Conservation of Food Crop Genetic Resources in Latin America

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ABSTRACT
The conservation of the earth's biodiversity emerged as one of the most prominent issues of the 1980s. Spurred in part by unprecedented deforestation in the Amazon Basin, which is believed to be the most diverse genetic reservoir in the world, concern over the loss of thousands of lifeforms annually centered on both economic and philosophical issues. The former included the possible loss of plants with as yet unstudied industrial, agricultural, and medicinal uses while the latter emphasized that, once a species becomes extinct, we have lost forever an irreplaceable part of our earthly selves.

Recognizing that genetic erosion of human food crops has accelerated, owing to both the loss of habitats of wild relatives and to the gradual decline of traditional agriculture, efforts continued during the 1980s to collect and conserve food crop germplasm. These efforts centered primarily on the *ex-situ* storage of foodcrop cultivars at International Agricultural Research Centers, three of the most active of which are in Latin America. Geographic contributions to the activities of these centers in the 1980s were limited but significant (Bebbington and Carney 1990).

While few would dispute the value of *ex-situ* crop germplasm storage efforts, many Latin Americanist geographers believe that increased emphasis should be placed on developing strategies to strengthen *in-situ* food crop conservation. These scholars believe that because *in-situ* conservation permits the on-going natural evolution of new varieties capable of withstanding environmental stress, a renewed commitment to strengthening traditional agriculture is warranted. Proponents of this position suggest that Latin American peasant farmers should be viewed by commercial agricultural interests as partners, rather than obstacles, in both the conservation of the earth's genetic food crop resources and in the economic development which the conservation efforts sustain.

The loss of the earth's biodiversity emerged as one of the most pressing concerns of the 1980s among academics and development planners alike. Taken in its broadest sense, biodiversity refers to the total number of life forms, both plant and animal, that exist on the earth or within a specific region or area. So incredibly intricate and diverse is the earth's biosphere, and so limited have been our efforts to identify and study its members, that estimates of the total number of life forms range from four to thirty billion (E. Wilson 1989, 1984; Wilson and Peter 1988; May 1988; Office of Technology Assessment 1987; Norton 1987; Oldfield 1984; Wolf 1985).

As a general rule, the warmer and wetter the environment of a given area, the greater the biodiversity is likely to be. Two of the most genetically diverse biomes on earth are the coral reefs found in warm, shallow tropical waters and the tropical rain forests (Johannes and Hatcher 1986; IUCN/UNEP 1988). Scholars estimate that over half of all life forms found on the planet today are associated with the tropical rain forests which are especially rich in flowering plant and insect life (Campbell and Hammond 1989; International Task Force 1985). An area of special concern to researchers alarmed by the loss of the earth's biodiversity has been the Amazon Basin which, during the 1980s, experienced rain forest deforestation at an annual rate equivalent to an area approximately the size of Belgium (Hecht and Cockburn 1989; Hecht 1982; Gradwohl and Greenberg 1988; Moran 1983; World Resources Institute 1985; Colinvaux 1987; Gentry 1988). By the end of the decade, it was estimated that tropical deforestation and other forms of habitat destruction were resulting in the loss each year of 4,000-6,000 species for the earth as a whole (E. Wilson 1989).

THE VALUE OF BIOLOGICAL DIVERSITY

Representatives of economic interests whose clients have reaped vast short-term profits from the exploitation of the raw materials obtained from destroyed habitats have asserted that concern for the earth's biodiversity is unjustified in light of the relatively small proportion of life forms that have been lost and the need to provide raw materials for ever more populous and affluent societies. Advocates of preserving the earth's life forms have countered these claims with arguments that efforts to perpetuate biodiversity are necessary for three reasons. The first is the ethical issue that each and every form of life on earth is unique and irreplaceable and that once one becomes extinct, its loss represents ultimately a loss of a small portion of our common earthly heritage -- in a sense, a loss of part of ourselves.

Secondly, it has been noted that less than one percent of all tropical rain forest plants have been studied for their potential medicinal uses. The magnitude of the potential loss of medicinal substances implied therein becomes evident when we learn that, of the 3,000 plant species known to contain anticancer properties, 2,100 are indigenous to the tropical rain forests (Daily 1988; Kricher 1989). In addition to risking the loss of an incalculable number of medicinal cures and treatments, the loss of the earth's biodiversity has the potential to hamper severely the future development of improved fuels, fibers, and industrial compounds (Reichert 1982).

The third argument in favor of preserving the earth's biodiversity is its present and potential value to human food supplies. Research on the utilization of food crop genetic resources undertaken by geographers and related scientists during the 1980s centered on: 1) the use of wild genetic resources for food (Prescott-Allen and Prescott-Allen 1983); 2) new uses of underutilized food crops (Popenoe and King et al. 1989; Tudge 1988, Vietmeyer 1986; Clement and Mora-Urpí 1987; Russell and Felker 1987); 3) contributions of traditional food crops to the utilization of environmentally harsh and/or fragile lands (Browder 1989); and 4) the use of genetic resources with resistance to specific disease and insect attacks (Chang 1984; Plucknett and Smith 1986; Hawkes 1983).

INTERSPECIFIC AND INTRASPECIFIC DIVERSITY IN TROPICAL AGRICULTURE

The utilization and enhancement by small-scale tropical agriculturists of the earth's food crop genetic resources occurs in two distinct, yet often concurrent, forms. That which is most visually obvious is the perpetuation by small farmers of interspecific diversity through the simultaneous cultivation of multiple species of crops in shared space. Students of tropical agriculture frequently refer to this practice as intercropping or polyculture and studies of its varied manifestations in Latin America abounded in the 1980s, often under the rubric of farming or cropping systems analysis. A pioneering study was that of Innis (1980) and equally useful contributions were made by Denevan (1984), Denevan and Padoch (1988), Denevan et al. (1984), Wilken (1987), Padoch et al. (1985), Gomez-Pompa (1987), Hiraoka (1989, 1986, 1985), Altiere (1987), Stadel (1986), Eden (1988), Alcorn (1984), National Academy of Sciences (1989), Nicholaides et al. (1985), Sánchez and Benites (1987), Sánchez et al. (1982), Richards (1989), Wolf (1986), Ewell and Poleman (1980), Peters and Neuenschwander (1988), Allan, Knapp and Stadel (1988), Hildebrand (1986), Hildebrand and Poey (1985), Clawson and Crist (1982), Mead and Willey (1980) and Vandermeer (1988).

These studies demonstrated clearly that the interspecific genetic diversity inherent in tropical Latin American polyculture has the potential to increase not only the harvest security of the small farmer but also the total amount of food produced in the course of a year. They also suggested that small-scale polyculture is an environmentally sustainable cropping strategy which, owing to its inherent genetic diversity, requires fewer industrial chemical inputs. Each of these studies also presented evidence, either explicitly or implicitly, that traditional small-scale Latin American farmers are marvelous conservators of *in situ* food crop genetic resources.

Less visually obvious but equally significant to the preservation of the genetic resources of the earth's food crops is the custom of traditional Latin American farmers of cultivating multiple varieties of the same species of food crops within their polycultural plots. This practice, which utilizes the intraspecific genetic resources of human food crops, contributes not only to the conservation of the existing genetic resource base but also to its expansion owing to the ongoing evolution of new cultivars in response to changing physical and cultural environments. While studied less frequently by geographers and related scientists, many of the most significant theoretical studies of food crop genetics in the 1980s centered on the analysis of intraspecific diversity. These included Horst (1989), Zimmerer (1988), Bergman (1980), Brown and Van Bolt (1980), Johannessen (1982), Brush, Carney and Huamán (1981), Turner and Brush (1987), Kaplan (1981), Altiere and Merrick (1987), Johns and Keen (1986) and Clawson (1985, 1987).

The majority of these studies analyzed the classification and utilization of intraspecific food crop varieties by traditional agriculturists who differentiate between varieties on the basis of color, length of growing season, yields, taste, and resistance to environmental stresses such as disease, drought, and cold. By the late 1980s, comparative molecular analysis by agricultural geneticists of intraspecific crop varieties was underway for many of the staple food crops of Latin America (Gepts 1988; Rousi et al. 1989; H. Wilson 1988a and 1988b). These advances hold great promise for the prospect in the coming decade of collaborative research between geographers and geneticists into the correlations between folk and molecular intraspecific classification schemes.(1)

Molecular analysis of intraspecific varieties has the potential also of enabling us to trace crop ancestries far more precisely than ever before and, in so doing, to contribute significantly to our identifying more exact centers of crop domestication and paths of diffusion.(2)

EX SITU VERSUS *IN SITU* CONSERVATION STRATEGIES

As the genetic base of earth's food crops continued to dwindle during the 1980s, two distinct conservation strategies were advocated. The first, called *ex situ* conservation, promoted the collection and storage in germplasm seed banks of as many varieties or cultivars of staple food crops as could be gathered. The foundation of this strategy is the worldwide network of 13 International Agricultural Research Centers (IARCs), three of which -- the International Maize and Wheat Improvement Center (CIMMYT) of Chapingo, Mexico, the International Potato Center (CIP) of Lima, Peru, and the International Center for Tropical Agriculture (CIAT) of Cali, Colombia -- are situated in Latin America. The IARCs are funded by an umbrella organization called the Consultative Group on International Agricultural Research (CGIAR) which received US$217 million in support in 1988 from such organizations as the World Bank, the United Nations Development Programme (UNDP), the Food and Agriculture Organization (FAO) of the United Nations, and the Inter-American Development Bank.

In addition to the three IARCs, there exist in Latin America smaller regional germplasm storage centers including the Tropical Agriculture Center for Research and Teaching (CATIE) at Turrialba, Costa Rica. Recent analyses have identified considerable duplication of holdings within the centers with the result that current revised listings of the number of accessions are generally lower than those previously published (Table 1).

Table 1: *Ex Situ* Germplasm Preservation of Human Food Crops in Latin America

Center/Crop	Number of Accessions	Date	Source
International Maize and Wheat Improvement Center maize (*Zea mays*) wheat (*Triticum* spp)	 10,700 66,931	 1900 1990	 Taba Skovmand
International Potato Center (Lima, Peru) potato (*Solanum* spp) sweet potato (*Ipomoea batatas*)	 4,165 3,212	 1990 1990	 Huamán Huamán
International Center for Tropical Agriculture (Cali, Colombia) common bean (*Phaseolus vulgaris*) other bean species (*Phaseolus* spp)	 35,950 5,111	 1989 1989	 IBPGR IBPGR

cassava (*Manihot esculenta*)	4,600	1989	IBPGR
Tropical Agriculture Center for Research and Teaching (Turrialba, Costa Rica)			
coffee (*Coffea arabica*)	1,218	1990	Villalobos
squash (*Cucurbita* spp)	1,093	1990	Villalobos
common bean (*Phaseolus vulgaris*)	874	1990	Villalobos
pepper (*Capsicum* spp)	591	1990	Villalobos
chocolate (*Theobroma cacao*)	540	1990	Villalobos
tomato (*Lycopersicon esculentum*)	259	1990	Villalobos
grain amaranth (*Amaranthus* spp)	236	1990	Villalobos

Proponents of ***ex situ*** germplasm conservation generally assume that traditional agriculture either cannot or should not be saved and that the last hope of humankind to preserve the genetic diversity of tropical food crops is to collect and store as many varieties as possible in IARC facilities where they can be used as needed in the future as breeding materials for the development of hybrid strains (Smith 1987; Plucknett and Smith 1982, 1986; Plucknett 1983; Plucknett et al. 1987; Hayami and Ruttan 1985; Brown 1983; Brown et al. 1984; Fishbeck 1981; Pray and Echeverria 1988; Frankel 1981; Compton 1989). The generally negative perceptions of small-scale Latin American agriculturists shared by many advocates of the *ex situ* conservation strategy are often founded on the presumption that hybrid monoculture is more productive than traditional polyculture and therefore promotes the socioeconomic development of the Latin American peoples.

The second strategy, *in situ* conservation, advocates both the setting aside of sizeable tracts of land as biological and/or cultural reserves and the strengthening of traditional agriculture itself. Implicit in the latter is the recognition that, as valuable as seed banks might be as repositories of the plant resources upon which modern genetic engineering techniques are based, these techniques will continue, at least in the short term, to be limited to single-gene modifications of existing species whereas multi-gene evolution of new varieties is an ongoing occurrence both within the wild relatives of food crops and within traditional farming systems themselves (Reid and Miller 1989; Brush 1989). Not only do seed banks represent a "freezing" of the development of new varieties and cultivars but they are also poorly suited to the long term preservation of recalcitrant seed and vegetatively propagated crops, including Latin America's principal tuber crops. Furthermore, IARC collections consist almost exclusively of the most widely consumed crops with little, if any, effort being made to store varieties of lesser used foods. Most advocates of *in situ* conservation programs thus believe that *ex situ* seed banks are useful as germplasm storage centers but should never be viewed as a panacea to the genetic erosion of food crops, which can be minimized most effectively only through a combination of *in situ* and *ex situ* approaches.

CONCLUSIONS AND RECOMMENDATIONS

As we look to the decade of the 1990s, three great challenges will face us in our attempts to stem the loss of biodiversity of Latin America's food crops. The most basic and perhaps the most difficult challenge will be to overcome the deeply-rooted adversarial attitudes between proponents of *ex situ* and *in situ* conservation strategies and to publicize the need to recognize the mutual interdependence of the two philosophies. Given the likelihood of continuing habitat losses in the 1990s, *in situ* advocates should acknowledge the value of the seed bank storage programs. *Ex situ* advocates should also recognize, however, that the IARCs are not adequate substitutes either for the ongoing genetic evolution occurring in nature or for the knowledge embodied in traditional cropping systems. They should further realize that the long-term integrity of the commercial agricultural interests served by the IARCs is ultimately dependent upon the genetic vigor of traditional agriculture, the practitioners of which should be viewed as full partners in the development process.

The second great challenge of the 1990s will thus be to devise successful strategies to preserve traditional agriculture. Various suggestions to date have included paying peasant farmers to not cut the tropical rain forests (Crosson and Rosenberg 1989), expanding cultural and biological reserves (Herlihy 1986 and 1989; Janzen 1986; Place 1988; Gregg and McGean 1985; Terborgh and Winter 1983), paying peasant farmers to cultivate endangered varieties and cultivars (Reid and Miller 1989), and selectively incorporating traditional crop varieties into new, improved cropping systems (Altiere, Anderson and Merrick 1987). Each of these approaches has arguable flaws yet each may work under certain specific settings in time and space. Additional strategies will likely be needed for the 1990s.

The third and final challenge will be to continue and even accelerate our efforts to collect and study the utilization of traditional food crop varieties. We should remember in doing so that the value of these cultivars lies not only in their genetic composition but in the niches they occupy within the polycultural cropping systems of which they are a part.

Notes

1. At the time of this writing, a pioneering study by Quiros et al. had appeared in the 1990 volume of *Economic Botany* comparing the biochemical and folk assessments of the variability of Andean cultivated potatoes. The study suggested that the genetic diversity of traditional agriculture may be even greater than indicated through folk classification schemes.

2. A useful collection of such studies appeared in 1990 as a special supplemental issue to the third number of volume 44 of *Economic Botany*.

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