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Farmers' valuation and conservation of crop genetic resources

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Abstract

This paper focuses on the value of landraces (traditional and local crop varieties) to farmers in centers of agricultural diversity. Additional information on the factors contributing to the private value which farmers assign to landraces may help to identify a strategy for ensuring the conservation of the crop genetic resources (CGRs) which are embodied in landraces while at the same time minimizing the costs. Economic and ethnobotanical approaches for examining the value of landraces complement one another. A formal economic approach establishes a framework for quantitative analysis while ethnobotanical methods provide qualitative data for assessing the likelihood that particular farmers or farm sectors will maintain landraces. Our research synthesizes the two approaches in order to examine farmer selection of local wheat landraces in relation to that of modern varieties in three provinces in western Turkey. Multiple farmer concerns (e.g. yield, risk, quality), environmental heterogeneity, and missing markets contribute to the persistence of landraces. Household characteristics informing variety choice will also affect the household's perceptions of the importance and value of landraces.

Organized collection, evaluation, and conservation of crop genetic resources (CGRs) have gone on for two hundred years, confirming the fact that politicians, scientists and consumers value these resources. The social value of CGRs has been described anecdotally by examples of the economic contribution of exotic crops and crop varieties (e.g. Iltis 1989) and analytically by the contribution of germplasm to breeding programs (Evenson & Gollin 1994; National Research Council 1993). Likewise, the existence of CGRs in farming systems implicitly suggests that farmers also value them, a suggestion that is confirmed by research on farmers' knowledge and their use of different crops and crop varieties. Whether or not farmers recognize a direct private value from genetic diversity as such is uncertain; however, the local crop populations (landraces) contributing to diversity levels do have a private value. Farm households benefit directly from the production and consumption of landraces and dedicate valuable resources to make their cultivation possible. The private value of landraces is suggested by their persistence in farming systems where alternative varieties exist (Brush 1995) and by studies on the evaluation and selection of local varieties (e.g. Bellon 1996; Zimmerer 1996; Sperling, Loevinsohn & Ntabomvura 1993). The decision to cultivate a traditional variety is determined by the household's perception of its ability to fulfill the household's requirements relative to alternative options. However, since the supply of crop genetic resources for society as a whole is largely determined by these private decisions, the actions of the households also play a role in a larger social context. Any discussion of the social value of crop genetic resources must, therefore, first address the value of landraces to farmers. Programs advocating *in situ* conservation of crop genetic resources must be conscious of the private costs and benefits of landraces to the cultivating households.

The recognition that a value be attributed to genetic resources, despite the absence of a formal market mechanism for determining price, seems to be increasingly accepted. Although the backers of genetic resource conservation have until recently accepted anecdotal and rather vague estimates of the value and cost of maintaining genetic resources, the need for better measures of value is now apparent. Crop resource conservationists want measures of value to justify budgets, and farmers' rights activists want measures of the value of crop resources in order to appeal for compensation to farmers or to less developed countries. These reasons for specifying the value of crop genetic resources are given legitimacy in the 1992 Convention on Biological Diversity. Unfortunately, political and economic motives for valuing genetic resources, however sound, cannot be easily satisfied.

From the common desire to obtain more precise estimates of CGR value, however, stems a lack of agreement regarding its exact nature and possible methods for its accurate estimation. Different methods for valuing non-market resources exist, but no single method is either available or appropriate to value the vast array of genetic resources. In his discussion of genetic resources, Brown (1990) assigns the value of genetic resources to five benefit classes: direct productive value, direct consumptive value, indirect productive value, nonconsumptive values, and future uncertain nonconsumptive (option) value. Most of the examples he utilizes to illustrate the classes, however, are drawn from a broadly defined set of genetic resources, e.g. tropical forests, wetlands, and other ecosystems. The private ownership of these systems is not always clear-cut, and the benefits from the use and existence of the resources are enjoyed by society as a whole. For these types of genetic resources, issues pertaining to valuation have most frequently been addressed from a wider societal perspective. Genetic resources for agriculture, however, present a unique and separate set of problems and characteristics which must be appreciated for valuing them, because of their wide distribution, their status as public goods, their daily use by individual farm households, and their association with less developed agriculture.

Our objectives are to examine household characteristics that contribute to the farm-specific private value of landraces to farmers in centers of agricultural diversity (Vavilov centers) and to explore the relationship between private value and the design and implementation of *in situ* conservation policies and programs. We view landraces as a proxy for crop genetic resources because landraces have historically been an important source of germplasm in crop improvement programs. In the collections of the CGIAR centers, 59% of all accessions are landraces and old cultivars, 14% wild and weedy relatives, and 27% advanced cultivars and breeders' lines. The last category derives historically from the first (FAO 1996a). The paper focuses specifically on the cultivation and farmer assessment of wheat landraces in Turkey. In examining the components of the private value of landraces, we consider variables suggested by economic theory to influence farmer's choices (e.g. risk aversion, resource endowment, access to markets) as well as qualitative assessments by farmers of several major crop characteristics. A better understanding of private value to households growing landraces will shed light on the potential costs involved in supporting on-farm conservation, should a public effort become necessary. However, any attempt to examine the value of a landrace to the farm household must be preceded by the identification of what exactly farmers perceive to be advantageous and therefore valuable about the traditional varieties they choose to cultivate. We assume that these characteristics will be the same as or largely similar to the factors that ultimately influence the farm household in its land allocation decision.

Part 1 is a general overview of the loss and conservation of crop genetic resources. Methods for studying farmers' valuation of crop resources are examined in Part 2. Part 3 uses the case of wheat in Turkey to discuss valuation of landraces on-farm. Part 4 reviews the cost of on-farm conservation in light of the framework developed above, and Part 5 is the conclusion.

The loss and conservation of crop genetic resources

Crop genetic resources include different types of plant germplasm as well as ecosystems which contain that germplasm. Agricultural plant germplasm is found in wild relatives of cultivated plants, weedy forms, locally selected crop varieties (landraces), plants used in crop breeding, and modern cultivars. The first three categories are especially important ones for conservation purposes because of their potential contribution of specific traits to the production of the last two types. Landraces in many crops have been identified as the most threatened category of genetic resource and are also the primary object of demands for compensation (Fowler & Mooney 1990; Hawkes 1983).

Landraces were the initial target of conservation, and today numerous accessions of crop varieties are stored in gene banks and botanical gardens around the world (*ex situ* conservation). On-site (*in situ*) conservation is not so much a new idea as one which has reemerged after the successful creation of *ex situ* conservation (Zeven 1996). As conservation of crop genetic resources has progressed, conservationists have concluded that *in situ* conservation is needed to complement gene banks and botanical gardens. Since *ex situ* conservation simply cannot capture or conserve all of the diversity in agricultural systems, *in situ* conservation serves as a back-up. It also covers types of genetic resources that cannot be protected in gene banks, such as crops that show recalcitrance to off-site conservation (Hammer et al. 1996), as well as local knowledge and ecosystem interactions (Brush & Stabinsky 1996; Oldfield & Alcorn 1987). *In situ* conservation does not directly provision genes for crop improvement but preserves evolutionary processes which will yield new germplasm in the future (Brush 1995).

The worldwide crop conservation effort was created in part because of the belief that the genetic legacy of our ancestors was threatened by modern conditions, especially record-high populations, technological change, and infrastructural development (Frankel 1970). Despite three decades of concern about the danger of genetic erosion, however, our understanding and measurement of it is woefully inadequate. Moreover, since genetic erosion of landraces has been inadequately tracked, the resulting uncertainty about their future has a potentially large impact on our ability to value them. The mostly widely used figures in estimating genetic erosion are indirect – the diffusion of modern crop varieties (MVs) released from crop breeding programs. Case histories of agricultural development in industrial countries suggest that modern varieties can quickly eliminate local ones (Hammer et al. 1996; Duvick 1984; Griliches 1958). The success of semi-dwarf wheat and rice in Asia convinced many agricultural scientists that the genetic erosion experienced in temperate industrial countries would repeat itself in tropical less developed ones (Frankel 1970).

Projections about genetic erosion in farming systems of centers of crop diversity rested on two conjectures. First, it was believed that MVs would diffuse throughout in these systems. Second, it was thought that the adoption of MVs would lead farmers to stop planting landraces. These conjectures were supported by aggregate data (e.g. Dalrymple 1986), but there is reason to question how broadly they apply. Field research among cultivators of traditional crops in several different farming systems suggests that the diffusion of MVs is complex and that the rate and extent of replacement of landraces by MVs is context specific (Brush 1995). Farmers do not necessarily replace local varieties even when they adopt MVs. Many countries have regions where landraces have not been replaced and others where they have been decreased but not eliminated by MVs.

Farmers' valuation of crop resources

Since the cultivation of landraces continues to take place, we can infer that the varieties selected hold some value for the households that cultivate them. This household value comprises one component of the overall value of the genetic resources. An estimate of their value to the farm households cultivating them provides a lower bound estimate of the total value of these resources to society. In the context of valuing biodiversity for pharmaceutical research, Simpson et al. (1996) point out that previously estimated values have likely been overestimated since issues of scarcity and redundancy were not addressed. They emphasize that an accurate assessment values a species on the basis of its incremental contributions. A similar precaution should be taken into consideration in the examination of landrace valuation.

Information about specific variety characteristics that the farmer finds important will provide insight on household preferences and behavior. If continued cultivation of landraces appears uncertain and if on-farm maintenance of some target level of diversity is a stated objective, then the accurate valuation of these genetic resources from the viewpoint of the farm household could provide crucial information for the development of policies to guarantee their existence in the future. Two approaches to describing farmers' valuation of landraces and crop genetic resources exist in the literature. Economic analyses of variety choice can be used to impute value, while ethnobotanical description of farmers' uses of and attitudes towards different varieties provides information on value. The synthesis of these two approaches is desirable particularly in peasant production systems with missing or imperfect markets where ethnobotany can provide useful information. Differences in the data developed for the economic and ethnobotanical approaches, however, may pose problems for a synthesis. For instance, ethnobotanical information on use and attitudes is qualitative and not formatted to quantitatively analyze choice among varieties or the allocation of land and labor; but for economists, choice and allocation of factors of production among alternatives is an essential element of valuation.

Economists have developed several theories to explain the variety choice of farm households. The desire to diversify and shield against risk (Swanson 1997; Fafchamps 1992; Finkelshtain & Chalfant 1991; Just & Zilberman 1983), transactions costs restricting household access to markets (Fafchamps 1992; Goetz 1992; de Janvry et al. 1991; Strauss 1986), and the presence of environmental constraints (Bellon & Taylor 1993; Jansen et al. 1990) have all been advanced and tested as important influences in the land use decisions of farm households. Risk aversion, transaction costs, and environmental constraints can each explain to some extent the occurrence of the partial adoption of improved crop varieties by farmers in developing countries (Meng, Taylor and Brush 1995). While yield is an important consideration in variety choice, it is not the only consideration and may not even be the most important (Evans 1993). Economic literature has particularly emphasized the role of risk, usually represented by yields, variances, and covariance of yields (Fafchamps 1992). Factors such as production stability, joint production, performance in different agroclimatic zones, and fit to household schedules may also lead to the selection of landraces instead of or along side of modern varieties. Alternatively, the demand for specific quality characteristics can result in a household decision to cultivate a traditional variety if transportation costs, search costs, or other transactions costs prevent household access to markets. It is unlikely that any of the explanations operates independently of the others. Variety choice in regions where landraces persist is characterized by multiple sustaining factors and unavoidable trade-offs in responding to different factors.

Ethnobotanical and anthropological research examining farmers' motivations in cultivating traditional varieties confirms the importance of production and consumption considerations in the variety choice decision. Field research on the maintenance of landraces in regions where modern varieties are grown confirms the multiple objectives of farmers and the importance of heterogeneity in the physical, economic, and cultural contexts of local agriculture (Bellon 1996; Brush 1992). Not surprisingly, factors that have been emphasized by economists have also been important to ethnobotanists in describing variety choice. For instance, risk has been discussed by ethnobotanists as an important factor in farmer attitude and use of varieties (Clawson 1985). Likewise environmental constraints are known to farmers and reflected in ethnobotanical studies of variety selection (Zimmerer 1991; Richards 1986). Bellon (1996) emphasizes that farmers look to varieties with different traits that are suitable for specific needs and constraints and proposes that farmers' concerns be divided into three overall categories: agroecological, technological, and use. These factors have been found to be important considerations in the variety selection for several crops, including maize, potatoes, and wheat (Brush 1995). Nevertheless, ethnobotanists have also emphasized attributes of diversity which have not been formally incorporated into economic models.

In general, the factors cited by ethnobotanists show a degree of complexity that, without appropriate data, is difficult to reflect in an estimable economic model. For instance, Quechua peasants in southern Peru cite fifteen principal maize uses and preferred maize landraces for each use, but several uses include sundry varieties, whose ranking is specific to each household (Zimmerer 1996). Moreover, an additional set of ceremonial and ritual uses for maize are important, and most of these use several preferred maize landraces. Finally, maize landraces in these Quechua villages differ in management (planting period) and elevation constraints, and household choice is affected by labor availability in different periods and land availability at different altitudes.

Two factors in particular favor continued cultivation of landraces within farming systems where MVs are also grown. First, heterogeneity in the physical, economic, and cultural contexts of local agriculture promote the maintenance of landraces. Second, missing markets and high household transaction costs in the peasant sector may contribute to continued cultivation of landraces. If peasants wish to consume landraces but live in locations where markets are deficient or missing, they may have no alternative but to continue to produce landraces. As de Janvry et al. (1991) argue, market failure in peasant economies is not commodity but household specific and is provoked by transaction costs such as transportation costs, mark-ups by merchants, the risk associated with uncertain prices, and other opportunity costs of market participation. The combination of physical, economic and cultural heterogeneity into a single estimable model has been difficult, largely due to data limitations, but is demonstrated below in our discussion of the persistence of wheat landraces in western Turkey.

Farmers' assessment and cultivation of wheat landraces in Turkey

Turkey falls within the Vavilov center of the domestication and diversity for wheat (Zohary & Hopf 1990). The cultivation of wheat in Turkey for over 8,000 years has resulted in a large number of named wheat varieties in addition to the existing wild and semi-domesticated wheat relatives. Modern (improved) varieties have been available in Turkey since the early part of this century and semi-dwarf varieties were introduced from Mexico in 1966; however, the level of adoption in the country varies greatly from region to region. The spring wheat regions of Thrace and the largely winter wheat areas of the Anatolian plateau are extensively planted in modern varieties, but CIMMYT (1993) reports that only 31% of Turkey's wheat area was planted in modern varieties in 1990. The Turkish Western Transitional Zone, located between the major wheat-producing Anatolian Plateau region and the Western Coastal Plains, was selected for this research due to its considerable variation from village to village in percentage of area cultivated in modern varieties. Our surveys show that the adoption of modern wheat varieties varies within as well as between provinces (Meng 1997).

Our data were collected in 1992 from a socio-economic household-level survey covering 287 households. The survey was conducted in 24 villages selected from the three provinces of Eskisehir, Kutahya, and Usak. According to the 1990 Turkish census, the villages studied ranged in size from 144 to 1,810, with an average of 586. A total number of households among the villages studied was 2881, with a total population of 14,060. Data collected during the survey reveal a total of area of arable land of 22,453 ha among the 24 villages. The villages also vary with respect to agro-climatic zones that are divided into three categories: valley land, hillside land, and mountain land. Households situated on valley land are more likely to have irrigation and to be connected with urban markets, while those located on mountain land are often the most distant from markets and are situated in or around forested zones. Hillside land shares attributes of both valley and mountain land. The socio-economic survey covers a broad range of information regarding household characteristics, detailed production data, and consumption preferences. Households participating in the surveys range from those which cultivate only modern varieties, those which cultivate both modern and traditional varieties, and those which cultivate only traditional varieties. Differentiation among households also exists with respect to the percentage of production output marketed. Table 1 summarizes several household characteristics by province and agro-climatic zone for the surveyed sample.

In our Turkish research, we find evidence that environmental heterogeneity, risk, and high household transactions costs of obtaining desired qualities in wheat contribute to the continued cultivation of landraces in specific areas of a nation which has successfully promoted modern varieties. As shown in Tables 1 and 2, both traditional and modern varieties are found in all three provinces, although at different percentages. A total of 22 distinct landraces and 7 modern varieties were found in the study region, with an average of 1.7 varieties per household.

Access to markets appears to play an especially important role in the decision to cultivate traditional varieties. Table 2 presents selected characteristics for households broken down by percentage of household wheat sales. Households with the smallest percentages of wheat market sales face the greatest distances to markets. These households are also among the lowest with respect to information transmitted through extension programs from outside the village. Finally, households with fewer market sales are characterized by the smallest amount of total land owned as well as a relatively small percentage of available irrigated land.

Survey results show that a considerable percentage of the households participate in some kind of market activity. However, market integration and efficiency of markets are not necessarily fully represented by road infrastructure and market distance. A relevant feature of the Turkish wheat market is that the sale and acquisition of different varieties contrast in important ways. Once the market is accessed, it is relatively straightforward to sell any variety of wheat. The policy of the government purchasing organization (Toprak Mahsulleri Ofisi –TMO) is to accept any wheat variety delivered. Wheat is classified by color and hardness, with no official distinction between traditional and modern varieties. All varieties are usually mixed together within their respective classes. The private purchase of wheat by a specific variety, however, is much more difficult. Quality attributes associated with specific varieties are not widely acknowledged in the market; consequently, search costs and other transactions costs involved in locating and purchasing traditional varieties are likely to be quite high. Table 3 provides a breakdown of the sales of modern and traditional varieties by location sold. Sales of traditional varieties make up only a quar-

Table 1. Household characteristics

	N	Off-farm income (%)	MV only	TV only	Both MV/TV	Total land (Ha)	Total irrigated land	Total plots	Mean plot size (ha)	# Hhld wheat plots	Distance from market (km)
All households	285	26.5	68	167	50	12.3	2.6	12.4	1.3	7.0	16.6
Eskisehir	96	21.9	65	16	15	15.5	6.7	13.2	1.8	7.2	20.4
Kutahya	96	22.7	1	64	31	10.4	0.9	20.3	0.7	10.8	12.9
Usak	93	35.1	2	87	4	10.8	0.1	8.5	1.4	2.8	16.6
Valley	100	17.0	46	33	21	15.0	6.7	15.8	1.7	7.3	10.6
Hillside	101	22.5	10	66	25	13.9	0.6	16.2	1.2	8.4	13.5
Mountain	84	42.4	12	68	4	6.9	0.02	9.5	4.7	24.0	

Table 2. Household characteristics by percentage production sold

Household Sales*	# of households	Total land (Ha)**	Total wheat land (Ha)	Total irrigated land (Ha)	% Land in modern varieties	% Land in traditional varieties	Home bread (% Hhlds)	Market distance (Km)	Extension visit (%)	Off farm income (%)
		7.4	2.7	2.1				18.1		
0	91	(10.1)	(2.1)	(1.6)	9.1	90.9	98.9	(7.3)	19.8	36.3
		10.8	5.4	4.3				18.4		
0<S<25	34	(10.7)	(4.3)	(4.4)	13.2	86.8	97.1	(7.5)	23.5	35.3
		13.4	8.3	5.8				15.9		
26<S<50	49	(13.3)	(7.9)	(6.6)	34.6	65.4	87.0	(7.8)	36.7	12.2
		13.9	10.4	5.5				15.7		
51<S<75	51	(10.0)	(13.0)	(5.8)	43.8	56.2	74.0	(8.4)	19.6	31.4
		17.4	11.9	4.2				14.8		
76<S<99	60	(16.2)	(15.5)	(5.6)	63.0	37.0	80.7	(8.2)	43.3	11.7
		14.7	3.5	0.8				12.8		
1	4	(10.9)	(4.4)	(1.2)	75.0	25.0	75.0	(9.9)	50.0	25.0

* S = % of wheat production sold
** (SD)

ter of all output sold. Moreover, only half of the total production of traditional varieties is sold compared to the much higher percentage observed for modern varieties. Local sales within the village make up only 9 percent of traditional variety sales, suggesting that local transactions occur after consumption needs are met rather than as a regular or formal market activity. Twelve percent (12.4%) of traditional variety sales are transacted with the TMO and will be taken out of the community with relative certainty. Merchant sales usually take place within the county or surrounding counties; however, the percentage of this wheat that will remain in the local community for potential variety-specific purchase is unclear. It appears that if the consumption attributes of a variety are important to the farm household, on-farm cultivation is the best solution to guarantee availability.

Cultivation of traditional varieties also takes place in order to ensure a continuous seed supply for the future. A market for traditional seed has been difficult to identify. Survey questions soliciting information on the purchase or loan of seed revealed that very few households participate in a seed market. Only 35 percent of the sample purchased wheat seed, while even fewer (11%) borrowed seed. Sixteen percent (16%) reported selling seed. Much of this limited activity took place among neighbors or otherwise within the village, and the overwhelming majority of transactions reported involved modern varieties. Our conclusion is that the market for traditional varieties is small and inadequate to satisfy a demand for either seed or grain of these varieties. Farmers who wish to plant or consume traditional wheat varieties must, therefore, produce them in their own fields.

Table 3. Location of sales by variety type

Variety type	# Hhlds cultivating variety type	# Hhlds with sales	% Sales of total wheat production	% Sales of total variety production	Location sold		
					Local (%)	Merchant (%)	Not local (%)
Modern varieties	136	108	76.3	74.3	1.5	24.4	73.3
Traditional varieties	221	127	23.7	46.7	5.8	65.3	28.0

As a result of accumulated experience in cultivating traditional and possibly improved varieties, farm households associate specific varieties with certain attributes and select their own varieties. These attributes include such characteristics as yield, resistance, and quality for bread making and storage. The total value of the variety's benefits to the household consists of the implicit value assigned to these attributes by the household. To illustrate a simplified case, if a household participating in market transactions chooses a variety over another solely for its improved yield attribute, the value of the attribute could be represented by the value of its incremental contribution to yield. The actual situation, however, is usually more complicated, since variety choice based on only one attribute is unlikely given the presence of multiple household objectives. The interaction among the various attributes is thus likely to play an important role.

Many variety characteristics also remain quite difficult to value. Households with less certain access to irrigation will be relatively more concerned with a variety's capacity for drought resistance. Capacity for drought resistance can be partially linked to yield performance, but it is unlikely that this linkage will capture the full value of the attribute to the household. Households that bake bread at home will likely place more emphasis on the bread quality attributes of wheat and cultivate varieties associated with baking quality, taste, and the storability of bread.

Qualitative evidence has primarily formulated the basis for attributing a higher value for many of these characteristics to traditional varieties than improved varieties. An examination of household rankings of specific attributes on a scale from 1 (best quality) to 5 (worst quality) from the Turkish survey data sheds additional light on the association of these characteristics with individual varieties. Households ranked each variety cultivated with respect to taste, bread quality, milling quality, yield, disease resistance, and drought resistance. These characteristics reflect important considerations for the household in both production and consumption. Table 4 presents the average scores of the five characteristics among all households for both traditional and modern varieties. In general, yield attributes are ranked higher for modern varieties while traditional varieties are ranked higher in terms of taste and baking quality. Traditional varieties also appear to be associated with better drought resistance attributes.

Seventy-one households in our sample provided rankings on both types of varieties. These households show no marked differences relative to other households in the sample with respect to age and education of household head, number of household members, or total land in wheat. They tend to have more plots, to be closer to markets, and less inclined to bake bread at home than households growing either only traditional or only modern varieties. Quality rankings given by these households are presented in Table 5. The attribute rankings for the households cultivating both modern and traditional varieties that are presented in Table 5 exhibit a similar overall pattern for the attributes as other households (Table 4). Nevertheless, a comparison between Tables 4 and 5 shows that the contrast between traditional and modern varieties sharpens, especially in the ratings for yield, drought resistance and disease resistance.

Households also responded to a survey question regarding their reasons for discarding a previously cultivated variety. These responses provide additional information on the relative importance of variety attributes to households. Table 6 presents information both on all households that have given up the cultivation of a traditional variety and on the subset of these households that currently grow at least one modern variety. Yield-related responses are the most frequently given. Reasons related to quality decrease sharply between the sample of all responding households and the subsample of households currently cultivating modern varieties. These results suggest that quality issues become relatively unimportant for the households that give up traditional varieties. Table 7 presents reasons provided by households that have given up the cultivation of modern varieties. Again, responses differ between the set of all households

Table 4. Variety attributes by household type

Household type	Attribute*					
	N	Yield	Drought resistance	Disease resistance	Baking quality	Taste
All households	352	2.13 (0.87)	2.24 (1.07)	1.86 (0.87)	1.93 (0.87)	1.86 (0.78)
Household cultivating Modern varieties	133	1.73 (0.67)	2.72 (1.02)	1.97 (0.81)	2.22 (0.92)	2.15 (0.81)
Households cultivating Trad. varieties	219	2.37 (0.89)	1.95 (1.00)	1.79 (0.90)	1.75 (0.79)	1.69 (0.72)

* 1 = best quality; 5 = worst quality

Table 5. Attribute rankings for households growing both variety types

Variety type	Attribute*					
	N	Yield	Drought resistance	Disease resistance	Baking quality	Taste
Modern varieties	71	1.65 (0.61)	2.78 (0.89)	2.17 (0.88)	2.35 (0.96)	2.29 (0.88)
Traditional varieties	71	2.71 (0.85)	1.71 (0.82)	1.74 (0.93)	1.96 (0.89)	1.76 (0.78)

* 1 = best quality; 5 = worst quality

responding to the question and the subset of households which continue to cultivate at least one traditional variety. Yield remains the most important reason for both groups, but slightly different motivations are likely to be relevant for these households as compared with households that give yield as their primary reason for discarding a traditional variety. In the case where a modern variety was abandoned, it is more likely that the yield response reflects a failure to attain expected yield whereas a traditional variety might be abandoned in the quest for a significantly higher yield. In addition, the percentage of households listing quality and drought resistance as reasons to give up modern varieties increases when examining the subsample of households that continue to grow traditional varieties. These results further suggest the influence of both consumption demand and environmental constraints in variety choice and the advantages of consumption quality and adaptability to climatic hardships associated with landraces.

What can information from the farm household's perspective on the relative importance of different attributes of landraces tell us about the effective design and implementation of *in situ* conservation policies? If the significant factors influencing variety selection decisions and landrace and characteristic valuation are identified, they can be used to target those households that give highest value to the attributes embodied in landraces. These households are the most likely ones to carry on the cultivation of landraces and, consequently, the least costly to incorporate into a conservation program. The suggested methodology to identify participating households links the probability of a household's cultivating a certain variety or variety type (e.g. traditional or modern) with the household's costs of production and profitability. Particularly in light of the difficulties in estimating the total benefits to society from landrace conservation, approaching the problem from the cost perspective provides a frame of reference for the magnitude of expenditures necessary to implement an *in situ* conservation policy for landraces. The potential costs of such a program will depend largely on the factors related to the scope of the program, such as the number of landraces targeted, the size of the area targeted, and the number of households determined appropriate to ensure an adequate level of security for landrace conservation.

Table 6. Reasons given to end cultivation of traditional varieties

All Hhlds responding (N = 163/285)			Hhlds cultivating modern varieties (N = 88/118)		
Reason	N	Percent	Reason	N	Percent
Yield	124	38.8	Yield	78	38.8
Cold susceptibility	38	11.9	Cold susceptibility	20	10.0
Production-related	27	8.4	Production-related	16	8.0
Quality problems	26	8.1	Quality problems	6	3.0
Drought susceptibility	24	7.5	Drought susceptibility	20	10.0
Lodging	23	7.2	Lodging	21	10.4
Other	18	5.6	Other	14	7.0
Seed availability	16	5.0	Seed availability	10	5.0
Marketing problems	12	3.8	Marketing problems	9	4.5
Disease susceptibility	5	1.6	Disease susceptibility	1	0.5
Price	4	1.3	Price	4	2.0
Climate adaptability	2	0.6	Climate adaptability	1	0.5
Soil adaptability	1	0.3	Soil adaptability	1	0.5
Total responses	320	100	Total responses	201	100

Table 7. Reasons given to end cultivation of modern varieties

All Hhlds responding (N = 100/285)			Hhlds cultivating traditional varieties (N = 54/217)		
Reason	N	Percent	Reason	N	Percent
Yield	43	25.4	Yield	22	25.9
Drought susceptibility	26	15.4	Drought susceptibility	19	22.4
Production-related	20	11.8	Production-related	7	8.2
Quality problems	14	8.3	Quality problems	10	11.8
Disease susceptibility	13	7.7	Disease susceptibility	1	1.2
Seed availability	12	7.1	Seed availability	3	3.5
Cold susceptibility	10	5.9	Cold susceptibility	10	11.8
Price	10	5.9	Price	3	3.5
Other	9	5.3	Other	4	4.7
Lodging	4	2.4	Lodging	1	1.2
Climate adaptability	4	2.4	Climate adaptability	4	4.7
Soil adaptability	4	2.4	Soil adaptability	1	1.2
Marketing problems	0	0	Marketing problems	0	0
Total responses	169	100	Total responses	85	100

The costs of on-farm conservation

As long as some farmers continue to select landraces for cultivation, thus continuing the *de facto* on-site conservation that we currently observe, it is possible that the establishment of a formal *in situ* program may not be necessary. However, if the continued cultivation of landraces appears uncertain and if on-site maintenance of a specific target level of diversity becomes a policy objective, then a method that elicits landrace value to the farm household, whether using formal valuation techniques or knowledge of relative attribute importance, could provide crucial information to estimate the cost of policies to guarantee the existence of the landraces in the future.

One potential estimate of the cost of *in situ* conservation is the amount of funding necessary to ensure that an adequate number of farms in key farming systems continue to maintain local resources and knowledge. An accurate specification of the cost is difficult due to a number of uncertainties about social and biological status and trends of farming systems and about prerequisites for maintaining crop evolutionary systems in some semblance of natural or historic order. It is important to remember that the goal of *in situ* conservation is not to preserve a given number of alleles or genotypes (i.e. diversity *per se*) but to maintain an agricultural system which generates CGRs in a manner similar to the historic system. The lower bounds of such a program are not known and are probably both crop and regionally specific. An objective of *in situ* conservation programs should be to locate sites to represent a sample of the general ecogeographic zones of the crop in its center of origin. The Turkish research reported here is an example of this conservation oriented research.

Two types of data are particularly important for estimating the cost of *in situ* conservation, one biological and one social. The biological data are the minimum size, composition and distribution of landrace populations which are needed to maintain the crops' evolutionary system in a site. In Turkey's Western Transitional Zone, where our research was conducted, the loss and conservation of wheat landraces varies among the three provinces sampled, three ecological zones (valley, hillside, mountain), and by farm-level conditions (irrigation, soils), as shown in Table 1. The number of farms involved in on-farm conservation depends on the degree of diversity that is found within different levels (e.g. farms, villages, micro-regions, etc.) as opposed to between these levels. The number of farms necessary to support *in situ* conservation may be relatively small if most of the diversity at a location is found at the single farm level.

The social data necessary for estimating the cost of *in situ* conservation concern the comparative disadvantage faced by a farmer who selects landraces as opposed to modern varieties, other crops or other economic pursuits. For the households that choose to cultivate them, landraces satisfy an often complex set of objectives. Yield is certainly a primary consideration, but it is only one of several. Analysis of yields of the modern and traditional wheat varieties cultivated in this region with environmental quality and input use held constant shows that traditional varieties are actually quite competitive with modern varieties (Zanatta et al., 1996). Bellon (1996) describes five concerns that are met by infraspecific diversity within a crop – environmental heterogeneity, pests and pathogens, risk management, and culture and ritual, and diet. Our Turkish study confirms the importance of infraspecific diversity in meeting these concerns, albeit expressed differently for the crop and location of our study. These concerns can be satisfied in other ways, for instance by purchased inputs (e.g. irrigation, fertilizer, pesticides), but markets in peasant agricultural systems are often unreliable or too costly to change household production strategies (de Janvry et al. 1991). The conclusion from Bellon's and other research (Brush 1995), confirmed in our Turkish study, is that landraces occupy specific niches in peasant economies and that these niches are difficult to close altogether.

In many centers of crop diversity, such as Turkey and Mexico, the present cost of *in situ* conservation is nil, because farmers are practicing on-farm conservation in a *de facto* way. In Turkey, wheat landraces are still present in at least eight of the nine major ecogeographic regions, with Thrace being a reported exception (Dalrymple 1986). This *de facto* conservation can be eliminated by driving the area planted in landraces to zero, but this possibility depends partially on the efficacy of investment to create viable substitutions for households which now rely on landraces as well as changes in household perceptions of the landraces. Investments include crop breeding for the marginal areas where landraces persist, improving the physical infrastructure, such as irrigation availability, for agriculture, and improving the market infrastructure to lower the transaction costs of market access. The possibility that households might switch out of staple crops or exit from agriculture altogether also exists.

We view scenarios for the complete replacement of landraces as unlikely. Currently, many of the farmers who grow landraces are bypassed by crop improvement programs, largely because they till small parcels for home consumption in marginal agro-climatic zones. This farm sector is not unreachable, but the costs of reaching it are beyond the capacity of most national agricultural research programs in countries with important genetic resources. At an aggregate level, public investment historically favors prime production zones rather than marginal ones, and the costs are relatively high for upgrading physical and market infrastructures in physically and culturally heterogeneous areas.

The sum of aggregate and local factors favors the conservation of landraces as much as the pressures against them favor their replacement. The balance between keeping landraces and not keeping them may be a matter of relatively small advantages rather than the apparently overwhelming advantage which yields of modern varieties seem to offer. Thus, a relatively small investment in conserving landraces may suffice to maintain their advantage in a particular farming system. The cost of *in situ* conservation can be expressed as the cost necessary to raise the comparative advantage of landraces above that of competing varieties, crops or off-farm activities. The cost may be a subsidy to one agricultural sector (producers of landraces in selected regions) but it need not be a direct payment to farmers. Alternative methods, such as developing markets for landraces, developing seed savers exchanges, participatory breeding programs (Eyzaguirre & Iwanaga 1996) and educational campaigns are arguably more effective for meeting conservation and agricultural development goals.

Conclusion

Ecologists have long pondered the paradox of biological diversity; that is, the reasons for which numerous species are able to persist in the same habitat. As Tilman and Pacala (1993) note, multiple species inevitably arise in situations where two or more environmental factors constrain fitness and where unavoidable trade-offs exist in the ways in which organisms respond to constraints. Our research on wheat landrace selection in Turkey suggests that farming systems do not differ markedly from natural ecosystems. Turkish farmers face numerous environmental factors which constrain the fitness of a single wheat variety (e.g. soil heterogeneity, water availability, altitude), and they seem to face unavoidable trade-offs as they select for a particular trait (e.g. yield, risk, taste). Because the household landuse decision is a result of a complex interaction factors at several levels, (plot, household, region, nation), the outlook for the continued cultivation of traditional varieties in the face of changing policies is difficult to determine, nevertheless we suggest it is a positive outlook. Turkey's wheat breeding programs might be specifically re-targeted toward marginal lands to alter expected yields and variances for low quality plots, but these improvements may not be enough to outweigh disadvantages in the market for certain households or the relative inability of other households to diversify risk by alternative means. Similarly, efforts focused specifically on improving market integration may have uncertain consequences on landrace cultivation if limitations on soil quality remain unchanged.

Landraces continue to have private value for cultivators, and thus they are maintained in many places in the world. Landraces also have social value as sources of crop genetic resources. Cultivation of landraces perpetuates local knowledge about crops and crop production, and this knowledge has served as an important resource for breeders and agricultural scientists in the formal sector. While much of the diversity of landraces is reportedly captured in *ex situ* collections, their continued cultivation, selection, and exchange by peasants is a source of new diversity. Moreover, peasant cultivation of landraces creates a reserve for the recollection of crop genetic resources, should there be a failure in the *ex situ* system. Finally, peasant farming systems with landraces constitute crop evolutionary laboratories for agricultural science. Investing in on-farm conservation to maintain the comparative advantage of landraces in selected areas is a way to merge the private value of landraces with their social value. Peasants now subsidize crop genetic resource conservation by their continued selection and cultivation of landraces. How long and how extensive this practice will continue is unknown. We have a window of time to develop an understanding of crop ecology and its social dynamics, to anticipate a possible time when it is no longer advantageous to produce landraces, and to devise methods to increase the private value of landraces.

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