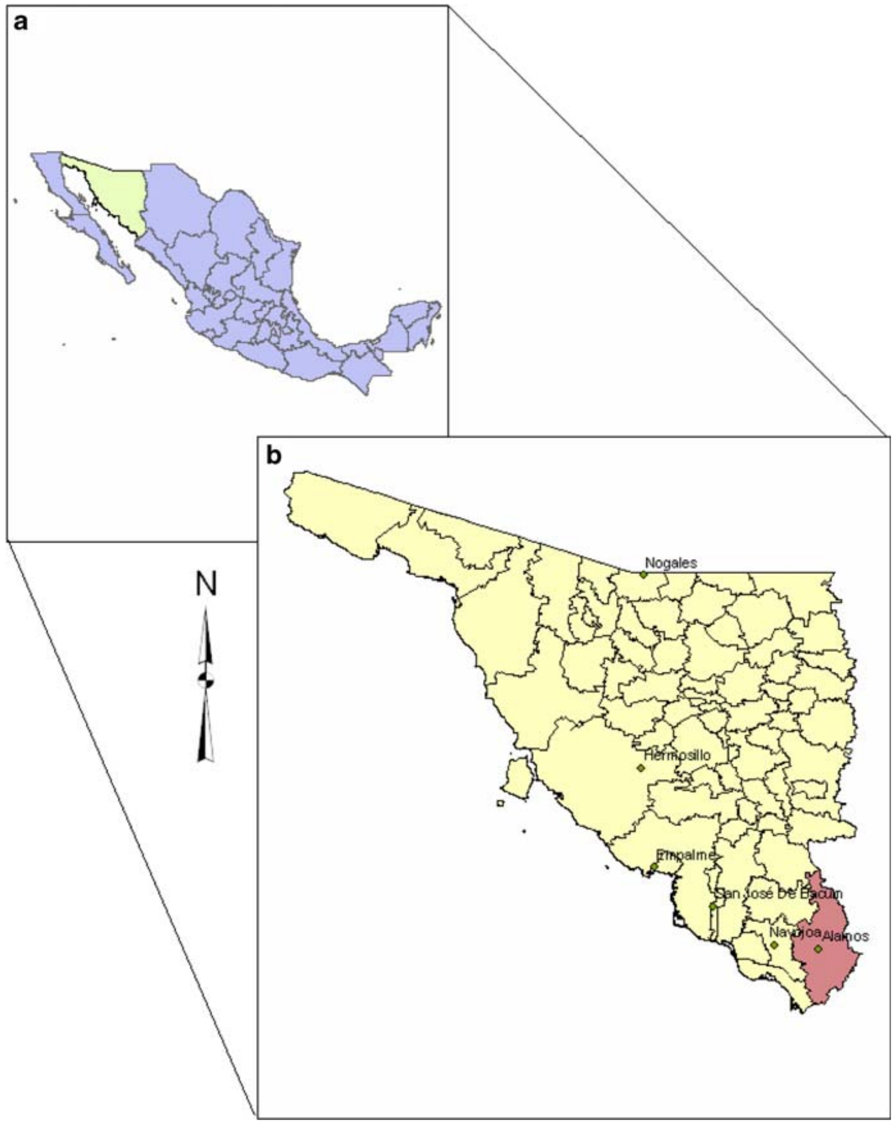

Fig. 1 **a** Mexico with an emphasis on Sonora. **b** Sonora, showing the municipality of Alamos. *Source*: INEGI. Elaboration is author's own

Table 1 compares demographic characteristics of Alamos with those of the rest of the state. With just under 24,500 inhabitants, the municipality represents slightly <1% of the state's population. Domestic in-migration to Alamos is lower than at the state level, and the slightly higher percentage of male residents in Alamos (52.3%, as opposed to 50% statewide) suggests that patterns of male outmigration observed elsewhere are less significant in this area. The municipality has a lower average education level (6.3 vs. 8.9 years) and a higher percentage of indigenous residents than the rest of the state (5.1% in Alamos vs. 2.5% statewide).

Alamos has higher levels of poverty than the Sonoran average (Table 1). Although the number of occupants per house is only slightly higher than the average (3.9 vs. 4.1), Alamos homes are 32% more likely to have dirt floors, and 13% less likely to have bathrooms. Alamos residents rank lower in the tendency to possess televisions, refrigerators, washing machines, and computers than Sonorans as a whole.

Excluding some 8,200 residents of the municipal seat (INEGI 2005), most Alamos residents live in small farming communities, generally structured as *ejidos* or *comunidades*. Although there are some large landowners in the region, the majority of the 3,000 farmers in the municipality cultivate fewer than seven hectares of land (J. Salido, SAGARPA, Alamos, personal communication).

The rain cycle in Alamos is the major determinant of farming activities. Seasonal rains come twice a year; first, in January and February, and again in July–mid-September after an intense dry period. The major plant growth of the year, including both field crops and non-farmed plants, occurs with the latter period of summer rains (Yetman and Van Devender 2002, p. 11). Although aridity and variable rainfall are typical of the region, recent years have heralded extreme drought conditions (Dean 2004).

Table 1 Statewide demographic characteristics versus the characteristics of Alamos, Sonora

	Sonora State	Alamos
Total population	2,394,861 (100%)	24,493 (1.02%)
Male	50.03%	52.26%
Female	49.97%	47.74%
In-migration		
Population over 5 years of age residing outside of the entity in October 2000	4.87%	0.38%
Population over 5 years of age residing in the US in October 2000	0.32%	0.13%
Average number of school years completed		
Total population	8.88	6.28
Male	8.89	6.16
Female	8.87	6.4
Indigenous population		
Population over 5 years that speaks an indigenous language	2.46%	5.14%
Population in indigenous households	4.47%	6.92%
Occupied private homes—demographics		
Average number of occupants per house	3.87	4.06
Average number of occupants per room	1.01	1.31
Male-headed households	76.53%	84.72%
Female-headed households	23.47%	15.28%
Occupied private home characteristics		
Dirt floors	8.67%	41.01%
Consisting of a single room	6.13%	11.88%
Has a bathroom	93.17%	79.75%
Occupied private homes with major consumer items		
No major consumer items	2.47%	20.93%
Televisions	91.95%	68.59%
Refrigerators	88.97%	60.64%
Washing machines	67.41%	25.10%
Computers	22.02%	5.23%

Source: INEGI II Conteo de Población y Vivienda 2005; Available at http://www.inegi.gob.mx

On small-scale farms, most farmers use permanent-field agriculture on relatively flat lands. Primary field crops include maize, beans (*Phaseolus acutifolia* and *Vigna unguiculata*), sorghum (*Sorghum bicolor*), sesame (*Sesamun indicum*), squash (*Cucurbita moschata* and *C. argyrosperma)*, and watermelon (*Citrullus lunatus)*. Field crops are typically planted between the end of June and the beginning of July, and harvested in September–November. Many families raise livestock, particularly cattle. These characteristics resemble the farming practices described in the lowland south of Sonora by Yetman (1998) and in northern Sonora by Sheridan (1996).

Maize diversity in Alamos has suffered under recent drought conditions. When compared with archival collection data from Native Seeds/SEARCH,[1] 2004 survey data from Alamos suggest that no named maize varieties that were collected in the early 1980s have been lost from the region (Keleman 2008). However, these data also demonstrate that some varieties are being planted at very low frequencies by local farmers (Table 2). In a survey of 79 farmers in 2004, five of nine named varieties reported were maintained by <10% of all maize farmers, with four varieties remaining under cultivation by only one farmer each. Farmers' observations suggest that this decrease in number of varieties has taken place over a period of 10–20 years, and has varied by sub-region of the municipality and by the characteristics of the variety itself.

Maize production in Alamos also suffered during this period. Data from the Mexican Agricultural and Livestock Information Service (SIAP; http://www.siap.gob.mx) point out that yields between 2002 and 2006[2] were uniformly less than one ton per hectare, and that the number of tons harvested varied from 0 to 1,625 during this time period

[1] Native Seeds/SEARCH is a Tucson, AZ-based non-profit seed bank maintaining collections of crop varieties from the southwest of the United States and northwest Mexico (www.nativeseeds.org).

[2] In SIAP's online database, data for Alamos are available only from 2002 onward.

Table 2 Distribution of landraces among Alamos farmers (2004)

Regional variety name	Maize race/mixture	Number of farmers planting ($N = 79$)	%
San Juan (range[a])	Tuxpeño	6–41	26–52
Mayobatchi	Tuxpeño/Onaveño	17	21.5
Pinineo	Onaveño/Tuxpeño	7	8.9
Ocho Carreras	Tabloncillo/Tabloncillo Perla	10	12.7
Chapalote	Reventador/Onaveño	1	1.3
Maiz Blando	Blando de Sonora/Onaveño	12	15.2
Maiz Dulce	Dulce	1	1.3
Acaromeño	(Unknown)	1	1.3
Maizón	(Unknown)	1	1.3
Unnamed variety (range[a])	(Unknown)	24–44	30–56

Source: Keleman (2008). Maize races are taken from fieldwork observations and have been cross-checked with CIMMYT and Native Seeds/SEARCH databases

[a] "San Juan" and "Unnamed Variety" are reported as a range of responses because it was discovered after completion of the survey that the presence of a field assistant during the interviews was significantly positively associated with naming "San Juan," and significantly negatively associated with declining to give a variety name. As such, low-end estimates of the number of farmers planting varieties in these categories were established from the surveys during which the field assistant was not present ($N = 23$). A full discussion of survey methodology is available in Keleman (2008)

(Table 3). This contrasts with the rest of the Navojoa Rural Development District (DDR) to which Alamos belongs. Taking into account the three other municipalities in the DDR, which lie on the irrigated coastal plane, average maize yields for the area ranged from 2.3 to nearly 6.5 tons. Alamos production accounted for less than 6% of maize production in all years except 2004. The variability in the percentage of planted area actually harvested—both within Alamos and at the DDR level—attests to the heavy and unpredictable impacts of drought on both the dryland agricultural system in Alamos and the irrigated land on the coast.

Research questions

This article focuses on a key question: Given current institutional and environmental conditions in Alamos, what options do farmers have for maintaining local maize varieties? Although the factors impacting farmers' options might include market and environmental variables, this analysis focuses on the relationship between farmers and agricultural support institutions. In the context of Alamos, this is an appropriate approach for two reasons. First, farmers generally do not sell maize, considering it to be a subsistence crop. Instead, farmers generate cash income via sales of sesame, young squash, and green beans.[3] Grain offered for sale in the municipality is generally brought from irrigated agricultural lands on the coast. Farmers use chemical fertilizers or pesticides only infrequently, and are likely less affected by rising input costs than farmers in other regions of Mexico.

Second, environmental conditions in Alamos are harsh. From 1994 to 2004 there was an unprecedented 10-year drought (Dean 2004) and both farmers' personal observations and long-term data suggest that the timing and distribution of the rains have shifted in recent years (Keleman 2008). Even under normal rainfall conditions the growing season is extremely short (approximately 4–5 months), and there is little irrigation infrastructure, despite the region's proximity to two of the state's major reservoirs. In other words, on both the market- and environmental fronts, farmers' options are already limited.

In principle, in the institutional context, farmers should have more room to maneuver. There are several state and federal agencies operating in the municipality whose stated purpose is to improve livelihoods and agricultural conditions in the rural environment, and major Mexican and international agricultural research centers are located within a 2-h drive of Alamos.

With these conditions in mind, research sought to answer a series of questions regarding the potential for local institutions to support Alamos maize production in a way that might contribute to in situ maize diversity conservation. Key questions included: Could improvement of local germplasm (by farmers or research institutions) combat drought and support maize diversity conservation? To what extent do farmers have access to technology or knowledge transfer to combat difficult environmental conditions and thereby maintain maize production? And, to what extent is there the

[3] In my 2004 survey of one Alamos ejido ($N = 30$), only 27.6% of farmers reported selling maize. In contrast, 100% of farmers reported selling their sesame crop, and 62.1% and 80.2% reported selling beans and squash, respectively.

Table 3 Maize grain production in Alamos and DDR Navojoa (2002–2006)

Year	Production (tons)			Percent of planted area not harvested		Yield (ton/ha)	
	Alamos	DDR Navojoa	Alamos production/ DDR production (%)	Alamos (%)	DDR Navojoa (%)	Alamos	DDR Navojoa
2002	224	27,703	0.81	80.0	30.7	0.4	5.47
2003	1625	30,847	5.27	0.0	0.0	0.65	4.58
2004	975	7,142	13.65	0.0	76.2	0.65	2.3
2005	0	43,154	0.00	100.0	43.6	0	6.46
2006	210	61,596	0.34	41.7	4.4	0.3	5.63

Source: SIAP Anuario Agrícola, http://www.siap.gob.mx; note that 2002–2003 data is classified as "unclassified maize grain," whereas 2004–2006 data was classified as "white maize grain." These are the only categories of grain reported in the years for which data is available

potential for collective action and advocacy by local maize farmers? Responses to these questions are best understood with reference to historical changes in the institutional context, given that the environmental changes negatively impacting maize production have coincided with major changes in agricultural support institutions.

The options offered to farmers by these institutions were assessed qualitatively and contextually. Information was drawn primarily from semi-structured interviews undertaken with officials in local, national, and international agricultural support and research organizations. These included municipal and regional branches of SAGARPA, the southern Sonora CIANO research station, INIFAP, CIMMYT, and the Alamos SDR/local development council (*consejo de desarrollo*). Program documents and other grey literature were also reviewed. Fieldwork was carried out during four-one-week to two-month periods between June 2004 and October 2006.

Information was also gathered from farmers, primarily through participant observation. Participant observation techniques included spending time with farmers in their houses and fields, as well as accompanying and observing individuals as they interacted with government institutions.

Below, I use language emphasizing maize *production* in place of "maize landrace maintenance." In Alamos, the maize varieties that farmers plant are almost exclusively varieties of local landraces, with some derived from improved germplasm introduced in the 1980s or before, which has been held in farmers' hands long enough to be considered "creolized" (see Bellon et al. 2005). There are currently no commercial hybrids marketed in Alamos that would be adapted to perform under harsh local conditions, and no publicly bred, locally adapted open-pollinated varieties have been promoted in the region since the mid-1980s (Ing. R. Valenzuela, CIANO, personal communication). Hence, although in most regions of Mexico it would be inappropriate to equate producing maize with maintaining maize landraces, in Alamos maize production is a reasonable conceptual stand-in for in situ conservation.

Small-scale maize farming and agricultural liberalization

The Mexican Revolution of 1910 marked a turning point in the relationship between the Mexican government and the nation's agricultural population. Perhaps the most marked manifestation of this new relationship was agrarian reform, which implemented the ejido-based system of collective land-tenure, granting land to marginalized, poor, and indigenous *campesinos*.[4] More recently, in the 1970s and 1980s, agricultural support played a pivotal role in Mexico's import-substitution development scheme (Appendini 2001). CONASUPO, a state-run institution which served as a guaranteed point of sale and distribution for rural producers' crops and provided a nation-wide price-fixing mechanism for maize, was the central element of this approach. Another key institution was BanRural, a state-run bank providing credit to small-scale farmers who could not use their ejido tenure for collateral for private loans (Biles and Pigozzi 2000). Meanwhile, institutions such as the Programa Nacional de Semillas (PRONASE) and the Industria Mexicana de Fertilizantes (FERTIMEX) provided publicly funded agricultural inputs to farmers nationwide.

The negotiations and signing of NAFTA marked a change in this long-standing State-agriculture relationship. Under President Carlos Salinas de Gortari (1988–1994), the Mexican government responded to the severe economic difficulties of the 1980s and looming competition from the opening markets of former communist bloc countries by making an aggressive move toward trade liberalization (Cameron and Tomlin 2002; Mayer 1998). Significant steps in this direction were taken prior to NAFTA, including limiting the credit that BanRural offered to small-scale farmers and beginning to reduce and eliminate

[4] See Haenn (2005) for a review of the structure of the ejido system and its implications for land tenure and community expansion in Mexico. Sheridan (1996) presents a similar review of the structure of ejido communities in Sonora.

the pricing structure that CONASUPO established for agricultural goods (King 2006; Appendini 2001; Biles and Pigozzi 2000). The Mexican constitution was amended to make it possible to privatize ejido land tenure in 1992 (King 2006; Cameron and Tomlin 2002); PRONASE and FERTIMEX were privatized in the early 1990s; and the majority of CONASUPO's sub-organizations, which had played a pivotal role in food distribution, were phased out in the run-up to the total elimination of CONASUPO in 1999 (Yúnez-Naude 2003; Appendini 2001). Notably, these processes did not always imply a wholesale elimination of subsidies, but rather a reorientation of government support toward "more efficient" agro-industrial production (Pilcher 2002; Appendini 2001).

The focus of NAFTA is international trade, and as such, the changes stipulated in the text of the agreement primarily address import and export regulations. In the context of ongoing changes to the domestic agricultural sector, however, NAFTA served as an important commitment mechanism, helping the Mexican government to justify far-reaching domestic policy reforms (Cameron and Tomlin 2002). This section reviews post-NAFTA changes in agricultural policy and institutions, as well as the impacts of these changes on small-scale farmers, maize production, and maize diversity.

Structural changes in post-NAFTA policy

In the agricultural sector, post-NAFTA restructuring fell largely under the jurisdiction of two government ministries: the Secretary of Agriculture, Livestock, Rural Development, Fisheries, and Nutrition (SAGARPA), and the state-level rural development ministries. As a federal institution, SAGARPA is in charge of implementing nation-wide policies, such as the Programa de Apoyos Directos al Campo (PROCAMPO). Meanwhile, the mandate of the state-level ministries consists of implementing the programs under the umbrella of *Alianza*.[5] In Sonora, the state-level ministry is titled the Secretaría de Desarrollo Rural (SDR).

In the agricultural sector, PROCAMPO is perhaps the most broad-based and well-known element of post-NAFTA restructuring. This nation-wide farm support program was explicitly designed to replace market-distorting, output-based subsides while simultaneously cushioning farmers during the transition to free trade (Romero and Puyana 2006; Klepeis and Vance 2003). Based on the area planted to any of nine staple crops in one of 3 years before 1993, PROCAMPO provides a yearly, per-hectare subsidy, which is intended never to exceed the number of hectares planted in 1994. The official goals of PROCAMPO are "(a) to transfer income to producers, as compensation for the effects of the elimination of barriers to trade through NAFTA and other trade agreements… and (b) to ensure that domestic processes reflect those in the world market" (Bonilla and Viatte 1995, p. 21).

Recent reports from Veracruz and Chiapas suggest that PROCAMPO payments have evolved to make up a significant part of maize producers' income. Results from a nationwide survey of 43,000 PROCAMPO recipients carried out by SAGARPA (2002) suggested that, for 24% of the recipients, PROCAMPO represented half of agricultural income. For 33% of recipients who did not sell their crops, PROCAMPO represented 100% of agricultural income.[6]

The SAGARPA study also underscores the broader importance of PROCAMPO for farmers' livelihoods. Forty-two percent of survey respondents specified that in utilizing PROCAMPO, their first choice was to apply these funds to food, transportation, clothing, and medicines. In contrast, preparing agricultural lands for planting, the second most frequent application of PROCAMPO monies, was specified by only 25% of farmers as a first-choice use.

Although PROCAMPO may have positive impacts at the household level, this may not lead to increased conservation of environmentally valuable public goods. A study of deforestation on the Yucatán peninsula (Klepeis and Vance 2003) suggests that the availability of PROCAMPO led to increasing levels of deforestation in the post-NAFTA period. Researchers measured an increase in deforestation carried out by PROCAMPO recipients ranging from 6.5% to 38%, observing that Yucatán farmers used their PROCAMPO-supported lands to grow cash crops, such as Chili peppers, while subsistence crops like maize and beans were shifted to newly cleared fields. These findings provide support for broader analyses suggesting that, under economic liberalization policies, small-scale farmers' limited access to credit and purchased inputs makes it difficult for them to undertake intensification using existing agricultural resources (Klepeis and Vance 2003; Shriar 2002; Barbier 2000). These behavioral patterns are relevant to the discussion of in situ conservation

[5] Initially, under the administration of Ernesto Zedillo (1994–2000) these programs were introduced as *Alianza para el campo*. However, under the Vincente Fox administration (2000–2006), the name of this program was changed to *Alianza contigo* ("Alliance with you"). There was significant continuity between these two administrations' management, and the term *Alianza* is used to refer to the programs of both periods.

[6] The amount of farmers' income accounted for by PROCAMPO varied by state in the SAGARPA survey, and this variation is mirrored in the literature. In Veracruz, where producers earn approximately $300 US per hectare for their maize crops, PROCAMPO offers an additional $82 US per hectare of support (King 2006), an amount equal to 21% of a given farmer's per-hectare income from maize. For poor maize producers in Chiapas, this proportion may be as high as 50% of the gross value of maize production (Hellin et al. 2007).

in that landraces may have "global public good" characteristics (Lipper and Cooper 2008), and as such, rural development measures improving private household welfare may not automatically lead to increased conservation if households prioritize private benefits over shared resources.

PROCAMPO is not the only program determining the impacts of Mexico's post-NAFTA agricultural policy. In addition to other programs administered by SAGARPA, the SDR-administered programs falling under the umbrella of Alianza are some 40 in number (FAO/SAGARPA 2003). These programs are designed to replace former market-distorting forms of assistance. In the words of a joint FAO/SAGARPA review of the program:

> Alianza came into being at the end of 1995, and began to operate in 1996, in a context marked by the growing influence the North American Free Trade Agreement on the Mexican economy. Within this structure, it was established that *Alianza* would seek to impact production and productivity, producers' incomes, the capitalization of producers' units, technological innovation, and capacity-building. (FAO/SAGARPA 2003, p. 3)[7]

Given that state-run agricultural services were privatized in the early 1990s (Appendini 2001), the programs that compose *Alianza* are some of small-scale agriculturalists' only remaining options for accessing government support for technical assistance. However, as the FAO/SAGARPA report points out, a chief failing within the broad mission of Alianza has been the program's lack of clarity as to *who* the farmers it was intended to help were, and exactly what was meant by "rural development." This observation is revisited below.

Small-scale farmers and post-NAFTA agricultural policy

In the growing body of literature reviewing changes in agriculture in Mexico in the post-NAFTA period, the effects of national policy shifts on small-scale farmers are a recurrent theme (see McDonald 1997, 1999, 2001; Stanford 1994; Barbier 2000; Biles and Pigozzi 2000; Nadal 2000, 2002; Nadal and Wise 2004; Biles et al. 2007; Gravel 2007). In 1990, Stanford observed that, in a reversal of a long history of government backing for farmers' organizations supporting cantaloupe production in the Valley of Apatzingán, Michoacan, the Mexican government chose to remove quotas for commercial purchase of cantaloupe for export, as well as restrictions on area planted, which had formerly been administered by farmers' organizations. Although these policy reversals responded to market imperfections that were themselves products of the local system, this total withdrawal of support resulted in a statistically significant trend toward concentration of the cantaloupe market in the hands of private producers over a period of 3 years. These observations raised questions about the effects that market restructuring would have on small-scale producers' market viability and self-determination.

Concern for the fate of small-scale farmers is expanded upon in McDonald's observations of the small- and medium-scale dairying sector in southern Mexico (McDonald 1997, 1999, 2001), which address specific mechanisms by which post-NAFTA policies impact dairy producers' organization, market access, and profitability. McDonald notes that, with milk prices falling in response to increased imports of powdered milk, it has become more important for producers to resort to new forms of organization, such as cooperatives. However, due to the challenges of producing enough milk that meets processors' standards for protein and fat content, not to mention internal organizational difficulties, few cooperatives have been successful (McDonald 1997).

This lack of success has much to do with the fact that support for the steps that could underpin successful modernizing efforts is largely unavailable to small-scale farmers. The policies currently in place promote a style of modernization entirely dependent on market competitiveness, and those producers who cannot organize or present themselves in such a way as to attest to their competitiveness are effectively blocked from credit. Lack of credit makes it impossible for small-scale producers to purchase new technological inputs necessary to modernize their farms, which in turn makes it impossible to produce a product that meets the technical standards required by the market (McDonald 1997, 1999, 2001). Furthermore, while mid-sized producers and processors may have sufficient education and government contacts to draw on patron–client relationships, their smaller-scale counterparts are less likely to be able to leverage these forms of social capital (King 2006; McDonald 1997, 1999, 2001).

The disadvantages that small-scale producers face under current Mexican agricultural policy are also highlighted in the Food and Agriculture Organization (FAO) and SAGARPA's 2003 review of Alianza. In this external evaluation, the FAO identified one of the key difficulties of the program as a lack of strategic vision. The review

[7] Translation by the author. The original reads: "La Alianza surgió a fines de 1995 y comenzó a operar en 1996, en un contexto marcado por la creciente influencia del Tratado de Libre Comercio de América del Norte sobre la economía Mexicana. En ese marco se estableció que la Alianza buscaría impactar sobre la producción y productividad, el ingreso de los productores, la capitalización de sus unidades productivas, la innovación tecnológica, y la capacitación."

pointed out that there existed at least three different conceptions of the intent of Alianza among the national and state offices: one vision considered Alianza to be a strategy for competitive development only for high-potential export and commercial producers, while a second saw it as a poverty-combating program, and a third view expressed the idea that Alianza was a neutral mechanism for leveraging public investment for agricultural purposes. These differing views underpinned divergences in thought and action on what the program's funds should support (FAO/SAGARPA 2003).

The FAO/SAGARPA evaluation also found that the *type of producer* accessing a given Alianza program was the most important determinant of the impact of the program itself. Having divided the beneficiaries of the program into five categories, which ranged from the poorest small-scale farmers to the largest farmers wielding the most capital, they found that the smallest farmers "face structural limitations which in many cases make it impossible to take full advantage of these investments, which at the same time reduces their impacts" (FAO/SAGARPA 2003, p. 23).[8]

Reviews of PROCAMPO suggest that these limitations are not restricted to Alianza. Of respondents to the SAGARPA survey, only 26% reported having changed to a different crop while receiving PROCAMPO, and only 6% reported improved opportunities for accessing technical agricultural assistance (SAGARPA 2002). Such observations raise the concern that, while the poorest small-scale farmers might register large initial impacts from participating in the capitalization- and technology-promotion programs that were put in place to cushion the impacts of NAFTA, these improvements are likely to be temporary without the benefits of additional technical assistance (FAO/SAGARPA 2003).

Maize production and diversity post-NAFTA

As the center of origin of maize, Mexico houses a high concentration of the crop's genetic and morphological diversity, and countless farmer-maintained varieties are planted on small-scale farms throughout the country (Ortega Paczka 2003). Historically, seed has been farmer-saved, rather than purchased from the large agricultural companies; farmers have planted maize races adapted to particular cultural specifications and environmental conditions; fields have been intercropped with more than one species; and maize cultivation has been part of a landscape that included forests and fallow areas.[9] The largest environmental threats from increased maize trade in the United States were probably the secondary effects of increased pesticide and fertilizer use. Meanwhile, the equivalent threat in Mexico was the loss of maize genetic diversity resulting from a switch to genetically narrower store-purchased seed (Nadal and Wise 2004).

In practice, maize production in Mexico has not behaved as was anticipated when NAFTA was negotiated, and there is evidence that farmers' maize diversity management practices have also responded to free-market conditions in unexpected ways. In the trade agreement, a 15-year transition period for maize was outlined, in which Mexico's import quotas would gradually increase, and over-quota tariffs would gradually drop to zero (Yúnez-Naude 2003). This long-term time-frame was designed with the intent of easing marginal lands and low-efficiency producers out of production. Meanwhile, maize liberalization would be coupled with public investment in agriculture, enabling some farmers to transition to higher-value crops, and others to exit farming altogether, transitioning to potentially more remunerative wage-labor (Levy and van Wijnbergen 1992). It was argued that these measures would have only a limited impact on small-scale maize producers, who were considered to be primarily subsistence producers, and whose planting decisions would therefore be affected little by changes in market price (i.e., De Janvry et al. 1995).

The scenario that materialized following NAFTA implementation, however, was very different than what had been envisioned. In the wake of the 1994 peso crisis, maize imports from the United States drastically increased, and the decreasing tariff and quota regulations which Mexico had negotiated the right to impose during the transition were not implemented. Mexican maize prices fell to the world-market price within a period of 30 months, rather than the originally anticipated 15-year period. Nonetheless, these price drops were neither accompanied by a decrease in the price of tortillas, nor by a net decrease in the area devoted to maize production (Keilbach Baer 2005; Nadal and Wise 2004; Nadal 2000, 2002). All remaining barriers to maize imports were removed in January 2008.

In fact, the area planted to maize increased after 1994 (Nadal and Wise 2004; Nadal 2000, 2002), and reports on maize production suggest that the volume of domestically produced maize has maintained relatively stable levels since NAFTA came into force, despite falling prices and

[8] Translation by the author. The original reads: "…enfrentan limitaciones estructurales que en muchos casos evitan el aprovechamiento pleno de las inversions, lo que a su vez reduce sus impactos." By the same token, however, the report found that large-scale farmers also were less likely to experience high impacts from Alianza's investment possibilities, given that the size of investment that the program was able to offer was likely to have little impact, in terms of relative improvement, on these farmers' productive schemes.

[9] See Haenn (2005), and Sheridan (1996) for more extensive reviews of this type of small-scale production in Mexico.

increased imports of maize from the United States (King 2006). While no single mechanism explaining maize production levels has been agreed upon in the literature, prominent formulations (Dyer and Taylor 2002; Nadal 2000) call attention to the fact that individual farmers experience market shifts not just as increases or drop-offs in the price of a single crop, but rather as a range of variables affecting their overall livelihood strategies. Indeed, Nadal (2000) argues that sharp drops in the prices of non-maize crops following the implementation of NAFTA shaped an economic environment in which maize cultivation remained more profitable than most of the other options available to small-scale farmers.

Although reports of stable or increasing maize production might suggest positive signs for Mexican maize diversity, the context of increasing economic difficulty for small-scale farmers poses reasons for concern. First, increased production is not necessarily synonymous with maize landrace preservation. Indeed, in high-production-potential regions of Mexico, improved varieties have gained importance in recent years (CIMMYT 2006) and have been promoted by the State and Federal governments due to their potential to increase yields (Hellin et al. 2007).

Economic difficulty has also led to new strategies among smallholder farmers, including migration, monoculture, and the simplification of labor practices in maize cultivation (Nadal and Rañó 2006; García Barrios and García Barrios 1990). As early as the 1980s, observers noted that out-migration from Oaxaca had led to significant labor scarcity, in turn contributing to the breakdown of community labor systems. With less labor available, maize cultivators reduced the number of cultural labors performed in their fields and increased the use of wage labor and mechanized land-clearing practices (García Barrios and García Barrios 1990).

More recent observations of international migrants from maize-growing regions in the state of Puebla (Fitting 2006, 2004) suggest that, while migration may initially lead to re-investment in traditional maize production in the form of remittances or the investments of returned migrants, only older migrants are likely to return to their communities and establish their own *milpas*. Younger migrants, in contrast, are less likely to have worked for a significant period of time in agriculture before migrating, and are also less likely to learn seed selection practices or common local-language agricultural terms describing maize cultivation when they return. These reports from Puebla are particularly concerning in light of observations that both national and international out-migration by the poorest two-fifths of Mexican producers, a demographic category coinciding with that of farmers who plant Mexico's most genetically diverse crops, has increased significantly since the mid-1980s (Nadal and Wise 2004).

Options for maintaining maize landraces: research, extension, and collective action

To maintain Alamos maize production, one initial hypothesis is that farmers might be able to select for more drought-resistant maize within their own genetic stock. However, given the severity of the recent drought, chances are slim that farmer selection could produce a drought-resistant variety faster than the pace of environmental selection pressures. Maize is a wind-pollinated crop, and as such, most formal maize-breeding techniques invest significant labor in the challenging task of controlling pollen flow. Breeding is still more difficult when selecting for resistance to a stress such as drought, which acts on many aspects of a plant's physiology, and the resistance to which may therefore be controlled by not just one but many genes (Bänziger et al. 2000). On-farm selection for drought tolerance in the absence of formal breeding or genetics knowledge would therefore be extremely unlikely.

Given the low likelihood that farmers themselves might breed more drought-resistant germplasm, a second option would be to seek either drought-adapted germplasm or drought-oriented technical assistance elsewhere. Alamos would seem to be auspiciously located for such an attempt; the municipal seat houses a local SAGARPA office and is within an hour's travel of the regional SAGARPA center. Furthermore, two agricultural research stations—a branch of the International Maize and Wheat Improvement Center (CIMMYT) and CIANO, a Mexican-funded research station—are located within 100 miles of Alamos, housed in the rich agricultural areas of the coastal plain.[10]

For Alamos farmers, there are barriers to accessing research or technical assistance from these organizations. CIMMYT's outpost in Sonora focuses largely on breeding wheat, one of the primary crops of the coastal plain. The majority of CIMMYT's maize-oriented research is based at the El Batán station, near Mexico City, and much is targeted toward high-poverty regions of Africa and Asia. Furthermore, as an international research organization and a guest on Mexico's soil, any technical assistance programs taken by CIMMYT must be carried out in collaboration with national partners. As such, the local applicability of CIMMYT's work rests to a great extent on the political will of the state and national governments.

[10] CIANO and CIMMYT both work in partnership with local universities to train students in agriculture. However, the training these students receive is shaped by the orientation of these institutions toward the irrigated, mechanized agricultural systems found on the coastal plain. Furthermore, with relatively lucrative opportunities available in private extension work within these systems, it would make little sense for a student to choose to study relatively unprofitable rain-fed agriculture.

CIANO's small-scale farming research is similarly limited. Although CIANO hosted a research program targeting rain-fed agriculture in Alamos through the 1970s and 1980s, funding for this program was cut in the early 1990s as part of a broader movement to transfer Mexican agricultural research into the private sector (see King 2006). Today, CIANO receives much of its mandate from the Agricultural Research and Experimentation Board of the State of Sonora (Patronato para la Investigación y Experimentación Agrícola del Estado de Sonora, or PIEAES). PIAES was formed in 1964, stemming from a Yaqui Valley producer-organization's desire to "provide continuous and systematic financial support for agricultural research" (PIEAES 2001, p. 3). By the year 2000, PIEAES funding covered the entirety of the operation and maintenance costs of CIANO's research infrastructure and contributed $750,000 to CIANO research projects (PIEAES 2001, p. 6). The interests of this organization, as such, wield a strong influence over CIANO's research programs.

The relationship between PIEAES and CIANO has been highlighted as a model for producer-driven research and technology transfer, a distinction which is not disputed here. However, two aspects of the system through which PIEAES relates to producers create a strong bias against research programs relevant to rain-fed agriculture. First, farmers' representation in PIEAES is circumscribed by their membership in one of the 32 member organizations. As is discussed below, organization among farmers around agriculture in Alamos is limited, leaving them with no adequate spokesperson for inclusion in PIEAES.

Furthermore, PIEAES' main source of funds are farmers' contributions, the amount of which is based on each farmer's expected per-hectare production values (PIAES 2001). These contributions are collected when the farmer pays for his or her yearly *permiso de siembra* (cultivation permit). However, Alamos farmers do not pay permisos de siembra, since the municipality is classified a "highly marginal" or "very highly marginal" in national poverty indexes. Furthermore, even under optimal conditions, per-hectare yields in Alamos are far lower than those in other regions of Sonora, suggesting that were Alamos farmers to make a proportional contribution to PIEAES, their economic weight would be small in comparison to that of producers from other production systems. These factors leave Alamos farmers effectively outside of the sphere that influences local agricultural research.

If seeking out targeted research or technology transfer from formal research institutions is not a likely option, might it not be possible for Alamos farmers to seek assistance from agronomists or extension agents, in order to learn techniques to better utilize the germplasm and water resources that are currently available to them? This approach is also unlikely to bear fruit; whereas agronomists were once employed by the government to provide technical assistance to agriculturalists, the current structure of SAGARPA funds employees only for "normative" activities, which include the administration, monitoring, and evaluation of a limited number of programs. Government funding for "operative" activities, which formerly included the planning and implementation of agricultural improvement projects, is now available only through non-salaried sources. Some communities in the municipality possess water-harvesting infrastructure from previous government projects, but much of this infrastructure is not in use.

Currently, three separate government programs, PRODESCA, PAPIR, and SINACATRI, govern access to government-funded agricultural extension in Alamos. PRODESCA (Programa para el Desarrollo del Campo) provides funds for agricultural improvement projects, while PAPIR (Programa de Apoyo a los Proyectos de Inversión Rural) provides parallel, linked funds to remunerate agricultural technicians assisting communities in undertaking such projects. These two programs are funded by Alianza, and are managed by the SDR through the municipal consejo de desarrollo (development council). SINACATRI (Sistema Nacional de Capacitación y Asistencia Técnica Rural Integral) aims to act as an umbrella organization for other groups working on rural development issues, providing training, coordination of activities of different agencies, and funding for local development projects (SINACATRI, n.d., http://www.sinacatri.gob.mx). SINACATRI is also managed locally by the consejo de desarrollo with input from SAGARPA.

These programs are designed to avoid repeating past failures in rural development assistance in Mexico, including improper targeting of programs or insufficient prior assessment of community needs. Funds available through PRODESCA and PAPIR are awarded on a competitive basis. Until 2005, these awards were made through a centralized state office in Hermosillo, but since 2005, half of the state-wide funds for these two programs have been "municipalized," meaning that proposals may now also be submitted through the *consejo de desarrollo*. To be approved, projects must be submitted by a government-certified *técnico* (technician, or extension agent), who has passed a course to gain formal recognition.

Funds awarded via PRODESCA and PAPIR are generally paid out in two parts, with 50% arriving at the beginning of the project, and the other 50% being distributed upon project completion. Funding for projects under PRODESCA is not complete; farmers are required to volunteer 40–50% of the expected total cost of the project, with some disadvantaged groups having access to higher percentages of governmental funding support. The purpose of this funding structure is to encourage farmers to use the government-provided funding as collateral with a private credit provision agency; however, there is no formal infrastructure in place to facilitate this interaction.

As in the case of PIEAES, there are significant structural barriers to Alamos farmers' access to these programs. First, the lack of government coordination between the farming community and the técnico implies that the extension agent and the community must find each other without an intermediary, essentially turning the extensionist into a "free agent." In the Sonoran context, where ejidos have a reputation for being "difficult," and where there is ample private-sector demand for technical assistance in the mechanized, profit-oriented agricultural regions of the coastal plain, there are strong incentives for college-educated agronomists to live near urban areas, rather than in zones like Alamos.[11] Moreover, PRODESCA and PAPIR's competitive process implies that proposals must be designed and written before they are considered for government funding, possibly involving some prior payment to the agronomist on the part of the community, with no guarantee that the community will receive project funding in return.

A further difficulty arising within this system is the lack of coordination between projects. Projects funded by PRODESCA and PAPIR are not unified under an agriculture-related banner, but rather share an orientation toward "rural development." There are both benefits and drawbacks to the fact that the details of a given project depend on the interests and abilities of the community and the técnico; despite providing the opportunity to address what community members see as their own most pressing needs, this system offers no assurance that projects will result in broader community benefits. The minimum number of participating families required to propose a PRODESCA project is six, far fewer than the number of households in a typical ejido.

Related, PRODESCA- and PAPIR-funded projects are supported on a short-term cycle, rather than being incorporated into programs with long-term funding and follow-up. Although these conditions may successfully winnow out projects whose short-term potential for profitability is low, it is questionable whether such programs are adequate to support projects with goals of long-term sustainability or public goods provision. As a good with both public and private characteristics (Smale et al. 1999), local maize may require long-term investment and monitoring, and is likely to fit poorly into a schema focusing on short-term profitability. Moreover, in a context where farmers face poverty, lack of clean water, poor sanitation, and limited of job opportunities, "maize landrace conservation" may not rank high enough on the list of local concerns to be the subject of a community-generated proposal for PRODESCA funds. Given these factors, it is doubtful that PRODESCA and PAPIR will provide the motivation, coordination, skill-sets, and funding necessary to support the maintenance of local maize varieties in Alamos.

In principle, SINACATRI seeks to respond to some of these failings. SINACATRI's five institutional strategies include training programs for specific local development initiatives; awareness-raising in farming communities about existing government programs; the creation of a national database on infrastructural resources available for training and capacity-building; the creation of a national network of trained professionals; and an evaluation, certification, and accreditation system for farmers who have passed through several levels of SINACATRI training (SINACATRI; http://www.sinacatri.gob.mx). Although these initiatives do not speak to larger issues of funding cycles or public goods provision, they do seek to facilitate relationships among farmers, government agencies, and técnicos that might ameliorate access and coordination problems.

Nonetheless, SINACATRI's influence in Alamos is limited. In 2006, pilot discussions and needs-assessments had been undertaken in two communities in the municipality, and training programs were in the planning stage. However, SINACATRI was not yet well established as an institution; no one in the municipality was employed full-time by SINACATRI projects, and the two individuals responsible for the advances registered in 2006 had taken on the project in addition to their full-time positions. Potential for positive impact exists, but the extent and nature of these impacts remains to be determined.

Given the conditions influencing agricultural research and access to government-sponsored extension programs, a final question is why small-scale farmers in this region do not address the problem of maintaining maize yields on a collective basis. Why do farmers not form farmers' unions, cooperatives, or farmer-to-farmer networks to advocate for improvements in the conditions surrounding maize production, as agriculturalists in other areas of Mexico have done? The lack of such formal community support networks in Alamos is marked. During fieldwork in 2004 and 2005, Alamos hosted one incipient farmers' cooperative focusing on sesame cultivation. Other focal points for farmer assistance included the cattlemen's association (Asociación Gandera) which was of long standing in the community but focused solely on livestock issues, and the Caja Solidaria, a fund offering credit to farmers on a members-only basis, which was in its early stages of organization in 2004. However, there was no maize-producers' association, nor any civil society unit dedicated to general advocacy for rural issues.

[11] In fact, one government-employed agronomist with whom I spoke in 2004 could think of only one acquaintance—a resident of Sinaloa—who worked as a private extensionist with small-scale, rain-fed agriculture.

Table 4 Changes in Alamos farmers' access to agricultural research and crop management resources over time

	Institutions (options)	Accessibility/use prior to neoliberal restructuring (ca 1990)	Change by 2005–2006	Qualitative change (accessibility)
Agricultural research	CIANO	Some access	Access functionally non-existent	Mexican government and producer-driven priorities shift away from rain-fed maize production; donor priorities shift regionally to Africa and Asia
	CIMMYT	Access mediated by Mexican government and donor priorities	Same	
Crop management resources (extension)	Government extension (SARH/SAGARPA)	Existent	Eliminated	Government channels for extension and technical assistance accessible to few farmers; focus is on project profitability, rather than public goods creation
	Local knowledge	Widely used	Widely used	
	Alianza (PRODESCA, PAPIR)	n/a	Available but access limited	
	SINACATRI	n/a	Weak/incipient	
Collective action	Farmers' unions, NGOs, political movements	Farmers unions emerged, then failed	No maize-oriented collective action apparent	Farmers express disappointment and disillusionment with previous attempts at collective action; drug trade contributes to a culture of mistrust

Logistical challenges present one explanation for the lack of farmer organization in Alamos. Most communities have few telephones, and cellular phone coverage was sparse outside of the municipal seat through 2005. Few families have vehicles with which they could travel over the bumpy dirt roads, and public transportation is similarly limited and relatively expensive. Although many houses receive national and international TV news programs, newspapers are not widely available in the ejido communities, and local or regional news frequently travels by word of mouth, with some input from a local radio station. Furthermore, while most towns have primary and secondary schools, until 2006 high-school-level education was only available in the municipal seat, requiring many students to commute two to three hours on a daily basis to attend classes. In other words, the potential "costs of organization" (Olson 1971) in Alamos present a basic obstacle to collective action.

Beyond these logistical barriers, however, Alamos residents also harbor unpleasant memories of past attempts at collective action. One farmers' union that had strong support in the 1980s collapsed when it was found that its leaders were using union-owned trucks to transport illicit drugs for their own profit. As the story was told in 2004, another union that was powerful in the 1990s was undermined when its leaders attempted to challenge the incumbent political party and assume governing power in the municipality. These power struggles are mirrored within ejido communities, where deep and lasting divisions frequently exist over land-use decisions, land-tenure, or familial disagreements. Furthermore, drug trafficking and drug cultivation in the region foster a secretive and frequently dangerous environment (Keleman 2005), making it difficult for farmers to accept the intentions of strangers at face value. Farmers in Alamos do not project hopefulness that such obstacles might be overcome; farmers typically voiced cynicism when discussing these conditions, rather than hope for change.

As summarized in Table 4, these observations suggest that the options provided by institutions to which a farmer might look for assistance in maintaining maize production—or maize diversity—are limited, and have become more so over time. It is unlikely that a farmer might breed new, drought-resistant germplasm without technical assistance, and the possibility of targeted research or technology transfer by national or international organizations is functionally nonexistent. Government-sponsored technical assistance programs also present strong structural barriers to small-scale farmers, and although recent developments on this front are promising, there is nothing to guarantee that these programs will either focus on maize production or variety maintenance, or be implemented in a timely enough fashion to curb the loss of local varieties. Furthermore, logistical, cultural, and historical barriers to collective action are high. These circumstances have negative implications for in situ maize conservation in Alamos.

Conclusions: Alamos farmers and maize diversity management

The research presented here suggests that the liberalization of Mexico's agricultural sector under NAFTA has changed the rules of the game in such a way as to place small-scale Alamos maize farmers at a disadvantage. The current policy environment makes it more difficult for small-scale farmers to adjust their practices in response to periods of environmental or market change, and thereby make community-based approaches to genetic diversity conservation at best unlikely to be successful, and at worst, impossible. Granted, even were favorable institutional conditions in place, it is possible that many Alamos farmers would choose not to invest time or energy in maize diversity conservation. Under current circumstances, however, farmers have few resources, other than their own determination and physical labor, with which to participate in this decision at all.

This case study contributes to discussions of the erosion of crop genetic diversity in two important ways. First, it adds to literature questioning the "stability" of local landraces. A key notion underpinning the concept of genetic erosion is that crop landraces are stable and locally adapted (Brush 2004, pp. 157–158). However, research on farming systems in which landraces persist has shown that these are much more dynamic than was originally assumed, with high variety-turnover rates and seed frequently sourced outside of a given community (Brush 2004, pp. 161–174). The Alamos example adds a twist to this story, presenting a case in which previously existing local adaptation may no longer be sufficient to deal with changing climatic conditions, and resources available outside the system are, for practical purposes, inaccessible to farmers whose practices contribute to in situ maize conservation.

A second contribution of this case study is to raise a set of questions reframing the role of agricultural technology and technology transfer in in situ conservation. Much of the literature analyzing genetic erosion operates under the assumption that technological change in the form of the introduction of high-yielding, genetically uniform seeds is the key factor driving the loss of genetic diversity (Brush 2004, p. 157). The case of Alamos, however, highlights the negative impacts of the *lack* of research and technological assistance—or the re-orientation of such assistance towards different kinds of crops and different kinds of producers—on farmers' ability to manage and maintain crop genetic diversity under novel environmental conditions. This suggests the need for a more nuanced approach to agricultural support for those farmers who conserve maize in situ. Rather than leaving small-scale farmers out of the loop of research and extension, a greater effort to give these farmers access to appropriate low-input technology that neither requires large capital investments nor obligates them to stop planting maize landraces could help them continue to conserve in situ even in the face of new conditions.

Observations from the 2006 growing season in Alamos highlight the element of time in this scenario. Although farmers interpreted the rains of 2006 as a return to relative "normalcy," observers reported that the availability of local maize variety seed at the time of planting was extremely limited. As such, farmers who had not already exited maize cultivation turned to any source of seed they could find, many of them planting varieties bred for the irrigated agricultural systems of Sinaloa and coastal Sonora. However, a period of low rainfall coincided with the flowering and silking phase of these varieties, and the development of ears in most farmers' fields was arrested before the grain-filling stage. Anecdotal observations suggest that only those few farmers who had managed to plant local maize varieties were able to produce a harvest (J. Salido, SAGARPA, personal communication, October 2006).

The long-term ramifications of these circumstances remain to be seen. If rains retain historical levels for the next several years, it is possible that maize landrace seedstock may be recuperated. However, if rainfalls remain below normal levels, or if farmers choose to orient their energies toward other crops, it is a real possibility that in situ cultivation of local maize germplasm may disappear within a matter of years. In the face of such risks, leaving Alamos maize diversity conservation to the will of farmers to self-organize within currently available government programs would likely be an ineffective strategy.

What other responses for supporting maize diversity conservation might exist? One option currently being explored is the reintroduction of seed of varieties collected in Alamos from the Native Seeds/SEARCH gene bank. Over the longer-term, participatory breeding projects might offer another way forward. At a state or national level, targeted agrobiodiversity subsidies, designed under the rubric of payments for environmental services and including support for maize landrace cultivation, could provide a counterweight to larger trends shifting away from maize cultivation for income-generation, favoring crops with more reliable yields, cash crops, or off-farm labor. It is noteworthy that such programs could easily be designed to be system-based, rather than production-based, and as such would not necessarily represent a return to the subsidy-influenced production that Mexico's neoliberal restructuring sought to correct.

In some sense, the combination of elements reported here is unique to Alamos. Although there are other regions of Mexico for which improved germplasm is either unavailable or not widely adopted, few areas of the country exhibit growing conditions as harsh as those reported in Sonora in recent years. Furthermore, market and cultural factors supporting landrace maize use are stronger in many other regions. In highlands Chiapas, landrace maize cultivation is associated with Maya identity and religious practices, while in the high-altitude *valles centrales*, some maize landraces are sought after for specialty maize-product markets in the booming urban market of Mexico City.

Even acknowledging the particularities of this case study, however, these experiences remain relevant because institutional and technological conditions in Sonora are frequently portrayed as the model which the rest of the Mexican agricultural sector should emulate. Further, the stark shifts in weather patterns observed recently in Sonora may not be isolated incidents. Given these possibilities, the options available to Alamos farmers for managing local maize varieties shed light on institutional conditions that will be relevant to other regions of Mexico.

Further, the options provided to farmers by agricultural support institutions have relevance beyond the in situ conservation of maize landraces. A perception frequently expressed among formally trained agronomists in Mexico is that to promote low-technology agriculture and landrace germplasm is equivalent to condemning farmers to poverty and marginalization. However, focusing on the ways in which existing institutions provide (or do not provide) options to small-scale maize farmers also raises broader questions of equity and participation. In this light, post-NAFTA Mexican agricultural policy is implicated in shaping an institutional environment in which the maize farmers who steward and renew maize genetic diversity have only limited support for responding to change.

Acknowledgements This research was supported by a the Yale Tropical Resources Institute Summer Fellowship; the Coca-Cola World Fund at Yale; the Yale Latin American and Iberian Studies Summer Travel Grants; the Yale Agrarian Societies Summer Travel Grants; and the EPA STAR Fellowship. Native Seeds/SEARCH provided institutional support, and Dr. Suzanne Nelson offered invaluable input and collaboration in fieldwork. The author is indebted to Drs. Michael R. Dove, Cheryl Doss, Jonathan Hellin, Alejandro Nadal, Antonio Serratos, John Tuxill, and David Cleveland, as well as three anonymous reviewers, for comments on a series of drafts. Finally, thanks are due to the Colegio de Mexico, CIMMYT, and the Fox International Fellowship.

References

Appendini, K. 2001. *De la milpa a los tortibonos: La reestructuración de la política alimentaria en México*, 2nd ed. Mexico City, Mexico: El Colegio de Mexico and the United Nations Institute for Social Development.

Bänziger, M., G.O. Edmeades, D. Beck, and M. Bellon. 2000. *Breeding for drought and nitrogen stress tolerance in maize: From theory to practice*. Mexico, D.F.: CIMMYT.

Barbier, E.B. 2000. Links between economic liberalization and rural resource degradation in the developing regions. *Agricultural Economics* 23: 299–310.

Barkin, D. 2003. El maíz y la economía. In *Sin maíz no hay país*, ed. G. Esteva, and C. Marielle, 155–176. Mexico City, Mexico: Consejo Nacional para las Culturas Populares.

Bellon, M.R., M. Adato, J. Becerril, and D. Mindek. 2005. *The impact of improved maize germplasm on poverty alleviation: The case of Tuxpeño-derived materials in Mexico*. Mexico City, Mexico: CIMMYT.

Biles, J.J., and B.W. Pigozzi. 2000. The interaction of economic reforms, socio-economic structure, and agriculture in Mexico. *Growth and Change* 31: 3–22.

Biles, J.J., K. Brehm, A. Enrico, C. Kiendl, E. Morgan, A. Teachout, and K. Vasquez. 2007. Globalization of food retailing and transformation of supply networks: Consequences for small-scale agricultural producers in southeastern Mexico. *Journal of Latin American Geography* 6: 55–75.

Bonilla, J., and G. Viatte. 1995. Radical reform in Mexican agriculture. *OECD Observer* 191: 21–26.

Brush, S.B. (ed.). 2000. *Genes in the field: On-farm conservation of crop genetic diversity*. Rome, Italy: IDRC/IPGRI/Lewis Publishers.

Brush, S.B. 2004. *Farmers' bounty: Locating crop diversity in the contemporary world*. New Haven, UK: Yale University Press.

Brush, S.B., and H.R. Perales. 2007. A maize landscape: Ethnicity and agro-biodiversity in Chiapas, Mexico. *Agriculture, Ecosystems, and Environment* 121 (3): 211–221.

Cameron, M.A., and B.W. Tomlin. 2002. *The making of NAFTA: How the deal was done*. Ithaca and London: Cornell University Press.

Chambers, K.J., S.B. Brush, M.N. Grote, and P. Gepts. 2007. Describing maize (*Zea mays* L.) landrace persistence in the Bajío of Mexico: A survey of 1940s and 1950s collection locations. *Economic Botany* 61 (1): 60–72.

CIMMYT. 2006. Is native maize diversity being lost in Mexico? *CIMMYT E-News* 3 (11). http://www.cimmyt.org/english/wps/news/2006/nov/fraylesca.htm. Accessed 10 Dec 2006.

De Janvry, A., E. Sadoulet, and G. Deanda. 1995. NAFTA and Mexico's maize producers. *World Development* 23 (8): 1349–1362.

Dean, A. 2004. Drought enters ninth year in birthplace of the Green Revolution crisis for farmers in the Yaqui Valley. Encina Columns, Spring Edition, Stanford Institute for International Studies, Stanford University, 11–14.

Dyer, G., and E. Taylor. 2002. Rethinking the supply response to market reforms in agriculture: Household heterogeneity in rural general equilibrium analysis. PhD dissertation, University of California, Davis.

FAO/SAGARPA. 2003. Evaluación de la Alianza para el campo, 2002: Informe de evaluación general, conclusions y recomendaciones. http://www.evalalianza.org.mx/eval2002/productos/informes/NAL_CONYREC_2002.pdf. Accessed 10 December 2006.

Fitting, E. 2004. "No hay dinero en la milpa": El maíz y el hogar transnacional del sur del valle de Tehuacan. In *La economía política de la migración internacional en Puebla y Veracruz: Siete estudios de caso*, ed. L. Binford, 61–101. Mexico City, Mexico: CONACYT.

Fitting, E. 2006. Importing corn, exporting labor: The neoliberal corn regime, GMOs, and the erosion of biodiversity in Mexico? *Journal of Agriculture and Human Values* 23 (1): 15–26.

García Barrios, R., and L. García Barrios. 1990. Environmental and technological degradation in peasant agriculture: A consequence of development in Mexico. *World Development* 18 (11): 1569–1585.

Gravel, N. 2007. Mexican smallholders adrift: The urgent need for a new social contract in rural Mexico. *Journal of Latin American Geography* 6: 77–98.

Haenn, N. 2005. *Fields of power, forests of discontent: Culture, conservation, and the state in Mexico*. Tucson, AZ: University of Arizona Press.

Hellin, J, M. Lundy, and M. Meijer. 2007. Farmer organization, collective action, and market access in Meso-America. Paper presented at Research Workshop on Collective Action and Market Access for Smallholders, Cali, Colombia, October 2–6,

2006. http://www.capri.cgiar.org/pdf/capriwp67.pdf. Accessed 29 Oct 2008.

Hendrickson, M., and H. James. 2005. The ethics of constrained choice: How the industrialization of agriculture impacts farming and farmer behavior. *Journal of Agricultural and Environmental Ethics* 18 (3): 269–291.

INEGI. 2005. II conteo de población y vivienda 2005. http://www.inegi.gob.mx/est/contenidos/espanol/proyectos/conteos/conteo2005/default.asp?c=6224. Accessed 11 Dec 2006.

Keilbach Baer, N.M. 2005. *Maíz y frijol en México: Perspectivas frente a la liberalización total de su comercio en el 2008. Reference document for the Oxfam-Central America Free Trade Campaign*. Mexico City, Mexico: Oxfam GB.

Keleman, A. 2005. Methodology in a time of crackdown. *Tropical Resources: The Bulletin of the Yale Tropical Resources Institute* 24: 9–14.

Keleman, A. 2008. Maize diversity loss and patterns of environmental and cultural change in Alamos, Sonora. Unpublished Working Paper.

King, A. 2006. Ten years with NAFTA: A review of the literature and an analysis of farmer responses in Sonora and Veracruz, Mexico. CIMMYT Special Report 06–01: Mexico City, Mexico: CIMMYT/Congressional Hunger Center.

Klepeis, P., and C. Vance. 2003. Neoliberal policy and deforestation in southeastern Mexico: An assessment of the PROCAMPO program. *Economic Geography* 79 (3): 220–240.

Levy, S., and S. van Wijnbergen. 1992. Maize and the free trade agreement between Mexico and the United States. *The World Bank Economic Review* 6 (3): 481–502.

Lipper, L., and D. Cooper. 2008. Managing plant genetic resources for sustainable use in food and agriculture: Balancing the benefits in the field. In *Agrobiodiversity, conservation, and economic development*, ed. A. Kontoleon, U. Pascual, and M. Smale, 27–39. New York, NY: Routledge.

Mayer, F.W. 1998. *Interpreting NAFTA: The science and art of political analysis*. New York, NY: Columbia University Press.

McDonald, J.H. 1997. Privatizing the family farmer: NAFTA and the transformation of the Mexican dairy sector. *Human Organization* 56 (3): 321–332.

McDonald, J.H. 1999. The neoliberal project and governmentality in rural Mexico: Emergent farmer organization in the Michoacán highlands. *Human Organization* 58 (3): 274–284.

McDonald, J.H. 2001. Reconfiguring the countryside: Power, control, and the (re)organization of farmers in west Mexico. *Human Organization* 60 (3): 247–258.

Nadal, A. 2000. *The environmental and social impacts of economic liberalization on corn production in Mexico*. Gland, Switzerland and Oxford, UK: WWF International and Oxford GB.

Nadal, A. 2002. *Zea mays*: Effects of trade liberalization on Mexico's corn sector. In *Greening the Americas: NAFTA's lessons for hemispheric trade*, ed. C.L. Deere and D.C. Esty, 143–162. Cambridge, MA: The MIT Press.

Nadal, A., and T.A. Wise. 2004. The environmental costs of agricultural trade liberalization: Mexico-US maize trade under NAFTA. Discussion Paper No. 4, Working Group on Development and Environment in the Americas. http://ase.tufts.edu/gdae/WorkingGroup.htm. Accessed 9 Dec 2006.

Nadal, A., and H. García Rañó. 2006. Trade, poverty, and the environment: A case study in the biosphere reserve Sierra de Santa Marta. Final Report to World Wildlife Foundation, Mexico, DF.

Olson, M. 1971. *The logic of collective action: Public goods and the theory of groups*. Cambridge, MA: Harvard University Press.

Ortega Paczka, R. 2003. La diversidad del maíz en México. In *Sin maíz no hay país*, ed. G. Esteva and C. Marielle, 123–154. Mexico City, Mexico: Consejo Nacional para las Culturas Populares.

PIEAES. 2001. A model for productive farmer-researcher partnerships. Organizational brochure. Sonora, Mexico: PIEAES.

Pilcher, J. 2002. Industrial tortillas and folkloric Pepsi: The nutritional consequences of hybrid cuisines in Mexico. In *Food nations: Selling taste in consumer societies*, ed. W. Belasco and P. Scranton, 222–239. New York, NY: Routledge.

Romero, J., and A. Puyana. 2006. *Diez años con el TLCAN: Las experiencias del sector agropecuario mexicano*. Mexico City, Mexico: FLACSO-El Colegio de México.

SAGARPA. 2002. Resultados de la aplicación del cuestionario a productores de PROCAMPO. http://www.procampo.gob.mx/result_enc_procampo.html. Accessed 11 June 2006.

Sheridan, T. 1996. *Where the dove calls: The political ecology of a peasant corporate community in northwest Mexico*. Tucson, AZ: University of Arizona Press.

Shriar, A. 2002. Food security and land use deforestation in northern Guatemala. *Food Policy* 27: 395–414.

SINACATRI. n.d. http://www.sinacatri.gob. Accessed 20 Nov 2006.

Smale, M., M.R. Bellón, and J.A. Aguirre Gómez. 1999. The private and public characteristics of maize land races and the area allocation decisions of farmers in a center of crop diversity. Economics Working Paper No. 99-08. Mexico City, Mexico: CIMMYT.

Stanford, L. 1994. Transitions to free trade: Local impacts of changes in Mexican agrarian policy. *Human Organization* 53 (2): 99–109.

Yetman, D. 1998. *Scattered round stones: A Mayo village in Sonora, Mexico*. Albuquerque, NM: University of New Mexico Press.

Yetman, D., and T. Van Devender. 2002. *Mayo ethnobotany: Land, history, and traditional knowledge in northwest Mexico*. Berkeley, CA: University of California Press.

Yúnez-Naude, A. 2003. The dismantling of CONASUPO, a Mexican State-trader in agriculture. *The World Economy* 26: 97–122.

Author Biography

Alder Keleman completed a joint master's program in Environmental Science and International Relations at Yale University, after which she spent a year as a Fox International Fellow in the Program on Science, Technology, and Sustainability (PROCIENTEC) at the Colegio de México. Her research interests center on the evolving human uses of wild and cultivated plants in current contexts of cultural, global, and demographic change. She is currently based in Rome, Italy, as a Mickey Leland International Hunger Fellow placed at the Food and Agriculture Organization (FAO).