Conservation of Plant Genetic Resources

In this section we examine two basic strategies for conserving genetic resources, three principal tools policymakers can use to support these strategies, and several multilateral agreements by which countries currently seek to coordinate international use of these tools. Decisions about these alternatives may affect U.S. access to genetic resources that are currently held outside the United States (and vice versa).

Basic Conservation Strategies

At the most basic level, genetic resources can be conserved either *in situ* (in their natural setting) or *ex situ* (outside their natural setting). *In situ* is the dominant method of conserving natural ecosystems. Crop genetic resources are commonly held *ex situ*, but they can also be held *in situ*—as wild relatives of cultivated varieties on wild land and as cultivated varieties in farmers' fields. Among the decisions policymakers face is the appropriate balance between *in situ* and *ex situ* conservation efforts. Each has its own benefits and drawbacks; the two are perhaps better viewed as complementary rather than as substitutes (table 1).

Table 1—Advantages and disadvantages of *ex situ* versus *in situ* conservation

***Ex situ* conservation**		***In situ* conservation**	
Advantages	**Disadvantages**	**Advantages**	**Disadvantages**
Costs generally centralized	Certain types of germplasm not readily conserved	Genetic resources used to produce valuable product	Costs borne by farmers (for landraces)
Can preserve large amounts of diverse germplasm	Regeneration can be costly, time-consuming	Evolutionary processes continue	May reduce on-farm productivity
Germplasm can be readily accessed by more breeders	Potential for genetic "drift" can reduce integrity of collection	May better meet the needs of certain farmers	Requires land
High-security storage impervious to most natural disasters.	In practice, many collections lack the resources needed to organize, document, and maintain their samples.	More efficient for some germplasm, e.g., animals, or crops that reproduce vegetatively.	Farmer selections may not preserve targeted diversity
		Existing wild relatives can be preserved without collection	Loss of wild relatives when land use changes

In situ conservation

Species preserved *in situ* remain in their natural habitat. Most of the world's genetic diversity is found *in situ*. For agriculturally important species, the greatest diversity in landraces and in wild relatives is typically found near where they were first domesticated. Early in the twentieth century, Russian botanist N. I. Vavilov defined "centers of origin" for most crops. These included Mexico and Central America (for corn, or maize as it is known in the rest of the world, and upland cotton); China (for soybeans); and West Asia (for wheat and alfalfa).

Since Vavilov's time, ideas about centers of origin have been refined. Some crops, such as sorghum, sugarcane, and peanuts, were probably domesticated over very broad areas rather than in a well defined center (Harlan, 1971, 1992). Furthermore, useful landraces of some crops have been found in parts of the world other than those in which they were originally domesticated. For example, wheat landraces found in the pedigrees of many modern wheat varieties have come from every continent except Antarctica (Smale and McBride, 1996).[11] Still, *in situ* preservation efforts, as well as germplasm collection activities for *ex situ* conservation, are often focused most closely in and around centers of origin (fig. 3).

Figure 3
Centers of origin of selected crops

Note: The pointer locations indicate general regions where crops are believed to have first been domesticated. In some cases, the center of origin is uncertain. Other geographic regions also harbor important genetic diversity for these crops.

Source: This map was developed by the General Accounting Office using data provided by the National Plant Germplasm System's Plant Exchange Office.

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[11] In another example, modern corn hybrids adapted to the Midwestern United States were derived from dent varieties from the Southeastern United States and flint varieties from the Northeast, which were themselves adapted by settler farmers from many locally distinct varieties selected and reselected by Native American farmers over many previous generations (Duvick, 1998)

Because *in situ* conservation of agricultural genetic resources is carried out within the ecosystems of farmers' fields or wild lands, species continue to evolve with changing environmental conditions. *In situ* conservation thus can provide valuable knowledge about a species' development and evolutionary processes, as well as how species interact. By allowing genetic resources to act as part of larger ecosystems, *in situ* conservation may also provide indirect ecological benefits, such as hosting diverse pollinators. However, since restrictions on land use may be necessary, *in situ* conservation can be costly. To conserve agricultural genetic diversity *in situ*, for example, a farmer may have to forgo the opportunity to grow a higher yielding (and more profitable) variety. Or, in the case of wild *in situ* resources, the land may need to be set aside from agricultural production or other production-related uses completely. This suggests one important constraint on *in situ* conservation that has been addressed in our discussion of habitat loss—the divergence between the social and private returns to conserving genetic diversity.

Ex situ conservation

The *ex situ* method removes genetic material from its environment for long-term conservation (table 1). Botanical gardens and gene banks are examples of *ex situ* conservation strategies. Certain methods of *ex situ* conservation can be used to store large amounts of genetic material at relatively low cost, certainly in terms of land needed, compared with *in situ* strategies. The world's gene banks presently hold more than four million accessions, or specific samples of crop varieties. It is estimated that samples of many of the world's cereal landraces are now held in gene banks (Plucknett et al., 1987). Although very few important crop species originated in what is now the United States, the U.S. national gene bank system (the National Plant Germplasm System, or NPGS) is today one of the largest *ex situ* collections in the world. *Ex situ* conservation also is appealing because it allows plant breeders easier access to genetic resources than is provided by *in situ* conservation.

However, crop genetic resources first must be collected, and samples of only a small fraction of the world's plant genetic resources have been collected thus far. Stored plant materials must be kept under controlled conditions, and periodically regenerated (planted and grown) in order to maintain seed viability. Not all kinds of plant genetic resources are easily conserved *ex situ*. Some lose their varietal identity when stored as seed. These plants may need to be kept as living plants, a more costly process that requires additional land and labor. And gene banks in politically unstable areas may be in danger of losing valuable genetic material. Even in stable locations, the resources necessary to maintain or improve plant gene banks are not always forthcoming because of competing demands for public resources (GAO, 1997).

Policy Tools To Promote Genetic Resource Conservation

Three major types of policy tools are available to support conservation of genetic resources: (1) public investment in *in situ* and *ex situ* conservation; (2) stronger intellectual property rights over genetic inventions, particularly in developing countries; and (3) material transfer agreements.

Public funding of ex situ and in situ conservation

Funding conservation is the most direct method of preserving crop genetic resources. Past efforts have convinced plant breeders that the current germplasm stock, if properly maintained, is adequate to maintain steady yield growth over the next 20 to 50 years (Shands, 1994; Sperling, 1994; Siebeck, 1994). There is growing concern, however, that this may not be sustainable in the long term at current funding levels (Keystone Center, 1991; NRC, 1993; OTA, 1987; FAO, 1996b). Studies of gene banks worldwide (FAO, 1996a), the U.S. National Plant Germplasm System (GAO, 1997), and the Vavilov Institute collection in the former Soviet Union (Zohrabian, 1995) conclude that most gene banks lack sufficient funds, facilities, and staff to maintain their germplasm collections.[12] Funding problems arise, in part, because individual nations do not capture the full benefits of investments in genetic resource conservation. While multilateral funding of international crop research facilities has been used to alleviate this problem, free rider problems suggest that funding for international facilities will remain less than optimal.

The UN Food and Agriculture Organization (FAO) reported on the most pervasive problems facing gene banks worldwide (FAO, 1996a). First, since 1970, more emphasis has been placed on collecting materials, than maintaining accessions, and most gene banks lack adequate long term storage facilities. Even accessions in suitable long term storage cannot be maintained indefinitely; collected material must be grown out or “regenerated” periodically. Many gene banks lack the funds, facilities, or staff to carry out needed regenerations. Second, while gene bank coverage of elite and landrace varieties of major cereal crops is believed to be fairly complete, coverage of many “minor” crops (such as root crops, fruits, and vegetables) and wild relatives remains spotty. Third, only a small fraction of accessions has been characterized. This lack of information about what actually resides in these collections constrains breeders from using new genetic materials (NRC, 1993) and makes it difficult to identify gaps in collections. Fourth, many countries have reported that funding has been unstable and uncertain year to year, hampering investment and planning decisions. The FAO (1996c) concluded that “without prompt and significant intervention, much of the stored genetic diversity of food and agricultural crops in the world-as well as the large public investment made in assembling the collections-will be lost forever.”[13]

The same public goods problem that inhibits optimal international investment in *ex situ* conservation of genetic resources-the inability of conserving nations to capture all the benefits from that conservation-also hinders optimal investment in *in situ* conservation. Moreover, *in situ* conservation is subject to several additional constraints. First, uncertainty surrounding the likely magnitudes of the benefits of in situ conservation is probably larger than it is for *ex situ* conservation. Second, the number of economic agents and levels involved in any *in situ* conservation effort (including landowners and/or individuals with rights to use the land) is likely to be considerably larger than for *ex situ* programs, making coordination of *in situ* programs more difficult.

[12] After the breakup of the Soviet Union, the Vavilov Institute, one of the largest collections in the world, has faced critical financial and structural problems. Funding for gene banks in Russia and in these republics has been greatly reduced and many accessions are at risk (Zohrabian, 1995; Webster, 2003).

[13] A GAO study of the U.S. Plant Germplasm System echoed the concerns of the FAO report (GAO, 1997).

In situ conservation of wild relatives and landraces require different strategies. Establishing habitat reserves could protect wild relatives. Turkey, for example, has received multilateral funding for an *in situ* pilot project to conserve wild relatives of wheat and barley (FAO, 1996b). For landraces, if farmers have private incentives to maintain local varieties, policy interventions for *in situ* conservation may be unnecessary. In areas where displacement of local varieties is more likely, access to modern varieties need not be completely prohibited. A less costly alternative might be to establish some type of conservation easement, paying local farmers the difference between returns to modern and local varieties if they grow a diverse set of varieties on part of their plots (Christensen, 1987). Yet another approach could be to purchase limited amounts of landrace seed from producers in regions with diversity

Most experts agree that *in situ* and *ex situ* conservation strategies are complementary, however the best allocation of resources is subject to debate. Plant breeders are concerned that increased investment in *in situ* conservation will compromise gene bank maintenance. Lack of data on the relative costs and benefits of *in situ* and *ex situ* conservation increases the difficulty of allocating funds across activities. Moreover, donor institutions, particularly at the national level, face competing needs, some of which offer more direct and immediate benefits.

Intellectual property rights

Adoption of stronger intellectual property rights (IPR) regimes has been one of the most commonly proposed methods to enhance genetic resource conservation internationally. Proponents argue that stronger IPR will allow the holders of genetic resources to reap the rewards from commercializing these resources and thus align private incentives more closely with public incentives for genetic resource conservation.

Historically, the set of IPR used for genetic resources internationally focused on the products of formal plant breeding programs rather than wild relatives and landraces. Even while varieties developed by breeders were protected by formal “plant breeders’ rights”, wild relatives and landraces continued to be considered a public good. For decades, many plant breeders have freely exchanged “raw” germplasm (Kronstad, 1996; Heisey et al., 2001).[14] National plant breeding programs and international agricultural research centers freely provide such unshielded genetic materials not only to other public breeding institutions but also to private breeders (many of them in developed countries) who may then use those materials to develop new commercial crop varieties for sale (Day, 1997).[15]

This asymmetry has proven controversial. Many developing countries and nongovernmental organizations (NGOs) make the case for “farmers’ rights,” arguing that farmers in developing countries have selected and saved landraces for thousands of years, making an essential contribution to plant breeding and crop variety development (Mooney, 1979, 1983; Brush, 1992). It is unfair, they argue, that private breeders have free use of wild relatives and landraces but require payment for elite varieties based, in part, on germplasm that originated in developing countries. Others counter that the exchange of genetic material for plant breeding has been beneficial to devel-

[14] Goodman and Castillo-Gonzalez (1991) also note that “improved breeding lines have been less freely exchanged, even among public agencies.”

[15] Unshielded genetic materials also contain improved varieties; in fact, improved breeding materials are the type of germplasm most frequently distributed by the U.S. National Plant Germplasm System. While public research institutions are the primary source of germplasm placed in the NPGS, private breeding concerns donate materials as well, particularly obsolete breeding materials.

oped and developing countries alike, although they disagree about whether foregone earnings from sales of raw genetic material by lower-income countries are compensated for by other benefits, such as unrestricted access to public germplasm and lower food prices for consumers (Shands and Stoner, 1997; Fowler, 1991).

Proponents of stronger IPR regimes argue that, generally speaking, they encourage commercialization of genetic resources, thus enhancing the incentives for conservation, both *in situ* and *ex situ*. They also maintain that greater IPR stimulate private sector research, relieve public budgetary constraints, and increase national incentives for germplasm conservation (Barton and Siebeck, 1991). Critics counter that stronger IPR would do little to increase innovation or maintain crop genetic diversity, arguing that private incentives favor specialization and product uniformity rather than diversity in the production of new seed varieties (Mooney, 1979, 1983; Acharya, 1991; Reid, 1992; Brush, 1994).

These arguments raise two empirical questions. First, what impact would stronger IPR protection have on germplasm use and exchange? A survey of 84 private plant breeding firms by Pray et al. (1993) assessed the impacts of a 1985 decision by the U.S. Supreme Court that strengthened genetic resource IPR (for modern varieties) by allowing plant breeders to acquire utility patents for new varieties.[16] More than a third of the firms felt that utility patents limited germplasm exchange both between private firms and between the public sector and private firms. Six of 84 firms reported that they had increased their research expenditures because of the availability of utility patent protection. Most reported that utility patents increased profitability. Rejesus et al. (1996) surveyed wheat breeders internationally, and reported that respondents believed that stronger international IPR for plant varieties would reduce germplasm exchange between developed and developing countries, reduce exchange between developing countries and reduce the use of foreign landraces. Pray (1990) noted that stronger IPR in developing countries would entail significant enforcement costs and other transaction costs. The effect of IPR targeted toward land races and wild relatives remains unknown.

Second, what are the implications of stronger IPR and increased private R&D for the diversity of new varieties developed? Some evidence suggests that the diversity of major crops has not declined in the United States as increasingly strong IPR protections have been enacted over the last 30 years, and diversity may have actually increased for some crops (Duvick, 1984; NRC, 1993; Smale and McBride, 1996; Falck Zepeda and Traxler, 1997; Pray and Knudson, 1994; Knudson, 1998). But the role of IPR is confounded by other efforts to increase crop genetic diversity (see NRC, 1993, pp. 67-81, for discussion on the impacts of its 1972 report “Genetic Vulnerability of Major Crops”).

Material Transfer Agreements

Material transfer agreements (MTAs) are legal instruments initially used as a means for transferring biological materials between entities, including public institutions, private companies, and countries. Initially, used for research only, MTAs may be bilateral agreements or may follow a standard

[16] Utility patents are the broadest class of patents and, unlike plant patents, they can be used for sexually reproducing plants.

template (such agreements are often used by public entities). The provider retains commercial rights to the material. MTAs have become a common instrument to outline the terms for sharing genetic resources and, sometimes, the gains from new product development. MTAs may include provisions for intellectual property rights, such as what, if any, IPR may be sought for the transferred material or inventions based on that material. However, not all MTAs address IPR and even if they do, IPR usually are just one element of the agreement.

Interest in using MTAs as an incentive to preserve germplasm stems from the idea that benefit sharing can reward suppliers of genetic resources (Barton and Christensen, 1988; Blum, 1993; Christensen, 1987; Simpson and Sedjo, 1992; U.S. Department of State, 1994; WRI, 1993). The benefits to be shared may include funds, materials, training, technology, or intellectual property rights (through provisions concerning their allocation).

The potential for benefit sharing MTAs to affect crop genetic resource conservation is unclear. Plant breeders of major crops use germplasm mainly from their own working collections, or acquire it from other breeders, botanists, or geneticists. Typically, this germplasm has already been enhanced and adapted for plant breeding purposes. While exotic germplasm may provide especially useful traits for disease or pest resistance, such germplasm is only one source of the many genes used in an individual variety. Statistics suggest that, for many commercially important crops, only a small percentage of the genes in released varieties are from newly incorporated exotic germplasm (Cox et al., 1988; Goodman and Castillo-Gonzalez, 1991). The expected value of such exotic germplasm is generally small, though on occasion benefits may be larger (Wilkes, 1991). When breeders do require genetic traits unavailable from their conventional sources, gene banks such as the Future Harvest Centers or the NPGS traditionally have had a vast, free supply of germplasm. To date, this germplasm has been provided freely to users, and not subject to MTAs that require benefit sharing. The use of MTAs to market germplasm from some developing countries may also be hindered by a lack of technical expertise. Breeders often require documentation of valuable genetic traits and the ease by which they can be transferred to commercial seed stock. Even if a country has rare and useful germplasm, breeders may remain unaware of its value or existence (Shands, 1994).

To date, the use of MTAs for crop genetic resources has not generated large financial gains for developing countries. In this respect, raw genetic resources, though lacking a well-developed market, are similar to primary export commodities such as timber or coffee. Much of the value added to commercial seed varieties comes from the laborious and time-consuming process of incorporating raw genetic material into elite crop varieties.

Multilateral Agreements Affecting Plant Genetic Resources

Because of the widespread geographic origins and current use of crop genetic resources and the public goods nature of their conservation, the three principal policy tools for conserving genetic resources involve considerable international overlap. A series of multilateral agreements embody the international coordination needed to preserve genetic resources, as well as the lingering debate over property rights for genetic resources.

U.N. Convention on Biological Diversity

The 1993 U.N. Convention on Biological Diversity (CBD) was designed to promote the conservation and sustainable use of biological diversity and to encourage the equitable sharing of resulting benefits. Language in the Convention relating to property rights over genetic materials, biological inventions, technology transfer, and benefit sharing was drafted more with pharmaceutical and industrial development in mind than seed variety development, though subsequent meetings to implement the Convention focused on agricultural biodiversity. On December 29, 1993, the CBD came into force for ratifying and acceding parties (which numbered 188 as of February 15, 2005).[17] Provisions of the Convention have direct implications for the collection, preservation, and exchange of genetic resources. The CBD states that countries have sovereign rights to their indigenous genetic resources, which institutionalizes the change from the practice of freely collecting and sharing of resources. Most countries have interpreted the CBD to allow countries to require payments or transfer of technology in exchange for access to germplasm. The Convention also included a provision for a biosafety protocol to regulate the international movement of the products of biotechnology. Adopted in January 2000, the “Cartagena Protocol” addresses only living modified organisms (LMOs), and makes a distinction between genetically modified organisms as seed and genetically modified organisms intended for food or feed (the assumption being that the latter will not be released into the environment). According to the protocol, LMOs (which include genetically modified seed) are subject to “Advanced Informed Agreement” procedures. Thus, implementation of the protocol has more impact on LMOs that are transferred as seed, or as germplasm for use in genebank system, than on food or feed.

Other agreements play a role. The World Trade Organization (WTO) agreements, which are negotiated, signed, and ratified by the bulk of the world’s trading nations, are enforceable through the WTO’s ability to levy sanctions. Therefore, countries have strong incentives for the CBD to be consistent with the Trade Related International Property (TRIPS) provisions and the WTO. The International Union for the Protection of New Varieties of Plants (UPOV) is another element affecting the exchange of genetic resources. UPOV-consistent IPR are the leading form of formal varietal protection globally (UPOV protection allows exemptions for breeding and research purposes). After the CBD came into force, the U.S. Department of State (1994) noted that the Convention could not be used to overrule existing intellectual property law, including TRIPS and UPOV. Therefore, both are likely to continue influencing implementation of the CBD.

The International Treaty on Plant Genetic Resources for Food and Agriculture

To address issues left unresolved by the CBD, the International Treaty on Plant Genetic Resources for Food and Agriculture was developed with the intention of (1) mandating conservation of plant genetic resources, (2) ensuring equitable sharing of the benefits created by using these resources, and (3) establishing a multilateral system to facilitate access. The

[17] The United States signed the Convention in June 1993, but the U.S. Senate has not yet ratified it

International Treaty entered into force in June 2004 (the U.S. has signed, but not yet ratified the treaty). Sixty-six countries are parties to the treaty. The treaty is to govern international exchange of germplasm and will cover 35 crops, including major cereals like rice, wheat, and maize, but excluding soybean and peanut and other important crops.

IPR have been a major source of debate in interpreting the treaty, particularly the patenting of materials discovered in public gene banks. The treaty states that "Recipients shall not claim any intellectual property or other rights that limit the facilitated access to the plant genetic resources for food and agriculture, [or their genetic parts or components,] [in the form] received from the Multilateral System." Interpretations of this clause abound, particularly with respect to whether the patenting of isolated compounds, such as genes, will be permitted.

The treaty is vague on a number of points. Disagreements remain about the implementation of benefit sharing and the development of a standard Material Transfer Agreement (MTA). The standard MTA is intended to establish the terms of access to plant genetic resources, and all germplasm exchanges under the new multilateral system will be governed by this standard MTA (rather than the bilateral approach suggested by the CBD). The benefits arising from commercial use of germplasm accessed under the multilateral system are to be shared through four mechanisms: (1) exchange of information, (2) access to and transfer of technology, (3) capacity building, and (4) sharing of monetary and other benefits of commercialization. A yet-to-be established portion of monetary benefits from commercial products are to flow, through a trust account managed by the Governing Body of the Treaty, primarily to farmers who conserve genetic resources, especially those in developing and transitional economies.[18] Because benefits will be shared according to conservation practices and income, rather than contributions to the multilateral system, the incentives for conserving genetic resources are likely to be less direct than originally envisioned. More broadly, the means and particulars of financing conservation activities also have not been specified.

Financing International Conservation of Genetic Resources

Given the public good characteristics of crop genetic resources, financing their conservation remains a challenge. Resources available under current and immediately foreseeable policies may be insufficient to conserve the resources agriculture will need. Though MTAs and the expansion of IPR are intended to be self supporting conservation policies, proposals to intensify *in situ* and *ex situ* conservation and to transfer technology and expertise would require additional public funds. Various efforts have been made to estimate actual amounts needed to finance gene banks, *in situ* preservation, and technology transfer. The Keystone International Dialogue (Keystone Center, 1990, 1991) recommended a fund of $300 million annually to support global and national efforts to conserve plant genetic resources. The U.S. National Research Council (1993) recommended that $240 million would be needed annually for maintaining worldwide base collections in addition to evaluation and documentation programs. The FAO (1997) estimated low (A), medium (B), and high (C) funding options ranging from

[18] Other aspects of the MTAs, such as recordkeeping and means of assigning parentage of a variety, have yet to be worked out in detail.

$150 million to $248 million to $455 million annually, averaged over more than ten years. The FAO figures include only costs that would be borne by the international community and do not include domestic program funding. The report considered Option A “basic or rudimentary” while Option B was “consistent with known and documented needs and realistic absorption and implementation capacity of countries” (FAO, 1997).

Grounded in the FAO’s Global Plan of Action for genetic resources is a relatively new organization focused more directly on *ex situ* genetic resource preservation. The Global Crop Diversity Trust is an international organization whose establishment has involved a partnership with the FAO and the 16 Future Harvest Centers of the Consultative Group on International Agricultural Research (CGIAR). The Trust aims to match the long-term nature of conservation needs with permanent, sustainable funding by creating an endowment that will perennially fund crop diversity collections around the world. The endowment is intended to facilitate the perpetual conservation of eligible collections that meet agreed standards of management. The Trust will serve as an element of the funding strategy to be implemented under the International Treaty described above.

The Global Crop Diversity Trust hopes to raise a minimum of $260 million from corporations, trusts, foundations, and governments as a permanent endowment for genetic resources. That figure is based on a study carried out by the International Food Policy Research Institute and the University of California, Berkeley, which provided best estimates of the annual funds needed to support the core services provided by the Future Harvest genebanks and the level of endowment needed to provide for the collections in perpetuity (Koo et al., 2002). (The annual costs were estimated to be $5.7 million, and the needed endowment was estimated to be $150 million). The Trust has approximately $45 million in commitments and $70 million under discussion to date (Global Crop Diversity Trust, 2005).

Some researchers have looked at methods beyond multilateral donor systems to fund conservation of genetic resources. Proposals have included a tax on seed sales to provide funds for conservation (Barton and Christensen, 1988). Barton and Christensen suggested either a “straight” sales tax on seed revenues or a system of royalty calculation similar to that used by record companies, with proceeds to be distributed among international, national, and private conservation programs to fund *in situ* and *ex situ* preservation. There are concerns that a royalty based system of direct payments may limit the exchange of genetic resources. Also, if royalty payments in the strict sense are used (i.e., payment upon use in a released variety), returns probably will be limited (Charles, 2001). Proposals to fund germplasm through sales taxes and user fees have been opposed by private seed companies. Even if the proposals were to overcome this opposition, formal seed sales are much less prevalent in self-pollinated crops and in some crops grown in developing countries. Thus, certain crops would not benefit as significantly from this approach.

Another proposal has been to tax agricultural commodities generally (Swaminathan, 1996). This proposal raises questions about the distributional implications (between regions and social classes within regions) of taxing seeds or all agricultural commodities. Because poor families generally spend more on food as a portion of the household budgets, such taxes may be regressive (though to raise equal revenues, the tax rate for a general commodity tax on agricultural, forest, and fish products would need to be only a small fraction of the tax rate for seeds). Another option lies with agricultural producer groups in developed countries (such as Australia, New Zealand, and the United States), many of which fund commodity specific research and market promotion through voluntary checkoff systems that act as a commodity tax. However, while national producer groups may be persuaded to help support domestic gene banks and germplasm characterization, they may be less willing to allocate checkoff funds to an internationally administered fund. As with other aspects of genetic resource use and conservation, private interests do not necessarily coincide with broader public goods.