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Journal of Law and Economics, Vol. 35, No. 1. (Apr., 1992), pp. 199-213.

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Journal of Law and Economics is currently published by The University of Chicago Press.

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PROPERTY RIGHTS, GENETIC RESOURCES, AND BIOTECHNOLOGICAL CHANGE*

ROGER A. SEDJO
Resources for the Future

IT is well recognized that wild genetic resources—the genetic constitutions of plants and animals¹—have substantial social and economic value as repositories of genetic information. Today, genetic information provides direct and indirect inputs into plant-breeding programs, the development of natural products including drugs and pharmaceuticals, and increasingly sophisticated applications of biotechnology.² Recognition of the potential of wild genetic resources in the development of drugs has led the National Cancer Institute to initiate a massive plant collection project,³ which is a follow-up to an earlier 1970s project that sought to identify drugs effective against a variety of cancers and to look at the immune system effects of various drugs. It is estimated that 70 percent of the 3,000 species known to have anticancer properties are found in the tropical forests.⁴ In recent years, a number of widely used drugs have been developed from plants, including two important anticancer drugs derived from the rosy periwinkle found in tropical Madagascar. With the recent major breakthroughs in biotechnology, the future potential of these resources seems limitless. Species that have no current commercial application, have useful natural chemicals, or are as yet undiscovered never-

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¹ Office of Technology Assessment (OTA), *Technologies to Maintain Biological Diversity* (1987).

² Margery L. Oldfield, *The Value of Conserving Genetic Resources* (1984); and Christine Prescott-Allen & Robert Prescott-Allen, *The First Resource* 529 (1986).

³ Matthew Suffness & John Douros, *Current Status of the NCI Plant and Animal Product Program*, 45 *J. Natural Products* 1 (1982).

⁴ National Academy of Sciences, *Ecological Aspects of Development in the Humid Tropics* (1982).

theless may have substantial value someday as a repository of genetic information with important commercial applications.

Despite the acknowledged social values, tropical deforestation and other forms of habitat destruction are widespread and generally believed to be generating significant extinction of genetic resources.⁵ Species with potentially very useful characteristics that might be transferred through future biotechnological innovations may be lost. Third World countries with large areas of tropical forest have received considerable criticism for not properly appreciating the values of their native forests—particularly the values of biological diversity—and protecting those forests accordingly.

This article is organized as follows. I will discuss wild genetic resources and their uses, particularly in the context of biotechnological change, and demonstrate that genetic resources have elements of both private and public goods. I will briefly examine some contemporary conflicts involving the protection and distribution of genetic-resource rents. I argue that the lack of property rights associated with the public good aspect of genetic resources contributes to the current rates of tropical deforestation and habitat destruction, which are excessively high by economic-efficiency criteria. I will examine mechanisms that may provide either de jure or de facto property rights to genetic resources, particularly as bioengineering raises the benefits and reduces the cost of property rights to genetic resources. Last, I will draw some conclusions about the property-rights mechanism that appears to be most effective for natural and wild genetic resources.

I. GENETIC RESOURCES AS PUBLIC AND PRIVATE GOODS

Genetic resources have elements of both private and public goods. Fisher treats genetic resources as a store of knowledge, while Brown and Swierzbinski approach the problem as a variation of the research and development (R&D) problem and treat R&D as “an economic proxy for species.”⁶ Phenotypes (individual plants and animals) are subject to rivalry in consumption: each person’s consumption reduces the amount available for others by the amount consumed. Thus, by definition, phenotypes are private goods. Genotypes (the information embodied in the

⁵ E. O. Wilson, *The Current State of Biological Diversity*, in *Biodiversity 3* (E. O. Wilson ed. 1988).

⁶ Anthony C. Fisher, *Key Aspects of Species Extinction: Habitat Loss and Overexploitation*, in *Environmental Resources and Applied Welfare Economics: Essays in Honor of John V. Krutilla 59* (V. Kerry Smith ed. 1988); and Gardner M. Brown, Jr., & Joseph Swierzbinski, *Optimal Genetic Resources in the Context of Asymmetric Public Goods*, in *Environmental Resources and Applied Welfare Economics: Essays in Honor of John V. Krutilla 91* (V. Kerry Smith ed. 1988).

genetic constitutions of plant and animal species), however, exhibit non-rivalry—in the sense that one person's consumption does not affect the amount available to others. Genotypes, therefore, conform to the definition of a public good. Both genotypes and phenotypes can possess exclusivity: that is, the ability to exclude consumption from some individuals while allowing access to others. This is currently the case for the provision of various property rights to improved and engineered plants and animals.

A wild plant (or animal) has three types of possible human uses.⁷ First, it can either be consumed directly or be a direct source of natural chemicals and compounds. These may either be consumed directly or be inputs in the production of "natural" drugs and other "natural" products. Second, natural chemicals often provide information and ideas about unique ways to develop useful synthetic chemicals and compounds.⁸ Finally, the wild plant (or animal) may be the source of a gene or set of genes with desired genetic traits. For example, germ plasm from wild species is used to maintain the vitality of many of our most important domesticated crops. The first type is used consumptively, and the wild plant can be viewed as a private good. The latter two utilizations, however, are essentially nonconsumptive and employ the genotype as a source of information.

The ability of modern biotechnology to transfer genes to and from unrelated natural organisms makes possible the development of a wide variety of engineered plants and animals with hitherto unattainable sets of traits. As biotechnology develops, the scope for utilization of genetic resource information embodied in wild plants and animals will surely increase. Although there may be a high degree of redundancy in the global gene pool and improved techniques are likely to obtain more information about a single cell of a species, our ability to utilize the information from different organisms is also likely to increase as our genetic engineering expertise grows. The returns to maintaining a rich and diverse biosystem are likely to be large since technology and natural genetic information may well be complements in production.

II. CONTEMPORARY CONFLICTS INVOLVING GENETIC RESOURCES

Serious conflicts involving genetic resources exist in a number of arenas today. The first is essentially a conflict over the distribution of rents

⁷ Norman R. Farnsworth, *Screening Plants for New Medicines*, in *Biodiversity* 83 (E. O. Wilson ed. 1988).

⁸ Aspirin, an early synthesized drug, modified the natural chemical, salicylic acid, which was too strong to be taken orally. Exclusive rights to the synthesis process gave Bayer an extensive period to exploit those rights.

generated by genetic resources and associated product development. It deals largely, but not exclusively, with the international exchange of seeds and food plants. Common-property plant genetic resources have conventionally included primitive cultivars, land races, and wild and weedy relatives of crop plants.⁹ This situation has generated a conflict between the "gene poor" but "technology rich" North and the "gene rich" but "technology poor" South. Historically, natural plant germ plasm (seed) has been exchanged freely between countries in accordance with the ideal that this "common heritage of mankind" should be available without restriction. The 1983 *International Undertaking on Plant Genetic Resources*,¹⁰ however, extends the concept of "common heritage" in plant genetic resources beyond its conventional usage to embrace special genetic stocks, including elite and current breeders' lines and mutates.¹¹ This extension of the application of "common heritage" is, not surprisingly, unacceptable to nations with highly developed seed industries investing in breeding proprietary crop varieties.

The second conflict is an extension of the seed dispute into the area of other wild genetic resources and rights to products such as pharmaceuticals and natural pesticides that can be derived from wild plant and animal genetic resources.¹² The vegetative cover of the earth constitutes the residence of wild genetic resources. In some cases, the biodiversity of an area may be modest, and the geographic range of the various species wide. In other cases, the biodiversity of a region may be great, but its geographic distribution narrow.

If preservation were costless, then all genetic resources would be preserved. In earlier periods of human existence, preservation of genetic resources was essentially costless, and all could be maintained. As the pressures on the habitat rise due to alternative uses, however, the costs of protection and preservation also rise. Two approaches—in situ and ex situ—have been used to protect these acknowledged values. In situ

⁹ Roger A. Sedjo, Property Rights and the Protection of Plant Genetic Resources, in *Seeds and Sovereignty: The Use and Control of Plant Genetic Resources* 293 (Jack R. Kloppenburg, Jr. ed. 1988).

¹⁰ United Nations, Food and Agricultural Organization (FAO), *International Undertaking on Plant Genetic Resources*, Resolution 8/83 (1983).

¹¹ J. R. Kloppenburg, Jr., & Daniel Lee Kleinman, Seeds of Controversy: National Property versus Common Heritage, in *Seeds and Sovereignty: The Use and Control of Plant Genetic Resources* 173 (Jack R. Kloppenburg, Jr. ed. 1988).

¹² Manuel F. Balandrin, James A. Klocke, Eve Syrkin Wurtele, & William Hugh Bolinger, Natural Plant Chemicals: Sources of Industrial and Medicinal Materials, 228 *Science* 1154 (1985); Kloppenburg, *supra* note 11, at 368; and Mark J. Plotkin, The Outlook for New Agricultural and Industrial Products from the Tropics, in *Biodiversity* 106 (E. O. Wilson ed. 1988).

approaches leave the species in their natural habitats, whereas the *ex situ* approach involves permanent collections such as zoos, botanical gardens, and germ plasm banks (where seeds and other genetic material are preserved in a controlled environment). Although the *ex situ* approach has the advantage of lower costs, it is feasible for only a small fraction of species; this, obviously, cannot be used for species as yet unknown.¹³ Furthermore, *ex situ* approaches preserve selected species, not ecosystems, and thus risk the longer-term losses of species that are reliant on the symbiotic relationships within the ecosystem.

Although the destruction of a unique genetic resource base can occur from the consumptive use of a particular plant itself, in practice a much more ominous threat comes from changes in land use. Land-use changes that destroy existing habitats and individual phenotypes can inadvertently drive to extinction potentially valuable genotypes (many as yet undiscovered) that are endemic to certain ecological niches. Furthermore, having no unique claim to the returns of the genetic information embodied in the wild plants, individuals and countries engaged in developing the land resource will tend to ignore the potential economic value of the existing habitat as a repository for potentially valuable genetic resources. The destruction of genetic resources becomes an unintended consequence, an externality, of habitat-destroying land-use changes, and the costs of investing in protection and preservation can become substantial.

In this context, the industrial world argues that wild genetic resources are global resources and that the development of better lines of food grains, new medicinal products, and so forth, generate global benefits that accrue to inhabitants of all countries. A landowner—public or private—whose land provides the habitat for a unique genetic resource, however, has no unique claim to its benefits. By contrast, a company that utilizes a wild genetic resource as input into the development of a useful commercial product protected through a patent-like right often captures substantial financial returns.

One result of the lack of private or national property rights is that almost all efforts directed toward preservation and protection of genetic resources are altruistic, and most proposals for preserving genetic resources involve actions by governments and the international community to preserve habitat.¹⁴ The usual approach is for environmental groups and the governments of industrial countries to persuade Third World governments to protect habitats, such as tropical rain forests, that are

¹³ Winston Harrington & Anthony C. Fisher, *Endangered Species*, in *Current Issues in Natural Resource Policy* (Paul R. Portney ed. 1982).

¹⁴ For example, see OTA, *supra* note 1.

rich in genetic resources. Although this approach has experienced some success with the establishment of various parks and preserves, in many Third World countries there is an indifference to seriously protecting habitat preserves, and often the protection is haphazard at best.

Some progress has been made in maintaining plant genetic resources used for breeding food and feed crops. An international system of germ plasm preservation, commonly called "seed banks" or "germ plasm collections," has been developed. The collections are in both public and private ownership. The private collections are often held by plant breeders who capture rents through the development of improved stock.¹⁵ The system of collections, however, is much less well developed for genetic resources that might have potential for drugs and pharmaceuticals than is the system for crops. In either case, however, collections can preserve only a small fraction of the total genetic resource base.

III. DIFFICULTIES CAPTURING GENETIC RESOURCE RENTS

One can think of wild genetic resources as a lottery containing a vast number of genetic "tickets," each with a different potential payoff. The intertemporal timing and size of the returns vary greatly. Some of these tickets are currently generating payoffs. Others would generate current payoffs if they were discovered and if the social benefits could be captured, that is, if an appropriate set of property rights were in force. Still others await further biotechnological developments before their potential returns can be realized. Although most of the tickets will ultimately provide no payoff in terms of newly available chemicals, compounds, or transferable genes, a few will eventually bring substantial payoffs—or "jackpots"—in the sense that large social values will eventually be generated by these genetic resources. It is difficult, however, to differentiate in advance between those with significant potential future value and those with none. Furthermore, no ownership of these genetic "tickets" exists today.

As shown above, most uses of wild genetic resources can be viewed as a store of knowledge and therefore a public good. Most public goods lend themselves readily to investments by the national state. The state perceives itself as readily capturing the returns to other public goods, such as defense and lighthouses. It is much more difficult, however, for

¹⁵ For example, see Harold J. Bordwin, *The Legal and Political Implications of the International Undertaking on Plant Genetic Resources*, 12 *Ecology L. Q.* 1053 (1985); and Charles F. Murphy, *Institutional Responsibility of the National Plant Germplasm System, in Seeds and Sovereignty: The Use and Control of Plant Genetic Resources* 204 (Jack R. Kloppenburg, Jr. ed. 1988).

the state to capture the returns to genetic resources. There are two reasons for this. First, international law does not recognize property rights to wild species or wild genetic resource genotypes,¹⁶ and, hence, any rents associated with valuable natural genetic resources typically cannot be captured simply through domestic management of the resource. In addition, the tradition that natural genetic resources are the "common heritage of mankind [that] should be available without restriction"¹⁷ provides an obstacle to the introduction of barriers to the unrestricted flow of wild genetic resources out of a country. Since countries have few vehicles for capturing the returns, they have little direct self-interest in preserving wild genetic resources. I will not discuss two examples.

A. *Mexican Maize*

A species of perennial maize (*Zea diploperennis*) was discovered in Mexico in 1977. This species has a number of desired traits, including immunity to two serious viral diseases. Hybrid cultivars should be available to farmers by the early 1990s.¹⁸ Also, although somewhat less of an issue for maize breeders, if the perennial genetic characteristic can be transferred, the growing of maize could be revolutionized worldwide. Whoever successfully introduces these traits into commercial maize will be able to obtain property rights to the improved maize germ plasm (seed) and will be very handsomely compensated via market-generated returns. The world would collectively benefit from a more efficient production of maize; however, only a very negligible portion of such benefits is likely to accrue to Mexico and even then only through benefits associated with imported seed. Under the current system, Mexico has no unique claim on the benefits or revenues generated by improvements to maize, even when they require genetic resources found exclusively in Mexico.

B. *Peruvian Potatoes*

A vast variety of potatoes is found in the Peruvian Andes, reflecting the early cultivation of the potato by the Indians on slopes with huge differences in elevation. Although varieties from this area are tapped regularly to invigorate and improve existing lines, neither Peru nor the Indians receive compensation. Hence, they have little incentive to protect the wide array of genetic diversity found in this natural repository.

¹⁶ John H. Barton, *The International Breeder's Rights System and Crop Plant Innovation*, 216 *Science* 1071 (1982).

¹⁷ FAO, *supra* note 10.

¹⁸ Prescott-Allen & Prescott-Allen, *supra* note 2.

When the traditional Peruvian cropping systems were active, there was little concern over losses of genetic variability. As modern agricultural methods begin to change traditional cropping patterns, however, concern grows over the viability of the genetic base. Again, since wild genetic resources are treated as the common heritage of mankind, landowners in Peru have few incentives to promote continued protection of the genetic diversity.

IV. BIOTECHNOLOGY AND LEGAL RIGHTS TO GENETIC RESOURCES

Natural plant germ plasm has historically been exchanged freely between countries in accordance with the idea that it is the "common heritage of mankind."¹⁹ The legal difficulties associated with gaining rights to wild genetic resources are exacerbated in this country because, although U.S. law does not *explicitly* treat discovery as different from invention, the distinction has always been present in U.S. case law.²⁰ By this criterion, wild genetic resources that are viewed as a discovery would be less likely to receive patent-like protection than would engineered, modified, or improved genetic resources that might be viewed as an "invention." Exclusive rights typically require either the utilization of the wild genetic resource as an input to the development of an improved plant or the development of a patentable unique process for extraction or synthesis. Rents to the wild genetic resource are captured with the returns to innovation that is embodied in the process or product. Plant breeders have traditionally focused attention on hybrids because the parental lines of the hybrid can be guarded and the seeds do not reproduce true to type. It can also be argued that American pharmaceutical producers have concentrated on processes and synthetics since they had no unique rights to natural plants.²¹ Consequently, the current institutional system allows the benefits to wild genetic resources to be captured only through rents to products or process development.

In the area of biotechnology, property rights in the form of patent protection have tended to evolve to accommodate benefit-generating innovations. The U.S. Patent and Trademark Office (PTO) granted what was probably the first patent for a microorganism to Louis Pasteur in 1873, and, by the early twentieth century, patents were granted for bacterial and viral vaccines. Most of the principles of heredity were worked

¹⁹ FAO, *supra* note 10.

²⁰ Friederich-Karl Beier, R. S. Crespi, & Joseph Strass, *Biotechnology and Patent Protection: An International Review* (1985).

²¹ John H. Barton, *Patenting Life*, 264 *Sci. Am.* 40 (1991).

out by 1900 and the Plant Patent Act of 1930 extended (with some exceptions) patent protection to the asexual reproduction of any distinct and new variety of plant.²² By the 1950s, technology had advanced to the stage where a process of breeding superior growth hybrids, which were used to generate superior varieties of crops and animals, had been developed. In 1970, the Plant Variety Protection Act (PVPA) created a vehicle for entrepreneurs to capture a portion of the value generated using plant breeding techniques. Under this act, a novel variety of plant or animal, one that is significantly different from existing varieties in observable ways, can be protected. The owner of a protected variety can exclude others from selling seeds of that variety and can transfer ownership to others. Although the PVPA provides for ownership of improved genetic combinations—that is, the product of the production process of plant breeding—it does not provide ownership of the inputs into this process—that is, knowledge of the genetic composition of wild plants.

A recent decision by an appeals board of the PTO has extended protection within this country to allow patents for genetically engineered plants, seeds, and tissue culture. The rationale is that, since it is now possible to describe a plant with the same specificity as a machine, the difficulties of assigning and enforcing property rights are now dramatically reduced.²³ If this is true for engineered organisms, it must certainly be true for wild organisms.

V. BIOTECHNOLOGY AND THE EVOLUTION OF GENETIC PROPERTY RIGHTS

Two types of mechanisms have been suggested to alleviate the inefficiency caused by an absence of property rights. The first is the evolution of legally established property rights in response to changes in the benefits associated with property rights and the costs of enforcing the rights, as posited by Demsetz.²⁴ Briefly stated, the argument is that, as the benefits of property rights rise and/or the costs of enforcing rights decline, new rights will evolve to take advantage of the changing cost structure. Some analysts have stressed the role of technological change as a prime determinant that can change the benefits and costs.²⁵ The Coase Theorem suggests a second mechanism:²⁶ an inefficient market outcome due to the

²² Beier, Crespi, & Strass, *supra* note 20.

²³ M. Sun, Plants Can Be Patented Now, 230 Science 303 (1985).

²⁴ Harold Demsetz, Toward a Theory of Property Rights, 57 Am. Econ. Rev. 347 (1967).

²⁵ For example, Terry L. Anderson & P. J. Hill, The Evolution of Property Rights: A Study of the American West, 18 J. Law & Econ. 163 (1975).

²⁶ R. H. Coase, The Problem of Social Cost, 4 J. Law & Econ. 1 (1960).

existence of externalities may be “corrected” through negotiation among the affected parties if transactions costs are not prohibitive. In essence, external effects can be internalized through the contracting arrangement. As in the evolving property rights case, changing technology may reduce the net transactions costs. This mechanism will be examined in the next section.

Following Demsetz, the previous section documented the continuing evolution and adaptation of property rights in the form of legal interpretations and administrative rules that accompanied changes in biotechnology. The increased ability to manipulate genes would increase the benefits to property rights, while the ability to precisely define and identify biological organisms would decrease, probably dramatically, the enforcement costs. The evolution in property rights is reflected in the fact that genetically engineered plants or animals now are patentable in the United States, thereby becoming private property.²⁷ A California Court of Appeals’ recent decision extended property rights for genetic resources by ruling that, if research reveals that a patient’s tissues may yield products of commercial value, the donor has a right to compensation.²⁸ This decision appears to extend the concept of property rights to unimproved genetic resources under certain conditions.

This brief historical survey suggests that Demsetz’s hypothesis (that property rights are likely to evolve in response to increased benefits from those rights and reduced enforcement costs) is borne out in a wide variety of new statutes that significantly extend property rights for genetic resources. Furthermore, technological change appears to be the driving force precipitating these changes. The evolution of property rights, however, has been largely but not exclusively in the direction of protecting improved (rather than wild) genetic resources. The distinction between invention and discovery appears to make it unlikely that property rights will be extended to naturally occurring genetic resources in the foreseeable future.

VI. EVOLVING COLLECTION ARRANGEMENTS

The second mechanism that could be utilized in confirming “rights” to the genetic constituents of naturally occurring species is the Coasean

²⁷ These genetically engineered animals are discussed in Malcolm Gladwell, *For Sale: Engineered Mice—Dupont to Offer First Patented Animals*, Wash. Post, November 16, 1988, at A1. It should be noted, however, that the Europeans have continued to deny patent rights for engineered plants and animals.

²⁸ *Moore v. The Regents of the University of California*, 249 Cal. Rptr. 494 (Cal. App. 2 Dist. 1988). The case is discussed in Mark Crawford, *Court Rules Cells are Patient’s Property*, 241 Science 653 (1988).

contract, where contracts can internalize the external effects if transactions costs are sufficiently small. Furthermore, if technology increases the values to natural genetic resources, the incentive to find acceptable contracts "internalizing" these benefits could be expected to increase. When dealing with wild genetic resources, three players are typically involved: (1) the country in which the genetic resource resides, (2) the user or "developer" of commercial products that use genetic resources as an input (for example, pharmaceutical firms), and (3) the collector who actually collects and inventories the plants and who may do some preliminary screening for potential uses (this has the clear practical advantage of not needing *de jure* property rights and hence circumventing the need for international legal agreements).

Collection rights have traditionally been extended gratis by countries in which the unique plant or animal resides. In the past, plants and animals were simply taken by collectors. More recently, countries in which plant collecting occurs have required an inventory of the plants collected and information as to the results of preliminary "screening." In some cases, technical assistance has been provided to the host countries.

Countries with rich endowments of natural genetic resources, however, could and are beginning to use their rights over access to limit or prohibit collecting in the absence of collectors' providing sufficient inducements for joint cooperation.²⁹ Several major tropical countries have restricted or are prohibiting collecting by foreigners. Countries realize that access and collection control to little known but potentially valuable genetic resources can be used to negotiate the capture of a portion of the potential resource rents of those resources.

In recent years, collection agreements have been evolving, presumably to reflect the perception of higher returns associated with capturing the externality. The increased perceived value of genetic resources as inputs into commercial resources is no doubt due in part to the impact of improving biotechnology. These evolving arrangements involve increasing degrees of payment and compensation for collectors and countries in which wild genetic resources reside. In a common arrangement, both public agencies (for example, the National Cancer Institute) and private pharmaceutical firms establish contracts with collectors whereby the collectors provide certain types of natural plants in return for direct payments. Other private firms are also beginning to offer direct payments for collected plants.³⁰ Recently, the newly created National Biodiversity Insti-

²⁹ In concept, private owners of land might restrict collectors in the absence of appropriate agreements as to how to share the receipts from commercial utilization of wild genetic resources. Most tropical forests, however, are effectively owned by the government.

³⁰ For example, Bio-Resource Research Facility, a division of the Office of Arid Land

tute (INBio) of Costa Rica signed an agreement with Merck, a major pharmaceutical firm, whereby Merck will provide the institute with \$1 million over the next two years in return for exclusive rights to screen the collection for useful plant chemicals and extracts. The agreement also provides for INBio to be provided with royalties from any successful commercial applications that result from these chemicals and extracts.³¹ In short, a variety of contractual arrangements have been made that move toward internalizing what had been external benefits. Such arrangements also have the great advantage of allowing for contract dispute litigation in existing courts under existing law.

At one level, the changes discussed above could be viewed as simply redistributive within the context of a zero-sum game; however, efficiency considerations also arise. Countries that can capture some of the rents associated with commercial developments of natural products or wild genetic resources have a positive incentive to invest in habitat preservation. The value of a tropical preserve to the individual or country now includes the actual or potential returns associated with its ability to sell or auction off collection rights and its share of subsequent royalties.³²

VII. SUMMARY AND CONCLUSIONS

Recent developments in biotechnology may substantially enhance the value of unknown wild and natural genetic resources for commercial applications in pharmaceuticals, breeding, and other uses. The absence of property rights for wild genetic resources, however, provides few incentives for habitat protection and causes externality problems that have contributed to the high and economically inefficient rates of tropical deforestation and habitat destruction. In addition, the distributional consequences of current institutional settings raise questions of income distribution and North-South equity. Individual and collective government actions, although sometimes helpful, have not directly addressed the problem.

The literature hypothesizes two alternative mechanisms to improve

Studies at the University of Arizona, has had a number of contracts with a major pharmaceutical firm to provide various types of desert plants found in the United States in return for direct payments. Joseph Hoffman, Assistance Director, Office of Arid Lands Studies, University of Arizona, interview with the author (November 9, 1988).

³¹ Christopher Joyce, Prospectors for Tropical Medicine, *New Scientist*, October 19, 1991.

³² A number of problems associated with the limited assignment of property rights—for example, monopoly implications, assignment of rights to well known natural plants, and so forth—are not addressed in this article. For a discussion of some of these, see Sedjo, *supra* note 9.

the efficiency of resource use in the absence of property rights. The first hypothesis suggests that property rights evolve when there are sufficient increases in the benefits to rights and sufficient reductions in the costs of enforcement to justify the establishment of new rights. Patents and property rights to genetic resources have expanded dramatically over the years as technology development has increased the benefits and reduced costs. This suggests that the first mechanism is in operation. Perhaps because the existing legal precedents make it difficult to establish property rights to "discoveries," as opposed to "inventions," most property rights have evolved in the direction of protecting improved and invented rather than wild and natural genetic resources.

More progress toward establishing rights to wild genetic resources appears to be occurring through the Coasean approach, which postulates that market externalities can be internalized by negotiation and contracts if transactions costs are sufficiently small. Developments in biotechnology that make genotype identification much more precise have reduced transactions costs. Gene-rich countries have begun, de facto, to trade collection rights in return for various types of compensation. Controlling access to areas with rich genetic resources provides a ready mechanism for negotiating compensation to Third World countries in which the genetic resources reside. Although the contracting process is in its fledgling stages, a host of alternative contracting arrangements can be envisaged. There are perhaps more important consequences than income distribution. The contracting mechanism can provide market incentives to supplement the existing altruistic motives for countries to protect unique habitats and biodiversity in which valuable genetic resources may reside. To the extent this progresses, economic efficiency will be enhanced, and, presumably, the rate of habitat destruction reduced.

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²⁶ **The Problem of Social Cost**

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²⁸ **Court Rules Cells are the Patient's Property**

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