THE RELATION OF PATENT LAW AND WILDLIFE CONSERVATION LAW IN THE UNITED STATES

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The existence of U.S. patents issued on inventions made using wildlife specimens presents legal, economic, policy, and resource management questions. The relation of patent law to wildlife conservation law is central to answering these questions.

Patent law is designed to foster technological advancement, and patents are economic instruments intended for market-related activities. Conversely, wildlife conservation law is generally intended to inhibit market forces, to regulate the possession and use of select wildlife populations, and to sustain this public resource.

The existence of U.S. patents on inventions from wildlife reveals a practical connection among market value of innovation, property law, and wildlife resources. Answers to fundamental questions of law and policy this connection raises require an understanding of the relation of patent law to wildlife conservation law. This work analyzes this relationship. The premise of the analysis is that the bodies of patent and wildlife conservation law are orthogonal. That is, these bodies of law are entirely separate and do not interact, except at one critical point: possession of tangible specimens.

The evaluation conducted here confirms that these two bodies of law have evolved in entirely separate domains, are essentially independent, and are mutually non-contingent. They do, however, intersect at the critical point of physical possession

of wildlife specimens. Possession of physical property in wildlife specimens is necessary to make patentable inventions. Furthermore, possession is the critical pivot in governmental control of wildlife under conservation laws. This single-point intersection creates an orthogonal relationship between these bodies of law that has legal and policy implications. For example, at these physical property intersections, wildlife conservation law generally fails to control patent-related market forces. Moreover, valid patent rights may be obtained in spite of violations of wildlife law.

The failure to control the patenting of inventions made through the possession of wildlife specimens produces natural resource policy and management problems, including a market failure in wildlife resource maintenance, a type of tragedy of the commons in the new resource of biotechnological utilities from wildlife, and a failure of the linkage between technological value of wildlife and its sustainable conservation.

BIOGRAPHICAL SKETCH

Richard Stuart Cahoon was born on April 28, 1954, in Salt Lake City, Utah, to Reynolds F. and Margaret M. Cahoon. He spent his boyhood years in Salt Lake City and graduated with his bachelor's degrees from the University of Utah. He married J'Nelle Hathaway in June of 1980 in Salt Lake City. They moved to Bozeman, Montana, where Richard received his master's degree from Montana State University and they had their first child, daughter Lauren, in 1982. Returning to Salt Lake City, they had their second child, daughter Lindsey, in 1986. After living in both Bozeman and Salt Lake City for several years, in 1990 the family moved to Ithaca, New York, where Richard took a position with Cornell University. Their third child, son Lochlan, was born near Ithaca in 1993. Except for final submittal of his doctoral dissertation, Richard completed all requirements for his PhD in Natural Resources at Cornell in 2003.

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1.1 The Fundamental Question

Patents from wildlife present interesting questions and opportunities. Patentable, technical innovations obtained from wild animals, plants, and microbes offer significant social benefits. But they also raise puzzling new questions of natural resource economics, public policy, and law. In this work, examples of wildlife patents that do not benefit wildlife conservation are described and analyzed, as are cases in which such patents are linked to sustainable wildlife use. Contrasting and comparing these case examples provides insight into the answers to some of these questions.

A variety of U.S. patents have been issued recently for inventions made using wildlife (see Table 1.1). The existence of these and other such patents raises a basic and important question: Is there a relation between patent law, which is designed to foster technical advancement, and biological conservation law, which has evolved to manage and maintain the public wildlife resource? If there is a relation, what is its nature, and what are the implications for society's desire for both innovation and wildlife conservation? Does the relation, if any, act to symmetrically or asymmetrically strengthen or weaken either one or both of these bodies of law? And, depending on the effect of the relation on the effectiveness of these laws, what are the implications for fostering invention or wildlife conservation, or both?

This work analyzes the relation of these bodies of law to determine whether they are entirely independent (i.e., parallel), intersecting at multiple points, or intersecting at a single nexus (i.e., orthogonal). This analysis requires three steps: in Chapter 2, an analysis of patent law that focuses on the patentability of biological subject matter; in Chapters 3 and 4, an analysis of wildlife conservation law that emphasizes activities related to invention and patenting; and, in Chapter 5, the identification and characterization of any intersections uncovered by the analytical juxtaposition of these laws.

Table 1.1. Recent U.S. Patents for Inventions from Wildlife Species.

U.S. Patent		Wildlife Species	
Number	Title	Species Name	Common Name
5,968,988	Methods of using Ajoene for treatment of shock	*Bothrops*	viper
5,863,954	Contraceptive method using Ajoene	*Bothrops*	viper
5,744,584	Anithrombosis Agents	*Bothrops*	viper
5,705,198	Test for lupus anticoagulant	*Bothrops*	viper
6,613,324	Adhesive for gluing biological tissues	*Bothrops*	viper
4,731,439	Snake venom growth arresting peptide	*Crotalus atrox*	western diamondback rattlesnake
5,164,196	Crotoxin complex as cytotoxic agent	*Crotalus durissus terrificus*	Cascaval rattlesnake
5,314,899	Epibatidine and derivatives, compositions and methods of treating pain	*Crotalus basilicus basilicus*	Mexican west coast rattlesnake
5,922,587	Phospholipid-dependent prothrombin activator obtained from snake venom	*Pseudonaja textilis*	Australian brown snake
5,260,060	Fibronolytic enzymes	*Agkistrodon contortrix contortrix*	southern copperhead snake
5,951,981	Thrombolytic agents with antithrombotic activity	*Agkistrodon contortrix contortrix*	southern copperhead snake
5,045,462	Basic protein called phospholipase A2 isolated from the venom of a snake of the family elapidae and its amino acid sequence	*Naja mozzambica pullida*	Mozambique red spitting cobra
5,866,160	Composition of soft-shelled turtle and tortoise		turtle
4,677,069	Clam-derived proteinases		clams
5,912,018	Methods for treatment of muscle spasm, edema, and dermatological conditions using epidermal gel secretion from an Arabian Gulf Catfish		Arabian Gulf catfish
5,196,204	Spider toxins and methods for their use as blockers of calcium channels and amino acid receptor function	*Agelenopsis aperta*	spider
4,490,360	Firefly-derived repellent composition and methods of use	*Photinus*	firefly
6,384,026	Macrocyclic polyamine lactones and derivatives thereof and their use as anthropod repellents	*Epilachna varivestris*	squash beetle
4,112,074	Compositions comprising ovomucoid fraction of white of quail's egg	*Coturnix coturnix japonica*	Japanese quail
4,737,510	Bioactive metabolites from the Caribbean Sponge agelas coniferin	*Agelas coniferin*	Caribbean sponge
5,801,020	Antibiotic producing microbe	*Tolypocladium*	fungus
5,395,919	PHA copolymers . . .	*Pseudomonas cepacia*	bacterium
4,814,470	Taxol derivatives [anticancer drug]	*Taxus*	yew tree
5,370,873	Therapeutic compounds	*Azadirachta indica*	neem tree
4,853,213	Use of periwinkle in oral hygiene	*Vinca major*	periwinkle plant

Source: U.S. Patent and Trademark Office Web-based database, available at http://www.uspto.gov/patft/index.html

The characterization in Chapter 5 of the relation of these laws provides the basis for a discussion in Chapter 6 of the implications for the political economy of the wildlife resource. Chapter 7 analyzes two cases that involve patents from wildlife. Ethical issues raised by property in wildlife and patents are considered in Chapter 8, and Chapter 9 provides a summary of the findings and a conclusion.

This analysis requires a basic appreciation for the complex interaction of different types of property rights that arise with patents, land, personal property, and wildlife law. The following hypothetical scenario illustrates a starting point for considering the relation of patents and wildlife: A private landowner in the United States holds title to land on which various species of wildlife are “fixed” (e.g., rooted plants), roam (e.g., locomoting animals), or otherwise reside (e.g., microbes). By common law and traditional practice, this landowner owns all the individuals of the rooted plant species “*Planta hypotheticum*” growing on this land, because the rooted plants are “fixed” to the land (“fixtures” in real estate law). The landowner’s control and ownership of these plants is likely to be diminished if the plants are removed from the land. *Planta hypotheticum* grows nowhere else. A previous owner of the land had given a scientist an unrestricted right to collect whole specimens and parts of *Planta hypotheticum* from those plants rooted on this land and to conduct unrestricted research on this collection. Because of the unrestricted nature of the collector’s rights to possess, the collected parts of hypotheticum have become the personal property of the collector. The scientist exercised this right of ownership through possession prior to the new owner’s possession of the land. While the plants were in his possession, the scientist discovered and (by meeting the requirements of U.S. patent law) obtained a patent on a gene from *Planta hypotheticum*. This gene confers useful traits to crop plants, giving it utility and a certain type of economic value. Because there were no restrictions on the scientist’s possession and use of the collected specimens, and because the landowner is not an inventor of the sequence of the gene, the present landowner has no rights in the patent on the gene. Conversely, regardless of his rights in the patent, the scientist has no rights in the remaining plants on the land. Therefore, if the patent owner needs more plant specimens, he must obtain permission from the owner of the growing plants—the current landowner. The landowner must, in turn, obtain permission from the patent owner in order to make, use, or sell the isolated and patented gene *per se*. This patent does not restrict the landowner from any use of the plants themselves. However, if the previous landowner had, through a contract, placed a restriction on the scientist's use of the plants (e.g., prohibiting commercial use without permission), the situation would be quite different. This scenario would be further complicated if *Planta hypotheticum* were covered by U.S. federal law (e.g., the Endangered Species Act) or if the species were an animal or microbe.

If the species of wildlife is an animal, the scenario is different. In the United States, a landowner does not own the wild animals on his or her land (Bean and Rowland, 1997). Federal and state laws list certain animals that are controlled by government. Depending on the species, the landowner's rights of possession and control of specimens or parts may be superseded by law. If so, the government may have rights in collected specimens or parts conveyed to the scientist-collector and, perhaps, in a patent obtained through possession. If the species is not controlled by government, the distribution of rights in the free-roaming animal and captured specimens and in the patent derived through possession will flow from the first possession and will be similar to the plant scenario above.

Microbes exhibit some characteristics of being fixed to the land (e.g., fungal mycelia) and of being free-roaming (e.g., microbial spores and protozoans). Although state and federal law does not explicitly articulate the status of these biota (Bean and

Rowland, 1997), the Roman legal doctrine of *ratione soli*[1] may provide a basis for establishing property in microbes. However, property in microbes is complicated by the existence of patents on pure microbial cultures. Such patents represent a critical overlap between intellectual property, chattel, and other property-like rights in wildlife.

These complex scenarios are fraught with ambiguity in terrestrial biota property. The dynamic balance of bioproperty rights held by state and federal governments and private landowners further complicates. Wildlife in rivers, lakes, and the sea present a different bioproperty milieu. In particular, the nested sovereignties and overlapping jurisdictions over ocean biota depend on the type of biota, its distance from the coast, and its physical relation to the sea floor and tidal zones, as well as the overlay of international treaties (Bean and Rowland, 1997).

1.2 Research Goal, Strategy, and Scope of Work

The goal of this work is to determine whether the relation of patent and wildlife conservation law in the United States is parallel, intersecting at multiple points, or intersecting at one point (orthogonal).

Evaluating the relation of patents and wildlife conservation law is conducted in four steps: 1) an analysis of U.S. patent law, emphasizing the patentability of biological subject matter; 2) an analysis of the historical evolution of property in wildlife in the United States; 3) an analysis of biological conservation law in the United States, emphasizing control of possession and use for purposes of invention; and 4) an analysis of the intersections of these bodies of law. Results of this evaluation are described in terms of their implications for the political economy of wildlife, and two case studies elucidate the results.

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[1] Ownership "by reason of the soil"; this pertained to ownership of bees via ownership of the land where they nest.

The scope of this research is limited to terrestrial wild (non-domesticated) biota (all non-human organisms, their parts, and by-products) in the United States. International aspects are considered only as they directly impact the United States. For example, international wildlife treaties such as the Convention on International Trade in Endangered Species and the Migratory Bird Treaty Act affect federal wildlife law. Domesticated biota, such as livestock and crops, are viewed only to the extent necessary to understand the biota-property milieu. *Ex situ* collections of wildlife are considered as a unique intersection of property in domesticated and wild organisms.

In the analysis of intellectual property and biological matter, the focus is entirely on patents.

In the sections on federal and state law, a summary of critical portions of relevant federal laws is provided, and an overview of some common themes in state law is described. A detailed analysis of state wildlife law is limited to New York State. In the section on policy analysis, the economic characteristics of biotechnological utilities from wildlife are summarized as a precursor to describing the political economy of this natural resource.

As an epilogue, ethical questions are considered. These questions center on the basis of property in non-human biota and on wildlife as a public good versus a private right. The discussion also includes the ethics of intellectual property generally, patents on biological matter, and the relation of biota property to religious and environmental ethics.

1.3 Background

The age-old relation of society to natural resources is multifaceted. In general, societies are characterized by how they maintain, access, and use natural resources as well as how they resolve issues that arise from these activities. A society's relationship to wildlife (i.e., all non-domesticated organisms, their parts, and by-products) is a case in point. Through law and custom, societies have defined rights to control the possession and use of wildlife.

Implicit in the term “wildlife resource” is the notion that wildlife is useful and/or desirable to humans. For some species, such as salmon and bald eagles, utility and/or desirability are obvious, but for others, they are less so. The exploitation and allocation of wildlife resources has created fundamental social, economic, and political tensions. It is within these tensions that U.S. wildlife conservation law and policy has evolved over several hundred years.

Conversely, there are wildlife that U.S. society neither desires nor wishes to conserve. For example, certain invasive species, animal and plant pests, and pathogens are wildlife, but not a resource. The flipside of laws designed to conserve wildlife species deemed beneficial are laws intended to eradicate and inhibit pathogen, pest, and nuisance species. Various federal and state laws impose the strictest level of governmental control over the possession and use of many species of deleterious organisms, including human and animal pathogens, agricultural pests, and environmental invasives that include viruses, microbes, plants, and animals. Federal and state laws that assert governmental control over undesirable wildlife are widespread, enforced by various agencies, and complicated. They play an important role in the overall picture of property in wildlife. However, this research work focuses only on desirable species and does not analyze undesirables and their controlling laws.

In the midst of traditional uses and control of wildlife, technology has created a “new” natural resource in wildlife. This biotechnologically based resource comprises biological materials such as animal cell lines, proteins and DNA fragments, microbial cultures, and methods, which I collectively call “biotechnological inventions.” Considering the effect of these utilities on the social relation to wildlife raises fundamental questions. These questions are made critical by the combination of the rising economic importance of biotechnology, the technological creation of new tangible and intangible property rights from wildlife, and the apparent decline of biodiversity. The landscape is made even more complicated by the overlay of information derived from wildlife (Parry, 2004). The questions are brought into focus by patents on inventions made by possession and use of wildlife. Although such patents present unique puzzles, the relation of intellectual property and wildlife is a subset of larger questions surrounding the “owning” of wildlife.

Ownership is a complex concept that comprises various components embedded in cultural and social contexts (Becker, 1977). It has been defined as the right to control the possession and disposition of things without interference from others (Grunebaum, 1987). Becker’s (1977) definition is more precise: Ownership is the aggregate holding of a “bundle” of several, distinct property rights. This “bundle of rights” concept of ownership is defined by Honoré (1961) as several fundamental rights in property including the exclusive right to physical possession, the right to use, and a handful of others. Such property rights originate when a society makes a distinction between an owner’s rights and those rights of property that derive solely from simple physical possession (Macpherson, 1978).

Most important, the bundle of rights is separable (at least theoretically), with different rights potentially held by separate entities. For example, the right of possession may be separated from the right to use (i.e., bailments). Conversely, one may hold the right to use but not the right of exclusive possession (i.e., usufruct).

Ownership is often an interdigitation of different rights in the same property held by distinct entities. Rights in the ownership bundle may be strengthened, weakened, or eliminated by the existence of other rights (e.g., human rights supersede property rights; public safety and animal cruelty laws trump use rights).

The concept of ownership is made more complex by the existence of different types of property. The ownership concepts above suggest a private-property right. But public-property rights also have a long history. And other property types, including communal property, are part of the ownership milieu. Even null property must be considered.

Ownership of wildlife is not a new issue. For centuries, the power and/or right to control the possession and use of wildlife has been a significant political and cultural matter (Lund, 1980; Tober, 1981; Bean and Rowland, 1997). The idea of owning wildlife seems oxymoronic: How can something wild be owned? The U.S. Supreme Court has clearly stated that the owning of wildlife is, at most, a legal fiction.[2] But in the same decision, the court also declared government's responsibility to protect, in trust for the people, wildlife legislatively selected for governmental protection. This trustee's obligation yields powers of control that exhibit some characteristics of ownership—the right of exclusive possession, for example. But what of wildlife that is not protected under federal or state law? The long-standing legal doctrine of acquiring private-property right through first possession (Rose, 1985; Dukeminier and Krier, 2000) allows personal property in wildlife to be obtained by various forms of capture.

Creating intellectual property rights in a biotechnological utility from wildlife requires physical possession of a specimen of that biota, and possession is a basic element of ownership. But what underlies the right to possess a wildlife specimen? The ultimate right to control access, possession, and use lies in sovereignty—the essence of the social relation to wildlife. Who has sovereignty over wildlife in the United States? The federal or state governments? Private land owners? Everyone? No one? Understanding sovereignty in wildlife is a necessary prelude to analyzing

[2] Justice O. W. Holmes, in the majority opinion of *Missouri v. Holland*, 25, U.S. 416, 1920.

wildlife property. Once this is clarified, questions of property rights in wildlife naturally follow, including personal property in captured biota specimens and consequent intellectual property.

Wildlife property is fundamental to the balance of socially distributed rights in this natural resource. This is because property is the basic mechanism for the allocation of rights to possess and use, especially with natural resources. To what extent is wildlife a public good rather than a privatizable property? Where is the equilibrium in this public/private resource allocation? Is the equilibrium altered by tangible biotechnological utilities and/or related intellectual property? In practice, how do current wildlife laws affect these natural resource questions?

Under current federal and state law, wildlife property rules variously apply to whole specimens (e.g., free-roaming and caged animals, and carcasses), parts (e.g., skins, flesh, organs), by-products (e.g., wool) and propagules (i.e., eggs and seeds) (Bean and Rowland, 1997). But do they similarly apply to tangible or intangible biotechnological inventions such as *in vitro* cell cultures and patentable information obtained from those cultures?

Issues of property in wildlife are underlain by philosophical questions of owning biota. Is it ethical to own any biota? Does it depend on the kind of biota? On the purpose of ownership? Who should own it? What about owning intellectual property from wildlife? Understanding these questions provides a basis for the social construct of wildlife property in the United States.

The relation between wildlife property and the balance of public good–private right shapes the political economy of wildlife, including the resource created by technology. This work provides a preliminary description of the unique economic character of biotechnological utilities from wildlife and creates a framework for analyzing this political economy. Focused analyses of property in wildlife and the intersection of intellectual property and biological conservation law lead to relevant questions of natural resource economics and political economy. Using this framework, we can evaluate particular legal mechanisms and policy scenarios and explore prescriptions for particular outcomes (for example, optimum technological development and/or conservation of wildlife).

1.3.1 Bioprospecting and the Biodiversity Convention Emphasize Wildlife Property

The development of "bioprospecting" (Eisner, 1990, 1991; Reid, 1993b) set the stage for a new perspective and emphasis on wildlife property and its potential role in technology development and resource management. Bioprospecting illustrates the intersection of wildlife property, technology, economics, and conservation (Farrier and Tucker, 2001). Similarly, the global Biodiversity Convention is implicitly based on the concept of wildlife property.

Bioprospecting is the systematic searching of biota for biotechnological utilities (Farrier and Tucker, 2001; Hamilton, 2004). In this respect, it differs little from the age-old practice of taking organisms from their habitat and using them with little regard for rights of possession, control, or use. However, traditional biota collecting lacks the explicit and legally binding provisions that characterize real bioprospecting arrangements, which establish property in biota and create obligations that link commercial returns to conservation. Unlike simple collecting, bioprospecting formally links the value of inventions from biota to financial obligations for conservation. An explicit allocation of rights in tangible and intangible property in inventions from biota is key to this linkage.

The potential economic value of undiscovered biotechnological utilities from wildlife in intact habitats underlies the bioprospecting rationale. The idea that biotechnological utilities from wildlife are a natural resource and that economic value can be ascribed to potential discoveries in wildlife in their intact ecosystems is not new (Sedjo, 1988, 1992). However, the concept of directly linking the economic value of inventions from wildlife to biological conservation was first described by Eisner (1990). Eisner envisioned a systematic search of wild biodiversity for useful chemicals, the subsequent commercialization of resultant products, and the dedication of a portion of the financial return to biological conservation. Wildlife property issues are embedded in Eisner's concept, although he did not acknowledge this relationship. Later, Reid (1993a) clearly stated the critical role wildlife property plays in bioprospecting.

Eisner's idea stimulated efforts to establish bioprospecting projects. The Merck/INBio arrangement for bioprospecting insects from national park land in Costa Rica was first, and is probably best known (Reid, 1993a); others have followed. The idea of using contracts and business arrangements as an approach to conservation was mentioned in brief by others (Sedjo, 1992), but it was not until the Merck/INBio agreement was finalized that a prototypical bioprospecting mechanism was given form (Reid, 1993a). Most bioprospecting arrangements developed to date involve the searching for and collecting of biological samples in foreign countries, especially those in the tropics. In each case, legally binding contracts integrate and structure the intentions of technology commercialization and conservation (Cahoon, 1994).

The bioprospecting concept has potential as a broadly applicable conservation instrument, but most initial efforts have focused on tropical, developing countries. There have been fewer efforts focused on temperate, developed countries, and discussions of bioprospecting (Reid, 1993a, 1993b) have largely neglected its broader applications. Because bioprospecting involves wildlife sovereignty and property issues and has focused on developing countries, the concept has been enmeshed in debates over the equity of North versus South technology transfer and resource exploitation.

The publicizing of bioprospecting deals and the increased biotechnologically based value of biota have stimulated a great deal of debate, often based on misconceptions and laden with rhetoric. Some believe that the Merck/InBio bioprospecting agreement would result in Merck owning intellectual property on Costa Rican wildlife that will prohibit Costa Rican scientists from further biological research (International Plant Genetics Resources Institute [IPGRI], 1994). Of course, this is wrong, given that wild organisms *per se* (with the exception of pure microbial cultures) are not patentable in any country. But this belief demonstrates a misconception about the relation between property in a wildlife specimen and a patent right. For example, the patentee of a gene sequence from an organism acquires no rights in the living organism by virtue of their patent rights (Bent et al., 1987).

On the other hand, some economists have suggested that effecting biological conservation through economic incentives can be accomplished by allowing the "ready patenting of naturally-occurring organisms" (Swanson, 1992). However, this runs counter to hundreds of years of intellectual property law throughout the world, in which wildlife is considered the common heritage of humanity. Many statements have been made that suggest patents confer an unlimited, worldwide monopoly (Kloppenburg, 1988a; Fowler and Mooney, 1990), when, in fact, patents are territorial (by country) and are limited in duration.

The collapse of some bioprospecting arrangements in developing countries has dampened enthusiasm for the concept (Rosenthal, 2002). But this should not diminish its utility as a conservation instrument—an instrument built on the creative application of wildlife property and the biotechnological properties it produces. Despite the controversies, the bioprospecting concept remains viable. McLaughlin (2003) points out the importance of linking the value of genetic resources to natural resources as well as the need for a new set of rules to govern this "new" natural resource. In particular, he calls for a move away from ownership by rule of capture. Examples of benefits lost through a failure to make the link between wildlife property and patents further confirm the value of bioprospecting (Svarstad, Bugge, and Dhillion, 2000). Regardless of the future of bioprospecting, the concept sheds light on fundamental questions of wildlife property. And, regardless of the viability of bioprospecting, there is a clear question of linkage between wildlife access, intellectual property, and benefit-sharing (Brand and Gorg, 2003) and the underlying importance of property rights (Farrier and Tucker, 2001).

The establishment of the International Convention on Biodiversity ("Biodiversity Convention") is one of the most important events related to wildlife sovereignty and property. The Biodiversity Convention, ratified by over 160 participating countries (but not the United States), provides a global-treaty basis for international cooperation on wildlife sovereignty and property (Coughlin, 1993). Key provisions of the Convention include the following: that biological resources are valuable both in proprietary states (e.g., patents) and in natural states (i.e., wildlife), and that nations will recognize this dual value; that nations may assert sovereignty over all biota (including domesticated and wildlife) within their borders; and that nations will create mechanisms to facilitate the equitable exchange of technology and biological resources between countries. Although the Convention has no enforcement mechanism, it serves as a guide for managing international wildlife property issues.[3]

The impact of the U.S. failure to ratify the Biodiversity Convention is a question. Increasingly, public-sector and private concerns are framing discussions of biological resource conservation and use in terms of wildlife property defined by the Convention (Chandler, 1993). Although some have claimed that bioprospecting arrangements render the Convention superfluous (R. Stone, 1992), this treaty looms

[3] The text of the International Convention on Biodiversity is available at http://www.biodiv.org/convention/convention.shtml.

over the U.S. biotechnology industry as a potentially significant factor (Burk et al., 1993); some question whether U.S. entities will have access to the wildlife of participating countries (Hoyle, 1994).

Some opponents of U.S. ratification of the Convention on Biodiversity have claimed that personal property rights will be abrogated and subsumed under some supra-national body (Margolis, 1994), despite the fact that the United States signed the Convention with the written condition that it would not alter the domestic *status quo* of wildlife sovereignty and property in the United States (Chandler, 1993).

Regardless of the debate over bioprospecting, the fact remains that valuable discoveries have been, and will continue to be, discovered in wild biota. Examples of this situation are implied in the patents described in Table 1.1 and by others (Svarstad et al., 2000).

1.3.2 Related Issues

Much of the international debate over rights in wildlife has focused on the tension between the “biodiversity-poor” but “technology-rich” industrialized countries of the northern hemisphere and the “biodiversity-rich,” developing countries of the southern. These debates are often antagonistic and rhetorical (Wiegele, 1992; Isla, 2005), with calls of “biopiracy” (Toly, 2005). But it is clear that bioprospecting undertaken without the appropriate sharing of benefits with the source of the discoveries is biopiracy (Toly, 2005). Much of this debate has centered on the control of plant genetic resources, and opposing views have been polarized (Kloppenburg, 1988b; Fowler and Mooney, 1990; National Research Council [NRC], 1993). Governments and private companies in industrialized countries generally advocate strong property rights in developed biological material, protectable through contract law and intellectual property, while adhering to the concept that wildlife should be a freely accessible common resource. Others believe this is not equitable because the holder of “raw genetic resources” of wildlife typically has no proprietary rights, whereas technology creators can establish property from the common resource. Such questions of property rights in crop-related, domesticated-plant genetic resources remain unsettled (NRC, 1993).

The rights of indigenous persons in discussions of property in biological material are another hotly debated topic (Crucible Group, 1994; Greaves, 1994), and some have labeled scientists involved in biological research “genetic colonialists” (Kahn, 1994).

In an interesting treatise, Vogel (1994) proposes “genetic homesteading,” in which governments would grant landowners rights in the “genetically-coded-function” from wildlife on their property. Landowners would then hold the requisite rights as an incentive to preserve biodiversity on their land. This novel idea addresses a basic problem of biological conservation: creating incentives to preserve wildlife. Wildlife property is implicit in Vogel’s thesis.

1.3.3 Sovereignty and Property in Wildlife

Sovereignty is the ultimate source of property. The sovereign has the ultimate power to establish, grant, and enforce property rights. The question of who holds or should hold the ultimate right of control over wildlife has taken various forms throughout history. Sovereignty over wildlife has been an issue at least since the first tribal hunting grounds (Laveleye, 1878, Lafargue, 1894). The history of the international struggle to acquire and exploit plants, fish, and game revolves around this question (Whittle, 1988; Juma, 1989). Questions of sovereignty in wildlife have been the focus of international disputes over marine fisheries, endangered species, marine mammals, migratory birds, and wild races of crop species (Lyster, 1985; Meyers, 1992; Richards, 1994).

It is useful to begin at the national level when analyzing sovereignty in wildlife (Bragdon, 1992). Nations have historically asserted sovereignty over transient biota such as coastal fisheries. In the United States, the federal government has absolute sovereignty over select taxa, including marine mammals, eagles, pelagic fisheries, endangered species, and migratory birds (Plater, 1992). National sovereignty over wildlife, particularly biota that are transient across national boundaries, is a cornerstone of various regional and international agreements and treaties that structure the international control of wildlife (Lyster, 1985; Groombridge, 1992). International treaties prescribe national sovereignty over certain species of whales, seals, polar bears, and birds (Lyster, 1985). Numerous regional wildlife treaties are built on the national sovereignty principle. Examples include the Andean Treaty for the Conservation of the Vicûna, the Kuwait Regional Convention on Marine Environment, and the Benelux Treaty on the Protection of Birds (Groombridge, 1992).

A review of the several international and regional wildlife treaties reveals no explicit treatment of biotechnological utilities or intellectual property (Lyster, 1985; Groombridge, 1992).

On some occasions, nations assert sovereignty over a specific taxon. For example, in 1911, the first national law governing the control and use of a wild plant (edelweiss) was enacted by Switzerland, a country with a strong private-property tradition (de Klemm, 1990). Ecuador controls its living cocoa resources, and Turkey its tobacco; Ethiopia embargoes its coffee plants, and Brazil its rubber germplasm (Fowler and Mooney, 1990). Even countries with a strong private-property tradition have passed legislation that limits private-property rights in certain wildlife found on private property (Groombridge, 1992). These are relatively rare historical exceptions, as most of the world’s biota have been rather freely exchanged across international borders. Some claim, however, that such disregard for any property right in wildlife is "biopiracy" and that developed countries are guilty of disregarding inherent national and tribal sovereignty and property in exploiting wildlife (Juma, 1989; Fowler and Mooney, 1990).

Biotechnology has generated controversy over sovereignty in wildlife and its relation to the ownership of "genetic material" (Sedjo, 1992). This topic dominated the discussion and debate over the Biodiversity Convention (Burk et al., 1993; R. Stone, 1993; Chandler, 1993; Hardy 1994).

In the future, national sovereignty over wildlife (particularly, "genetic resources") will be an increasingly critical issue (NRC, 1993) as countries assert rights in their wildlife as provided in the Biodiversity Convention.

Within nations there are questions of intra-national sovereignty. For example, to what extent, if any, is national sovereignty over wildlife asserted and shared with regional governments, and, if so, how? How is sovereignty asserted in wildlife that is transient across jurisdictions? What are the impacts of "nested" and overlapping sovereignties in which the ultimate right to control wildlife is held by more than one entity? For example, in the United States, sovereignty over a wildlife species can be a complex conglomeration of federal and state jurisdictions.

The derivation of property rights from sovereignty over wildlife involves an interplay of real and personal property. Whereas personal property in domesticated biota is an ancient and largely uncontested concept (Field, 1989), property in wildlife is fraught with questions—questions that revolve on the relation of land ownership to rights in wildlife. For example, any consideration of property in a wildlife specimen depends on its taxon and location: Is it free-roaming or caged, alive or dead, whole or a part, transient or fixed, on government-owned or private land? (Bean and Rowland, 1997).

In free-market economies, property rights, held and freely exchanged by individuals, are essential (Demsetz, 1967). Under such regimes, the sovereign grants rights of possession and use of tangible and intangible property to individuals and other legal entities (Andrews and Hill, 1975). Tangible property includes real and personal property. In the United States, property rights in land extend to traditionally useful wildlife that are “fixed” to the land (i.e., rooted plants), for example, rights in valuable timber. The question of whether this tradition extends to less obvious, fixed and “semi-fixed” biota such as bacteria, fungi, algae, and invertebrates has been raised by inventions from these obscure biota. In the United States, transient wildlife do not automatically fall within a landowner’s real-property rights because they are not fixtures. This situation is confused when mobile wildlife resides permanently and entirely within the bounds of private, real property. Property rights in an endemic population entirely within a landowner’s property boundary[4] are ambiguous.

Possession is the fulcrum of the wildlife-property question. Possession is also necessary to create inventions. And because the law presumes that physical possession of personal property is ownership, personal property plays a pivotal role in resolving these puzzles of property in wildlife. The classic case of *Pierson v. Post*[5] tested the question of establishing a personal-property right in a wild fox wounded and pursued by hunters. This case helped define the legal doctrine of creating private-property rights through first possession (Rose, 1985). How does this tradition relate to the acquisition of personal-property rights in free-roaming, captured, or tamed wildlife as constrained by biological conservation law?

[4] For example, the desert pupfish that exists only in very small desert pools of Nevada.
[5] 3 Cai. R. 175 2AM. Dec. 264.

1.3.4 Biological Conservation Law and Wildlife Property

The idea that property in wildlife can be defined by land ownership, biota type, and first possession is confounded by a variety of laws that assert the governmental control of possession and use of certain wildlife. In the United States, the patchwork of federal and state wildlife conservation laws overlay other property considerations. These include federal laws that protect endangered and migratory bird species and state statutes that control fish and game (Lyster, 1985; Bean and Rowland, 1997).

In the early years of the American colonies and the United States, all wildlife was a commons, free for the taking. Eventually, public-safety concerns, commercial disputes, and resource conservation led to a gradually increasing assertion of governmental control (Lund, 1980). The 1700s and 1800s were characterized by minimal assertion of state control of fish and game and the lack of a federal role. Throughout the 1800s, states retained almost total sovereignty over biota within their borders. In the 1900s, the rise of federal control of migratory birds led to significant questions of federal versus state sovereignty and jurisdiction over wildlife. Today federal and state governments control various wildlife through a labyrinth of conservation laws (Lund, 1980; Tober, 1981; Bean and Rowland, 1997). This mix of national sovereignty, state control, and private property is then overlain by international treaties (Lyster, 1985).

Although the dynamic tension of state versus federal control of wildlife adds complexity to these issues, the U.S. Supreme Court has clarified that the federal government may assert ultimate sovereignty over any wildlife species that Congress so selects.[6] For example, the Endangered Species Act (ESA) asserts federal control over listed species regardless of other property considerations. Nonetheless, it is the states that assert governmental control over most wildlife, through a complex web of fish

[6] *Missouri v. Holland*, 1920.

and game law, public land control, and endangered-species and related conservation statutes (Bean and Rowland, 1997).

The nature of property in wildlife in the United States is confusing, even for traditional fish and game, well-established property institutions, and biological-resource management laws (Bragdon, 1992). This confusion is multiplied with less obviously valuable biota such as microbes, invertebrates, and obscure plants. For example, questions have been raised over rights in discoveries of economically valuable microbial enzymes from Yellowstone National Park (Robbins, 1994; Milstein, 1994c) and microbial resources on federal lands, in general (Wolf, 1994). A reading of the relevant federal laws that might resolve such questions provides ambiguous answers.[7]

These already-complex issues of sovereignty and property in wildlife and their parts are being made more complicated by biotechnology that is pushing the envelope of legal tradition, definitions, mechanisms, and policies. And where do the intellectual-property rights in patents on inventions made from wildlife fit in this context?

1.3.5 Patents and Property in Wildlife

The creation of inventions from wildlife establishes novel tangible and intangible property rights: tangible personal property in biological matter *per se,* and intangible intellectual property. Of the several forms of intellectual property, patents are of particular relevance to wildlife-property questions.

Historically, patents have had little relevance to biological-resource management. This changed with the trend to extending patents over an increasingly broader range of biological subject matter (Bent et al., 1987). Biotechnology

[7] That is, the National Park legislation includes the Organic Act 1916, Yellowstone Enabling Legislation of 1872, the Redwoods Act Amendment of 1978, and pertinent policies and regulations in the U.S. Code of Federal Regulations.

accelerated the process of developing utilities and intellectual properties from wildlife, driving the economic motivation to control and possess wildlife specimens. This pressure runs headlong into that law and policy which concerns the disposition of wildlife for both public good and private benefit.

Anyone who obtains information from biological materials and/or methods that meets the legal criteria of patentability may be issued a patent covering that information. Using intellectual property law to establish patent rights from wildlife information has historically created both opportunity and wealth, and anger and confusion. But what is the relation between patents on biological subject matter obtained from wildlife and other forms of property in wildlife?

Patent law is national in scope, although international treaties such as the Patent Convention Treaty (PCT), the Trade-Related Aspects of Intellectual Property Rights (TRIPS) portion of the General Agreement on Tariffs and Trade (GATT), and regional treaties such as the European Patent Convention (EPC) act to harmonize the variety of national laws. Holding patent rights in one country does not grant rights in another country—there is no "world-wide patent." Patents are issued only by national governments, and their force is limited by national boundaries. U.S. patents have no validity in another country, and *vice versa*.

Patent laws exist to provide incentives for the creative genius of inventors. Such laws are based on the concept that granting limited-term, exclusive rights to inventors for their own inventions, in exchange for complete public disclosure, provides inventors the incentive to invent, thereby stimulating technological advancement for the general benefit of society.

To be patentable, an invention (or "discovery"—the terms are synonymous under U.S. patent law) must be conceived and "reduced to practice." Physical laws, mathematical formulae, methods of business, and "products of nature" are not patentable in any country. The legal tradition of prohibition on “product of nature” patentability bars patents on wildlife species *per se* or their specimens. This doctrine is a manifestation of the “common heritage” principle that wildlife are a common resource of the public that may not be converted into private property. The idea that “living matter” may be patentable is based on the concept that the invention did not exist as such in nature and that significant intellectual work was required to create the invention. Breeding a new plant variety, sequencing a gene, and characterizing a biochemical all require significant ingenuity to create something that did not exist in nature before the invention was conceived and reduced to practice.

A patent is essentially a limited, negative, intangible personal-property right by which the national government grants to the inventor a limited-term right to prohibit others from making, using, or selling the patented invention. In exchange for this grant, the inventor agrees to provide a complete, accurate, and enabling public disclosure of the invention. This disclosure permits the public to learn from the invention and provides a basis on which others may invent and patent improvements. Patents are the antithesis of secrets because they require full disclosure.

Like any invention, to be patentable a biological invention must have some utility (particularly, of some economic relevance). It must be novel, and it must not be obvious to someone with “ordinary skill in the art.” An important aspect of a patent, established by the novelty and nonobviousness criteria, is that it must not take anything away from the public that the public did not have before the patent was issued. For example, to be patentable, a gene must not have previously existed as a DNA-sequenced, technologically useful entity. By isolating and characterizing the gene’s DNA sequence, the inventor has made the gene technologically useful, thereby advancing knowledge and technology, but has not taken anything from the public, because the patentable matter (the isolated and characterized gene) did not exist for the public in its prior, unpatentable condition. This is the fundamental characteristic of patents that precludes inventors from inappropriate privatization of portions of the common good.

Upon issuing a patent, the national government grants the patent holder the right, for a period of twenty years (from submission of the patent application), to exclude others from making, using, or selling the patented invention. A patent does not grant the inventor the right to make, use, or sell the patented invention—only to prohibit others from doing so. Owning a patent on a discovery from an organism does not give the patentee rights to control the organism that was the source of the invention.

Another form of intellectual property relevant to biota is “plant breeder’s rights” (PBR). The international convention known as the Union for the Protection of New Varieties (UPOV) gives plant breeders limited, exclusive rights to propagate and sell sexually propagated plant varieties made by breeding. In the United States (a member of the UPOV Convention), the Plant Variety Protection Act provides this right through a Plant Variety Protection (PVP) certificate. Also, since 1930, the United States has granted plant patents to breeders and discoverers (if the plants are discovered in a cultivated state, i.e., in orchards or fields) of asexually propagated, novel plant varieties that are uniform, distinct, and stable. PBR laws preclude property rights in wild flora and so are not relevant to the wildlife-property milieu. However, such laws do not prevent the use of wild flora in the breeding pedigree of a variety covered by PBR.

Biotechnological utilities are a relatively recent phenomenon. But the evolution of patents in biological matter has much earlier roots (Crespi, 1982; Beier, Crespi, and Straws, 1985; Cooper, 2000). In the United States, the first patents on living subject matter were issued in 1873 to Louis Pasteur for “yeast as an article of manufacture." In Germany, patents for yeast cultures in brewing, vinegar manufacture, and bread making were granted soon after the enactment of the German Patent Law of 1877 (Beier et al., 1985). In the United States, this trend continued with patents issued for an antitoxic serum in 1877, a bacterial vaccine in 1904, a bacterial sewage treatment in 1908, and a viral vaccine in 1916. The trend toward patentability accelerated in the 1940s and 1950s in the United States and the United Kingdom with patents issued on purified vitamins and antibiotics. In 1980, biotechnologists eventually pushed the U.S. Supreme Court to declare that the scope of patentable subject matter includes "anything under the sun made by man," enabling inventors to obtain patents on all manner of biological subjects including genes, antibodies, and even whole organisms.

The expansive view of the patentability of biological subjects is in fundamental tension with the traditional proscription of patents on "products of nature." This tension, manifest by patents on microbial strains purified from nature but otherwise unaltered, impacts wildlife-property issues. What is the threshold of human endeavor when an unpatentable "product of nature" becomes a patentable "product from nature"? This threshold directly affects the wildlife-property equation.

1.3.6 Possession, Personal Property, and Patents from Wildlife Specimens

In order to invent patentable subject matter from a wildlife specimen, it is necessary to physically possess the specimen. In some cases, a few cells may suffice. A biotechnologist may require only a single cell or a strand of DNA, but, originally, someone had to possess an entire, intact organism. Therefore, invention requires physical possession of a specimen, and possession requires access.

Physical possession is the critical event in the process of transforming access to wildlife into patent property. Elucidating the rights a possessor holds in a biological specimen requires analysis of the extent of control over possession and use asserted by governmental and/or private entities, if any.

In a clear acknowledgment of the link between possession and patent rights, it has been recommended that national patent offices require proof of legal possession of source biota as a prerequisite to patent issuance (Williams, 1997). Although this policy could help control "biopiracy," it also might create administrative bottlenecks in already overburdened patent offices.

1.3.7 Inventions from Wildlife: The Political Economy

The political economy of wildlife is a complex equation defined by property rights, the economic value of wildlife, and the dynamic that balances the protection of this resource as a public good against its private exploitation. Wildlife was historically considered a common good like the sea, air, or sunlight (Ciriacy-Wantrup and Bishop, 1975), and conflicts over the wildlife commons typically involved game, fisheries, and useful plants. In the early years of the American colonies and the United States, all wildlife was freely accessible to all. This philosophy was based on a rejection of the feudal rights of kings and aristocrats in wildlife (Lund, 1980) and on resource abundance. Although public-safety issues led to a few early assertions of governmental control over wildlife, it was a growing awareness of resource scarcity and the importance of conservation that led to a shift away from valuable wildlife as a commons to a government-regulated resource (Tober, 1981).

Long-held questions on the optimal distribution of the right of access to wildlife have been predicated on the economic value of useful wildlife. Tangible and intangible biotechnological inventions from wildlife significantly alter this situation. Biotechnology has created a "new" natural resource—a resource with all of the characteristics of traditional wildlife, but with new attributes as well. I believe one must understand the characteristics of biotechnological inventions, including their suitability for transformation into intellectual property, before one can analyze the relation of patents to the political economy of wildlife.

This new natural resource presents a new set of economic problems. Some species that were economically trivial in the past have acquired significant new value because of the inventions made with them. Previously non-scarce wildlife are now being transformed into scarce commodities by one technically useful discovery. Wildlife species that were never considered in the public-good versus private-good debate are now relevant. Because of invention, the traditional debate over property rights and the sustainable use of fugitive biological resources such as fisheries must now be extended to other creatures such as arthropods and protozoa.

The issue of technologically valuable microbes from Yellowstone National Park raises important questions about wildlife and biological conservation. Some claim the microbes in Yellowstone are, like all wildlife, a common resource that belongs to the public (Milstein, 1993). But a publicly accessible wildlife commons may act against the preservation of biodiversity. Hardin (1968) describes a "tragedy of the commons" in which a resource, freely available to all, is valuable to individuals only by capture. Individuals have no incentive to conserve the resource and attempt to maximize their value in the resource without considering the cumulative impacts of other individuals who are also acquiring value through capture. The resulting "tragedy" is the destruction of the common resource. If wildlife is a common good not owned or controlled by anyone (*res nullius*), no one has any economic incentive to husband it. An assertion of property rights in wildlife populations may be necessary to avoid a "tragedy of the commons" of biodiversity loss and to induce investments needed to preserve biodiversity (Swanson, 1992).

How should property rights in wildlife be distributed if the natural-resource economic equation is changing so significantly? Will the public good in wildlife be optimized by strengthening or restricting private-property rights? Should governments assert broader or tighter control over the right to possess and use wildlife, particularly that wildlife which is now *res nullius*? Should governments allow individuals to assert ownership in biotechnological utilities and patents from "public" biota? Will technology advancement and economic development be best served if governments regulate the exploitation of the inventions of wildlife? Is *laissez-faire* government perhaps the best way to achieve the public good in inventions from wildlife? What about the sustainability of wildlife use? How could sustainability be accomplished in a distributive-rights scheme? And what of future generations—should their needs be considered when society determines the value of yet-to-be-discovered biotechnological utility in wildlife? Are there novel institutional mechanisms that could prove useful in the distributive-rights equation of wildlife? In the continuum of private property and free markets versus governmental control, could communal institutions perhaps play a role in the sustainable use of biotechnological utilities from wildlife? This work should provide insight into the resolution of some of these questions.

1.3.8 Ethical Considerations

The complex issues of property in wildlife described here present a number of ethical questions. What is the ethical basis for owning any biota? Are there differences between owning domesticated biota and owning wildlife? What if the owned biota is a whole, living specimen, or just a part? What are the ethical issues surrounding patents generally, and patents on biological subject matter in particular, especially from wildlife? What is the philosophical basis for the balance between the public good and private rights in wildlife? Who, if anyone, should own wildlife, or inventions made from it? And, if such ownership is acceptable, for what purposes is it acceptable?

1.4 Case Studies

I analyze each of the following two cases in the context of the legal orthogonality of patents and wildlife. In each case, the physical possession of specimens presents a pivotal point in the relation of the value of patented invention to the cost of conservation.

1.4.1 Yellowstone and Its Valuable Microbes

Economically valuable biotechnological discoveries made by companies from microbes collected in Yellowstone National Park present legal and policy questions of the public good versus private rights in wildlife, the government's public-trust responsibility, the ownership of obscure biota on federal land, and issues of the conservation and use of national park lands.

The fact that neither the U.S. government nor any of its agencies (e.g., the Department of Interior, the National Park Service, or Yellowstone National Park) have received any share of the significant economic return generated by this commercial exploitation of discoveries from Yellowstone National Park's biota has raised questions (Clifford, 1994; Milstein, 1994c).

This case poses fundamental questions about the federal government's public-trustee management of the common good of wildlife resources: Does the federal government "own" all biota on federal lands? Does this ownership extend to all organisms, including microbes? Do such federal rights depend on the type of governmental lands (e.g., Bureau of Land Management [BLM], National Forest, National Park, Wildlife Refuge)? Should the federal government actively control access to and use of biota on federal land and, if so, to what end? What role does the balance of state versus federal jurisdiction play in the sovereignty over wildlife on federal land? Is there a significant difference between microbial biota and other biota in this context? Is there a significant difference between the federal government's responsibilities for wildlife on public lands versus public-trust lands? Should the discovery of inventions from wildlife be controlled in national parks? Should it be encouraged or discouraged? What about other federal lands?

1.4.2 Bioprospecting Fungi and The Finger Lakes Land Trust

The Finger Lakes Land Trust (FLLT) was established in 1989 as a non-profit corporation for the purpose of preserving unique natural habitats in the Finger Lakes region of upstate New York. The FLLT's activities include inventorying natural resources and acquiring land, as well as owning and managing its lands to preserve natural resources. In 1997, the FLLT acquired the Biodiversity Preserve, a unique parcel of land near Ithaca, New York, valued by Cornell University researchers for its biodiversity. One of the reasons for acquiring the preserve was to develop its bioprospecting potential. A variety of taxa could have been chosen as bioprospecting targets. But an intriguing preliminary discovery led to the selection of fungi.

Fungi are unique. They comprise a separate kingdom that falls outside most traditional legal definitions of wildlife. They are transient and fixed, depending on their life cycle, blurring the traditional legal distinction between plants as fixtures and animals as transients. Also, fungi are fixed to the soil but may also be fixed to plants and animals. Is a fungus fixed to the land because it is fixed to a plant that is fixed to the land?

The FLLT entered into collaboration with nearby Cornell University to exploit the bioprospecting potential of fungi on FLLT land. This collaboration led to an arrangement between the FLLT, Cornell, and a commercial partner, Schering-Plough, in which the three parties would cooperate to find and commercialize useful discoveries from FLLT fungi and share in the costs and returns of commercialization.

Unlike Yellowstone, the bioprospecting value of these biota was imagined *a priori*, and legal structures were put into place that allowed for this value to be shared.

This case prompts questions: What ownership rights does the FLLT, a private landowner, have in the fungi on its land? How far do those rights extend? And what roles do intellectual and personal property play in bioprospecting?

CHAPTER 2:
PATENT PROPERTY IN BIOLOGICAL SUBJECT MATTER

2.1 Introduction

The obvious, first step in analyzing the research premise of the orthogonality of U.S. patent law and biological conservation law is a review of U.S. patent law as it relates to biological subject matter. The following review isolates aspects of U.S. patent law that affect the scope of patentability of biological materials and methods. A general overview of the philosophical and economic rationale for patents precedes a description of their statutory and case-law foundation. From this background, I analyze the history of the evolution of biological subject matter patentability, beginning with the first patent on a living invention: Pasteur's Patent No. 141,072 on certain microbes in 1873.[1] This history identifies salient and watershed legal events that defined the evolution of this type of patentability. All of this leads to any articulation of the current status of patentability of biological invention.

Throughout this review, I emphasize those features of U.S. patent law and its history that I believe to be most relevant to the laws concerning biological conservation. In that vein, this chapter concludes with a discussion of the current state of the patentability of whole organisms.

2.2 The Patent and Its Rational Basis

Patents are a grant of limited property rights by the federal government for the subject claimed in the patent. They are an intangible personal-property right institutionalized in a body of federal statutory and case law. The philosophical justification for patents is based on the general social good of technological progress that arises when inventors have property rights in their inventions. A society, through

[1] All U.S. patent information cited in this dissertation is from the U.S. Patent and Trademark Office Web-based database, available at http://www.uspto.gov/patft/index.html.

its government, provides these limited property rights as an incentive and in exchange for certain social obligations. The flow of social benefits of developments that derive from granting exclusive property rights to creative individuals (Machlup, 1958) includes technological progress, civil improvement, and economic growth (Mansfield, 1977, 1986).

Patents have their antecedents in the western European concept of "inventor's privileges," with roots in the Merchant Guild systems of the Middle Ages (Lipscomb, 1984). The first codified patent law was the 1623 British Statute of Monopolies. The role of patents in motivating the British industrial revolution may have led the drafters of the U.S. Constitution to include a provision in Article 1, Section 8 of that document (General Powers of Congress) granting individuals exclusive rights in their inventions and discoveries "to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries."

Walterscheid (1997) describes the legislative debate and passage of the first U.S. Patent Law by the U. S. Congress in 1790.

Machlup's (1952, 1958) economic analyses of the U.S. patent system, commissioned by Congress, defined the four-part basis of U.S. patent law: 1) to recognize the intellectual property of the inventor; 2) to reward inventors for their useful service as "teacher of the nation"; 3) to encourage inventors and industry to invent, invest, and innovate; and 4) to further the early public disclosure and dissemination of technical knowledge. Machlup's analyses support the premise that the patent institution's primary function is to promote the public welfare through technical and economic progress, a premise that underlies patent jurisprudence.

A patent issued by the federal government grants the patent owner the right to stop others from making, using, selling, or importing the invention claimed in the patent. It is enforceable for a period of twenty years from the date of application. As with all property rights, a patent is enforceable by the ultimate coercive power of the state (i.e., the federal government).

In the United States, the exclusive right to a patent on an invention is based on the legal doctrine of property-right acquisition by first possession. This right, defined in Roman Law as *qui prior est tempore potior est jure* ("who is the first in point of time is stronger in right") is the root of most property rights (Rose, 1985). Patent law manifests this doctrine in the patentability requirements for "novelty" and "nonobviousness."

The private appropriation of intellectual property in the midst of the public pool of human knowledge creates a fundamental tension between the public good and private rights (Boyle, 1992). This tension is manifest in the realm of patents on biological subject matter, particularly when derived from wildlife.

U.S. patent law acknowledges the public good in wildlife by prohibiting patents on "products of nature." The balance between the private right of a patent and the public good ultimately served through such right is evident in the patent law's intent that patents "teach the nation," embodied in requirements of enablement and candor.

Biotechnology and the evolution of patent case law have produced a complex legal milieu that allows patents on some biological inventions but not on others. Understanding this milieu provides a basis for analyzing the relation of patents to wildlife. How does patent law enable the creation of private intellectual property from the public domain of wildlife?

2.3 U.S. Patent Law

2.3.1 Statutory

Utility patent law in the United States is codified in the original Patent Act of 1790, the revised Patent Act of 1952,[2] numerous Patent Act amendments, Title 35 of the United States Code, and the *Manual of Patent Examination Procedure* of the U.S. Patent and Trademark Office. The Patent Act grants patent rights as defined in U.S. Code, Title 35, Section 101: "whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefore, subject to the conditions and requirements of this title."[3]

U.S. Code, Title 35 establishes the Patent and Trademark Office and defines the rights conferred by a patent and procedures for patent application, examination, issuance, and maintenance. Its several sections define the criteria for patentability.[4]

Invention: Section 100 follows the wording of the U.S. Constitution, defining "invention" as "invention or discovery." Despite arguments for a difference in justification for a patent right in an invention versus a discovery (Hettinger, 1994), the Constitution and the Patent Act make no such distinction.

Originality: Section 102 requires that a patent be issued only to the true inventor or inventors.

Novelty: Section 102 requires that the invention not be publicly known (i.e., previously patented, documented in print, used, or sold) more than one year prior to the date of patent application.

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[2] Patent Act of 1952, c.950, 66 Stat. 792 (1952).
[3] Consolidated Patent Laws (January 2007), p. L-20, available at http://www.uspto.gov/web/offices/pac/mpep/consolidated_laws.pdf
[4] Unless otherwise noted, all references to Title 35 of the U.S. Code, "Patents," refer to the 2006 version published by Lexis Publishing, Charlottesville, VA.

Nonobviousness: Section 103 defines "invention" as a contribution to the useful art requiring greater ingenuity or skill . . . than that of an ordinary mechanic acquainted with the business." Nonobviousness also requires that the invention go beyond what a person of ordinary skill in the art, as defined by all the prior art, would find obvious to seek and obtain.

Diligence in Filing: Section 102 requires applicants to diligently pursue (i.e., in a reasonably timely manner) the perfection and filing of an application once the invention has been conceived.

Priority: Section 102 provides that only the first to invent is entitled to a patent.

Utility: Section 101 requires that the invention be "useful." Section 112 requires that the invention be capable of performing at least one beneficial function and that the specification disclose the "manner and process" of using the invention so that one of "ordinary skill in the art" may use it without undue experimentation.

Enablement: Section 112 requires the applicant to precisely disclose how to make and use the "best mode" of the invention. For inventions that require a viable microorganism, enablement requires the deposit of the organism in a public repository.

Distinct Claiming: Section 112 requires "well-marked boundaries" of the patent claims.

Candor: Section 1.56 requires that the patent applicant disclose all "prior art" references believed to be relevant to the patentability of the invention (with an emphasis on novelty and nonobviousness).

2.3.2 Judicial Decisions

The federal patent statute, summarized above, is relatively spare. Case law provides most of the definition of patent law. Judicial patent law consists of cases decided by federal courts and the Patent Office Board of Appeals (POBA).

Summarizing the salient decisions of these courts defines the nature of the patent and the rights it confers.

The intent of patent law is to promote technological advancement and to stimulate invention,[5] and to stimulate innovation and the "progress of science and useful arts" while avoiding monopolies.[6] Patents are issued primarily for the public good, and private benefits are granted as incentive to disclose so that the invention published as a patent adds to the sum of freely available knowledge.[7,8] One purpose of the patent law is to ensure that the subject of a patent will ultimately be dedicated to the public.[9] The inventor's reward is merely a means to the main object of patents: to promote the progress of science and the useful arts.[10] A patent's reward should go exclusively to the first and original inventor only as an incentive for the resulting public good obtained.[11] Inventor's rights are subject to the convenience of public policy,[12] and patent law is to be construed to give effect to this intended public policy.[13]

Courts should adhere to both the letter and spirit of patent law.[14] Courts have interpreted Congressional intention of the Patent Act to be comprehensive and inclusive in patent coverage and to be liberal in protection for any invention that is new and useful.[15] Similarly, courts believe Congress appreciates the social importance of patents and, therefore, expect a high level of conduct on the part of all participants: "Far-reaching social and economic consequences of a patent give the public a

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[5] *Milwaukee Rubber Works Co. v. Rubber Tire Wheel Co.*, 210 U.S. 439 (1908).
[6] *Bonito Boats, Inc. v. Thunder Craft Boats, Inc.*, 489 U.S. 141 (1989).
[7] *Griffith Rubber Mills v. Hoffai*, 313 F.2d 1, C.A. Or. (1963).
[8] *United States Plywood Corp. v. General Plywood Corp*., 389 U.S. 820 (1967).
[9] *International Std. Elec. Corp. v. Marzall*, 184 F.2d 592, D.C. Cir. (1950).
[10] *U.S. v. Masonite Corp.*, 316 U.S. 265 (1942).
[11] *James B. Clow & Sons, Inc. v. U.S. Pipe & Foundry Co.*, 313 F.2d 46; U.S. App. (1963).
[12] *Sinclair & Carroll Co. v. Interchemical Corp*., 325 U.S. 327 (1945).
[13] *In re Flude*, 34 C.C.P.A. 939; 159 F.2d 878 (1947).
[14] *Howes v. Great Lakes Press Corp*., 459 U.S. 1038 (1982).
[15] *Dennis v. Pitner,* 308 U.S. 606 (1939).

paramount interest in seeing the patent monopolies spring from backgrounds free from fraud or other inequitable conduct."[16]

Invention is a mental act[17]—the finding out, contriving, or creating by the action of the intellect something not existing or not known before;[18] it is not "susceptible of precise and vigorous definition."[19] Invention requires conception and reduction to practice.[20]

Patents are not intended for every "trifling device" nor every "shadow of a shade of an idea."[21] The utility requirement dictates that a patentable invention practically (not speculatively) perform a beneficial function described in the patent, although perfection is not essential.[22] Patentability requires novelty, utility, and nonobviousness,[23] as well as a "substantial advancement in the art."[24] The inventor must clearly add something of value to the sum of human knowledge or make the world's work easier, cheaper, or safer.[25] However, patentees are not required to understand the scientific principles underlying their inventions.[26] Liberal interpretations of patent law should be favorable to inventors.[27]

The patentability of an invention should be construed in light of the purpose of promoting social welfare by stimulating discovery and invention.[28] A patent must exhibit a public benefit. A patent may not be granted on an invention if it exhibits public detriment unless it also has a concomitant public benefit.[29] The patent office

[16] *Carter-Wallace, Inc. v. Riverton Laboratories, Inc.* 433 F.2d 1034; U.S. App. (1970).
[17] *Stero v. Ringold*, 54 C.C.P.A. 1407; 377 F.2d 652 (1967).
[18] *Koppe v. Burnstiingle*, 29 F.2d 923; U.S. Dist. (1929).
[19] *West Branch Novelty Co. v. Bloom*, 31 F. Supp. 673; D.C. Pa. (1940).
[20] *S.W. Farber, Inc. v. Texas Instruments, Inc.*, 382 U.S. 843 (1964).
[21] *Fowler v. Sponge Products Corp*., 246 F.2d. 233; C.A. Mass (1957).
[22] 35 U.S.C. § 101 (2000).
[23] Ibid.
[24] *Comm. of Patents v. Deutsche Gold-Und-Silber Schier deanstalt Vormals Roessler*, 397 F. 2d 656; 130 U.S. App D.C. 95 (1968).
[25] *In re Gibbons*, 41 C.C.P.A. 788; 210 F.2d 299 (1954).
[26] *In re Alfred Aufhauser*, 399 F.2d 275 (1968).
[27] *In re Briede*, 27 App. D.C. 298 (1906).
[28] *McCashen v. Watson*, 131 F. Supp. 233; D.C.D.C. (1955).
[29] *Beckman Instr., Inc. v. Chemtronics, Inc.*, 428 F.2d 555; L.A. Tex. (1970).

should take safety into consideration to the extent that any invention that is so dangerous as to fully negate utility is unpatentable.[30] A patent is not invalid if the invention is used for illegal purposes.[31]

2.4 A History of Biological Subject Matter Patentability

Since the passage of the U.S. Patent Act in 1790, the U.S. Patent and Trademark Office has issued over seven million patents (7,213,669 as of May 1, 2007), many of which have entailed biological subject matter in some way. The historic case-law pattern of biological subject matter patentability is an intellectual "hopscotch" of judicial patent rejection and acceptance, breadth and narrowness. However, the general trend of patent jurisprudence has been to widen the scope of patentability to potentially include any biological subject. Although courts have held against the patentability of "products of nature," the trend has been to consider as patentable "products from nature" (i.e., biological subject matter that is purified, altered, or otherwise technologically improved over nature by human endeavor). Pasteur's 1873 patent on yeast cultures and several pre-1900 patents on vaccines started a trend of patentability of biological subject matter *per se*, but for most of the 18th, 19th, and 20th centuries, courts were reluctant to support patents on organisms or on biological compositions of matter, creating a basic tension. The rush of biotechnology-based invention over the past thirty years pushed the courts to resolve this tension.

Appendix A summarizes salient events in the evolution of jurisprudence on patentability of biological subject matter. More than eighty years after the passage of the first patent legislation, the U.S. Patent Act of 1790, the first U.S. patent on animate matter was issued to L. Pasteur (U.S. Patent No. 141,072). This patent claimed "yeast,

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[30] *Carter-Wallace v. Riverton Laboratories*, 304 F. Supp 357, *affmd*. 433 F.2d 1034; D.C.N.Y. (1969).
[31] *Koppe v. Burnstingle,* 29 F.2d 923; D.C.R.I. (1929).

free from organic germs of disease as an article of manufacture." Conversely, the following year, the Supreme Court rejected the patentability of purified cellulose in *American Wood Paper Co. v. Fiber Disintegrating Co.*[32] Three years after this rejection of patentability, the first U.S. patent on lymph cells as a vaccine (U.S. Patent No. 197,612) was issued in 1877. Twelve years later, the Patent Commissioner rejected the patentability of isolated pine-needle fibers as "products of nature" in *Ex parte Latimer*.[33] Five years after *Latimer*, the scope of patentable biological matter was broadened by the issuance of U.S. Patent No. 525,824, the first U.S. patent to claim a fungal fermentation method and composition. The trend of broadening patentability of biological matter continued in 1899 with U.S. Patent No. 634,423, issued on the "Septic Tank" method, which employed living microbial cells. The expanding patentability of biological matter was furthered in 1904 with the issuance of U.S. Patent No. 778,767, the first U.S. patent on a living attenuated bacterial cell vaccine.

Courts have long held that laws of nature are not patentable subject matter[34] and that natural phenomena *per se* are also not patentable.[35]

The patentability of natural products made by artificial synthesis was first tested by the Supreme Court in *Cochrane v. Badisch Anilin & Soda Fabrik*,[36] which centered on the patentability of the dye alizarine, which was made from a plant. This court decision produced a mixed bag of biological matter patentability. It rejected the patentability of the purified product *per se* because it existed in nature, but it implied that the synthetic process was patentable and that, specifically, a patent claim of "an old product by new process" could be allowed.

[32] *American Wood Paper Co. v. Fiber Disintegrating Co.*, 90 U.S. 566 (1874).
[33] *Ex parte Latimer*, 125 Comm'r Patents reprinting 46 O.G. 1638 (1889).
[34] *Gottschalk v. Benson*, 409 U.S. 63, (1972); in *re Taner*, 681 F.2d 787 (1982).
[35] *Perkins Glue Co. v. Crandall Panel Co.*, 294 F.135; D.C.N.Y. (1923).
[36] *Cochrane v. Badische Anilin & Soda Fabrik*, 111 U.S. 293, 311-312 (1884).

In 1908, the patentability of living subject matter was disputed when the validity of the 1899 "Septic Tank" patent (U.S. Patent No. 634,423) was challenged as inappropriately claiming a "process of nature." However, the Second District Court found that "the use of one of the agencies of nature" for a practical purpose "was patentable matter."[37]

The legal criteria for biological patentability has often centered on the "purification doctrine," which holds that human intervention that transforms a naturally occurring, impure material into a pure form, which is thereby more useful for humans, transforms a product of nature into a patentable invention (Cooper, 2000). For example, in 1909 the 7th Circuit District Court found that a process for making acetyl-salicylic acid (aspirin), a compound derived from a naturally occurring plant chemical, was patentable because the invention "took a comparatively worthless substance and changed it into a valuable one."[38] The court held that purified aspirin acid was patentable because it was "therapeutically available," unlike the naturally occurring substance. Similarly, in 1911, the U.S. Second Federal Circuit Court decided in *Parke-Davis & Co. v. H. K. Mulford & Co.* that purified adrenaline was "for every practical purpose a new thing commercially and therapeutically. That was a good ground for a patent . . . the distinction is to be drawn rather from the common usages of men than from nice considerations of dialectic."[39] On the other hand, in the 1928 *General Electric v. De Forest* case, the Third Circuit Court held purified tungsten unpatentable,[40] and three years later, the Circuit Court of Patent Appeals (CCPA) found pure vanadium unpatentable.[41]

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[37] *Cameron Septic Tank Co. v. Village of Sarasota Springs*, 159 F. 453, 462; 2d Cir. (1908)
[38] *Kvehmsted v. Farbenfabriken of Elberfeld Co.*, 220 U.S. 622 (1911).
[39] *Parke-Davis & Co. v. H. K. Mulford & Co.*, 196 F. 496; 2d. Cir (1912).
[40] *General Electric Co. v. De Forest Radio Co. et al.*, 28 F.2d. 641, 643; 3rd Cir. (1928).
[41] *In re Marden* 47 F. 2d 958, 958; CCPA (1931).

In the years 1910 through 1927, the inexorable expansion of biological subject matter patentability proceeded, with various U.S. patents issued on vaccines and microbial cultures including bacteria, viruses, yeast, and fungi.[42]

A watershed in biological matter patentability occurred in 1930, when the U.S. Plant Patent Act was enacted. This act provided the patentability of crossbred or cultured mutants of asexually propagated higher plants and was the first law in the world that explicitly allowed patents on eukaryotic organisms *per se*. Fowler (2000) describes the history behind the Plant Patent Act as a tension between the rewards due plant breeders (as inventors) and the protection of the public domain of plant varieties. Resulting compromises in the passage of the original act included patent coverage on a plant *per se*, but not its fruit, flowers, or pollen. The act prohibits patents on plants discovered in a wild state and excludes potato and Jerusalem artichoke, but has been amended to include fruit and flowers.

An important U.S. Supreme Court decision in 1931 partially opened the door for patents on living subject matter beyond domesticated plant varieties. In *American Fruit Growers v. Brogdex*,[43] the court majority opinion rejected the patentability of natural products that were simply "altered" but did not reject "living matter" as patentable.

Several cases in 1932 produced mixed signals on patentability. The POBA upheld the patentability of a biological process (a fermentation) and its isolated microbes, rejecting the Patent Examiner's argument that "fermentation is [an unpatentable] power of nature."[44] That same year, the 3rd Circuit Court upheld the patentability of a biological process (microbial production of acetone) but implied that

[42] See for example: U.S. Patent Nos. 1,210,053 (hog cholera virus), 1,391,599 (swine pneumonia virus).
[43] *American Fruit Growers, Inc. v. Brogdex Co.*, 283 U.S. 1 (1931).
[44] *Ex parte Prescott* 19 USPQ 178, 179; POBA (1932).

the patentability of organisms *per se* was prohibited.[45] Also, contrary to *American Fruit Growers*, the 2nd Circuit Court found that altered natural products (i.e., bleached-then-dyed animal fur) were patentable,[46] swayed perhaps by the significant increase in the economic value of the invention compared with the natural product and the novelty of the bleaching process (Cooper, 1998). Only nine years later, however, the POBA determined that deveined and beheaded shrimp were unpatentable products of nature.[47]

In 1934, the 7th U.S. Circuit Court upheld a patent on the "Activated Sludge" biological wastewater treatment process, ruling that it was neither a natural process nor a discovery of a law of nature.[48] And in 1936, the patentability of a purified natural substance (dextrose hydrate crystals) was upheld in *International Patents Development Company v. Penick & Ford Ltd*.[49]

Despite trends of expanding patentability, several cases in the late 1930s to mid-1940s effectively reduced the scope of patentability of natural products. In 1938, the CCPA invalidated a patent claim to pure "ultramarine" as an unpatentable natural product.[50] Similarly, in 1935, the CCPA denied a patent on pure alpha-alumina as a natural product,[51] and in 1939, it found pure vitamin C unpatentable.[52] In 1944, with *In re Sparhawk,* the POBA held as unpatentable a material extracted from muskrat glands.[53] Similarly, in 1950, the CCPA decided in *In re Mardeno*[54] that an antibiotic

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[45] *Guaranty Trust Co. v. Union Solvents Corp.,* 54 F.2d 400, 403, 410; D. Del (1931); *aff'd,* 61 F. 2d 1041 (1932).
[46] *Steinfur Patents Corp. v. W. Beyer,* 62 F.2d 238; 2d Cir. (1932).
[47] *Ex parte Grayson,* 51 USPQ 413, 414 ; POBA (1941).
[48] *City of Milwaukee v. Activated Sludge, Inc.* 69 F.2d 577, 582-583; 7th Cir. (1934).
[49] *International Patents Development Company v. Penick & Ford Ltd*.,15 F. Supp. 1038, 1046; D. Del. (1936).
[50] *In re Merz,* 25 C.C.P.A. 1314; 97 F.2d 599 (1938).
[51] *In re Ridgeway* 25 U.S.P.Q. 202; CCPA (1935).
[52] *In re King* 43 USPQ 400; CCPA (1939).
[53] *In re Sparhawk,* 64 USPQ 339; POBA (1944).
[54] *In re Cavallito,* 47 F. 2d 958; CCPA (1931).

compound extracted from ground garlic[55] was unpatentable. The question of patentability in these cases turned on whether the purified natural product was obvious over the unpure natural product rather than on product-of-nature versus product-from-nature distinctions.

Countering this trend of retracting patentability, some courts began to consider germane the significant technological distinction between a naturally occurring substance and the made-pure product. For example, the 7th Circuit Court considered increased utility in its *Dennis v. Pitner* (1930) and *Kalo v. Funk* (1947) decisions, which held purified biological matter patentable because the unpure matter has undesirable properties. These decisions also considered in determining patentability whether those “skilled in the art” were previously unable to obtain the pure substance.

In 1940, the CCPA limited the scope of the Plant Patent Act by excluding bacteria.[56]

The modern era, characterized by liberal interpretation of the scope of patentability in biological matter, began with the 1948 Supreme Court case of *Funk v. Kalo Inoculant*.[57] In this case (the first issue of patentability in biological subject matter to come before the Supreme Court), the court was asked to decide on the patentability of a unique, human-made mixture of specified, naturally occurring bacterial species as an inoculant for enhanced plant growth. The court rejected the patentability of this microbial product for obviousness and for “want of invention.” The obviousness of purified natural products over their naturally occurring state was to remain a key issue of patentability in future cases. For example, in 1955, a district court found a natural substance purified from its naturally occurring racemic mixture to be not obvious and, therefore, patentable.[58] However, most important, aside from

[55] 89 USPQ 449, 450 (POBA).
[56] *In re Arzberger*, 112 F.2d 834; C.C.P.A. (1940).
[57] *Funk Brothers Seed Co. v. Kalo Inoculant Co.*, 333 U.S. 127 (1948).
[58] *Sterling Drug v. Watson*, 135 F. Supp. 173; D.D.C. (1955).

the obviousness issue, in *Funk* the court did not explicitly exclude living organisms *per se* as patentable subject matter, which provided a basis for later arguments for extended patentability.

A watershed occurred in 1958 with *Merck & Co., Inc., v. Olin Mathieson Chemical Corp.,*[59] in which the 4th Circuit Court upheld the patentability of purified Vitamin B-12. Arguments for patentability were based on the doctrines of purification and utility, in which a purified natural product that exhibits greater human utility than the unpurified natural products is grounds for patentability. This doctrine was fleshed out eight years later in *Graham v. John Deere*: “There is nothing in the language of the Patent Act which precludes the issuance of a patent upon a ‘product of nature’ when it is a new and useful composition of matter . . . All of the tangible things with which man deals and for which patent protection is granted are products of nature in the sense that nature provides the basic source materials.”[60]

In 1961, the POBA flip-flopped on the patentability of a purified substance. In *Ex parte Reed*, the POBA originally held purified alpha-lipoic acid to be obvious and unpatentable.[61] Just several months later, it reversed this opinion, deciding that the purified substance did not exist in nature and that purity was necessary for utility.[62] In 1962, the POBA determined that a patent claim to concentrated streptimidone in a fermentation broth was not pure and, therefore, not patentable.[63] Conversely, two years later in *In re Doyle*, the CCPA held “substantially purified” 6-aminopenicillonic acid patentable, even though the compound had previously been identified in trace quantities.[64] The more liberal view of patentability by this court was also demonstrated in 1964 when, unlike the 1928 rejection of patentability of pure tungsten (*General*

[59] *Merck & Co., Inc., v. Olin Mathieson Chemical Corp.*, 253 F.2d 156; US App. (1958).
[60] *Graham v. John Deer*, 383 U.S. 1, 17-18 (1966).
[61] *Ex parte Reed*, 135 USPQ 34; POBA (1961).
[62] *Ex parte Reed*, 135 USPQ 105; POBA (1961).
[63] *Ex parte Frohardt*, 139 USPQ 377, 338; POBA (1962).
[64] *In re Doyle*, 140 USPQ, 421; C.C.P.A. (1964).

Electric v. De Forest), the Court found Elements 95 (Americium) and 96 (Curium) patentable.[65]

In 1966, the CCPA reversed the decision of the Patent Examiner and the POBA in upholding a patent claim to crystals of pure 2, 2-bis-(2, 3 epoxy-propoxypheryl) propane even though the compound existed in nature in a liquid form.[66] Conversely, a year later a district court held that "a patent may not be awarded for a product of nature or for a substance that is merely extracted from its parent material and purified."[67]

The patentability of purified substances that naturally exist in useless trace amounts was confirmed in the mid-1960s in *Charles Pfizer & Co. v. Barry-Martin Pharmaceuticals, Inc.*[68] This district court held that the prior art knowledge of tetracycline in trace amounts in fermentates did not render purified tetracycline unpatentable,[69] stating that "since the prior art . . . broths and antibiotics contained insufficient tetracycline to be of any benefit to mankind, they do not as a matter of law negate the validity of [said] . . . patent claims."[70]

In the 1970 case *In re Bergstrom*,[71] the CCPA held purified, naturally occurring prostaglandins as patentable, rejecting the rule that a purified natural substance was patentable only if it exhibited superior qualities over natural forms. It also held that a purified natural substance is novel even if the substance *per se* was previously known, concluding that "pure materials necessarily differ from less pure or impure materials and, if the latter are the only ones existing and available as a standard

[65] *In re Seaborg*, 328 F.2d 993; CCPA (1964).
[66] *In re Cofer*, 354 F. 2d 664; CCPA (1966).
[67] *Merck & Co. v. Chase Chemical Co*., 273 F. Supp. 68; U.S. Dist. (1967).
[68] *Charles Pfizer & Co. v. Barry-Martin Pharmaceuticals, Inc*., 241 F. Supp. 191; U.S. Dist. (1965).
[69] 145 USPQ 29; S.D. Fla (1965).
[70] Ibid.
[71] *In re Bergstrom*, 427 F.2d 1394; C.C.P.A. (1970).

of references, as seems to be the situation here, perforce the ‘pure’ materials are ‘new’ with respect to them.”[72]

Cooper (1998) describes the historical pattern of discontinuities in judicial patentability of “altered” natural products and compares the 1931 Supreme Court’s holding in *American Fruit Growers v. Brogdex*[73] with the 1932 decision of the 2nd Circuit Court in *Steinfur Patents Corp. v. W. Beyer, Inc.*[74] In *American Fruit Growers*, the Supreme Court found intact oranges with rinds impregnated with borax to be unpatentable “products of nature”:

> Addition of borax to the rind of natural fruit does not produce from the raw material an article for use which possesses a new or distinctive form, quality or property. The added substance only protects the natural article against deterioration by inhibiting development of extraneous spores upon the rind. There is no change in the name, appearance, or general character of the fruit. It remains a fresh orange, fit only for the same beneficial uses as theretofore.[75]

Conversely, a year later, in *Steinfur*, bleached-then-dyed animal furs were found patentable by the court, which relied on the *American Fruit Growers* test of utility, stating,

> While it was true of the orange that impregnation of its rind with borax only protected the natural article against deterioration by mold and give it no new beneficial uses, the same cannot be said of impregnation of the unbleached skin with ferrous sulphate. By such impregnation the skin attains a new quality which gives it a new beneficial use . . . An orange has the same use whether or not impregnated with borax. A fur skin unimpregnated with ferrous sulphate cannot be used in the same way as one which as been so impregnated. The orange does not, in our opinion, require a decision that the product patent in suit is invalid.[76]

[72] *In re Bergstrom*, 427 F.2d 1394; C.C.P.A. (1970).
[73] *American Fruit Growers v. Brogdex*, 283 U.S. 1 (1931).
[74] *Steinfur Patents Corp. v. W. Beyer, Inc.*, 62 F. 2d 238; 2d Cir. (1932).
[75] *American Fruit Growers v. Brogdex*, 283 U.S. 1 (1931).
[76] *Steinfur Patents Corp. v. W. Beyer*, 62 F.2d 238; 2d Cir. (1932).

Much of the confusion over patentability criteria was eliminated in 1966 with the Supreme Court's *Graham v. John Deere Co*. decision. The court held that patentability of something from nature compared with the prior art "product of nature" depends on novelty and rules now known as the "Graham Criteria." These criteria require 1) definition of the differences between the invention and naturally occurring materials, and 2) determination of the obviousness of the invention's differences, including the commercial success, long-felt need, and failure of others.[77]

The trend toward liberal interpretation of patentability is demonstrated in 1968 with the Texas District Court holding that inventions that are novel embodiments of natural laws and phenomena "in a practical mode of carrying them into useful effect" are patentable.[78]

In the early 1970s, the scope of the patentability of biological matter was enhanced by *In re Argoudelis,*[79] in which the CCPA determined that the Section 112 enablement requirement is satisfied by the public deposit of organisms. This case also implicitly raised the question of the patentability of an organism *per se*—a question raised and resolved in the several *Bergy* decisions.

In 1974, Bergy et al. filed a patent application with a claim to a pure culture of the bacterial species S*treptomyces vellosus*. The Patent Office Examiner rejected the claims as drawn to "products of nature" and, therefore, as unpatentable subject matter, a decision confirmed a year later by the POBA.[80] The POBA viewed the Patent Act as precluding the patenting of living organisms and pointed to the Plant Patent Act as evidence that Congress created a special category for such patents because it did not intend to extend utility patents to living organisms *per se*. The majority POBA opinion

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[77] *Graham v. John Deere Co*., 383 U.S. 1, 17-18 (1966).
[78] *Phillips Petroleum Co. v. Sid Richardson Carbon & Gasoline Co.*, 293 F. Supp. 555; *D.C.* Tex. (1968).
[79] *In re Argoudelis*, 434 F.2d 1390; CCPA (1970).
[80] *Ex parte Bergy* 197 USPQ. 78; POBA (1976).

also expressed a fear that if a broad interpretation of patentable subject matter was to be used, “new types of insects such as honeybees or new varieties of animals produced by selective breeding or cross breeding would be patentable.”[81] However, a dissenting member of the POBA pointed out that the Supreme Court did not reject microbial cultures *per se* as unpatentable subject matter in its previous decisions. This dissenter found the bacterial culture invention unpatentable because of obviousness, not because a bacterium is inherently not patentable subject matter.

This dissent was prescient: Three years later the CCPA reversed the POBA’s *Bergy* decision, finding a “living organism” to be patentable subject matter.[82] This court rejected “product of nature” arguments as not relevant and relied on the analogy of microbes as “living processes”: “There is nothing in the words of Sec.101 which excludes patents for living organisms . . . we think that the fact that microorganisms, as distinguished from chemical compounds, are alive is a distinction without legal significance.”[83]

Dissenters of the CCPA *Bergy* decision labeled the distinction of microbes as categorically different from other organisms as “gratuitous” and “improper” and argued that under patent law there is no distinction between microorganisms and honeybees. The CCPA held that pure microbial cultures were patentable subject matter:

> processes are considered statutory subject matter not withstanding the employment therein of living organisms and their life processes . . . it is in the public interest to include microorganisms . . . it seems illogical to us to insist that the existence of life in a manufacture or composition of matter in the form of a biologically pure culture of a microorganism removes it from the category of subject matter that can be patented.[84]

[81] *Ex parte Bergy* 197 USPQ. 78; POBA (1976).
[82] *In re Bergy*, 563 F.2d 1031, 1035; CCPA (1977).
[83] Ibid.
[84] Ibid.

However, the majority opinion of this court further established a distinction between microbes and higher organisms:

> The nature and commercial issues of biologically pure cultures of microorganisms like the one defined in claim 5 are much more akin to inanimate chemical composition such as reactants, reagents and catalysts than they are to horses and honeybees or raspberries and roses.[85]

In a further move away from "product of nature" patent proscriptions, the patent claims to a purified form of 2-methyl-2 pentenoic acid (a naturally occurring strawberry-flavor molecule) were upheld in 1979 by the CCPA on the basis that "the purified chemical does not apparently occur in nature."[86]

The judicial dialectic of "products of nature" patentability was largely settled in the Chakrabarty case, in which the Supreme Court held that patentable subject matter includes "anything under the sun made by man."[87] The decisive question is the meaning of the phrase "made by man." A transgenic animal is clearly made by man, but is a pure culture of an otherwise unaltered organism similarly made?

Despite the dissent on the CCPA, the *Bergy* decisions combined to set micro-organisms apart from other organisms as no more nature's handiwork than chemical reagents. By the purification doctrine presaged by *In re Bergstrom* (i.e., the patentability of pure prostaglandins), *In re Williams* (i.e., purified racemic compound), *In re Seaborg* (purified Americium and Curium), *Merck & Co. v. Olin Mathieson Chem Corp*., and *Merck & Co. v. Chase* (purified vitamin B-12), the *Bergy* Court found a microbe patentable by virtue of its isolation from its natural milieu by human ingenuity.

However, the simple isolating of an organism may not rise to the level of invention. Although *Chakrabarty* encompassed "anything under the sun made by

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[85] *In re Bergy*, 563 F.2d 1031, 1035; CCPA (1977).
[86] *In re Batz,* 201 USPQ 71; CCPA (1979).
[87] *Diamond v. Chakrabarty*, 447 U.S. 303 (1980).

man" as patentable subject matter, in the same decision, the court also stated that "a new mineral or a new plant found in the wild is not patentable." Mere extraction and purification does not necessarily rise to the level of "made by man," according to *Merck v. Chase* and *Chakrabarty*, but it does in *Bergy* and in *Katz*. The *Manual of Patent Examining Procedure* states that "a thing occurring in nature which is substantially unaltered is not a manufacture."[88] The *Bergy* decisions shed some light on this dilemma. The courts in *In re Bergy* decided that "any product of nature which is induced to possess a new characteristic, however induced, is patentable."[89] So, for example, in the case of a pure culture of a microbe, freed from the competition of the biosphere and thereby taking on a new property, the pure culture is "*made by man*" and patentable.

In *Funk Bros. v. Kalo Inoculant*, the majority of the Supreme Court rejected the patentability of a mix of *Rhizobium* species, not because they were not patentable subject matter but because the invention was obvious and not novel over the prior art of the naturally occurring organisms. Cooper (2000) believes that the rejection of the patentability of headless/deveined shrimp *(Ex parte Grayson*, 1941) and pine-needle fibers (*Ex parte Latimer*, 1889) should have been based on the same obviousness criterion, not on the "product of nature" conundrum. The "product of nature" rejection of borax-impregnated oranges (*American Fruit Growers v. Brogdex*, 1931) and beheaded/deveined shrimp (*Ex parte Grayson*, 1941) juxtaposed with the patentability of bleached-then-dyed furs[90] exemplifies the confusion created by the "product of nature" rule—a confusion appreciated by Justice Frankfurter in the *Funk* decision:

> it only confuses the issue, however to introduce such terms as "the work of nature" and the "laws of nature." For these are vague and malleable terms infected with too much ambiguity and equivocation. Everything that happens

[88] *Manual of Patent Examination Procedure*, see 706.03 (a).
[89] *In re Bergy*, 563 F.2d 1031, 1035; CCPA (1977).
[90] *Steinfur Patents Corp. v. W. Beyer*, 62 F.2d 238; 2d Cir. (1932).

> may be deemed "the work of nature" and any patentable composite exemplifies in its properties "the laws of nature." Arguments drawn from such terms for ascertaining patentability could fairly be employed to challenge almost every patent.[91]

Moving beyond the "product of nature" criterion, the patentability of biological subject matter hinges on obviousness and novelty and the application of the "Graham criteria." These criteria provide the basis for patents on microbes *per se.* The following exemplify the issuance of U.S. patents on pure cultures of whole organisms:

U.S. Patent 6,033,659—Claim 1: "A biologically pure culture of a Bacillus cereus strain having all of the identifying characteristics of Bacillus cereus strain W35 ATCC 202074."

U.S. Patent 6,190,903—Claim 1: "A biologically pure culture of a microorganism capable of degrading organic material designated SH2A and deposited under ATCC Accession No. 55924, or a mutant derived therefrom having degrading activity of said microorganism."

U.S. Patent 5,529,927—Claim 1: "A substantially biologically pure culture of an alga species Lobosphaera TM-33 deposited as ATCC 75630."

Higher organisms represent another arena of patentability. It is now well established that "wild" microbes are patentable *per se*. But is there any reason *a priori* why higher organisms *per se* are not patentable, other than the difficulties in satisfying all patentability criteria? Courts have found that plants made by breeding techniques are not products of nature and thus are patentable (*Ex parte Hibberd*, 1985).[92] The database of issued patents reveals a large number of such patented plant varieties. The 2001 Supreme Court case of *J.E.M. AG Supply v. Pioneer*[93] reinforces the patentability of higher plants made by breeding. Cooper (2000) points out that given

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[91] *Funk Brothers Seed Co. v. Kalo Inoculant Co.,* 333 U.S. 127 (1948).
[92] 227 USPQ (Bd. Pat. Apps & Interfs. 1985).
[93] *Pioneer Hi-Bred Int'l, Inc. v. J.E.M. Agric. Supply, Inc.,* 200 F.3d 1374; U.S. App. (2000).

the patentability of higher plants made by breeding, it is illogical that animals similarly made would be unpatentable, although he acknowledges potential difficulties presented by the enablement and nonobviousness requirements. The existence of patents on mutant mice[94] suggests that the scope of patentability includes higher organisms made, in some fashion, by human ingenuity.

In 1977, the CCPA stated in *In re Bergy* that the Patent Act does not exclude living organisms. "It seems illogical to us to insist that the existence of life in a manufacture or composition of matter . . . removes it from the category of subject matter which can be patented."[95]

A year later, this liberal view was manifest when the first U.S. patent (No. 4,070,453) on an animal cell line (embryonic porcine cells) was issued and the POBA considered fungi patentable under the Plant Patent Act in *Ex parte Solomons*.[96]

The broad view of biological subject patentability created a legal tension that required a Supreme Court decision to resolve. The stage for this resolution was set when the first U.S. patent application on an engineered bacterium (i.e., inserted plasmids) was submitted in 1972 by A. Chakrabarty and his employer, General Electric. The filing of this application initiated an intellectual struggle with the U.S. Patent and Trademark Office over the patentability of a living creature, regardless of the level of human involvement in its creation. By 1976, the POBA had rejected the Chakrabarty application as being drawn to non-statutory subject matter. The POBA agreed that the invention was not "a product of nature," but stated, "we do not believe Congress intended [the U.S. Patent Act] to encompass living organisms."[97]

[94] U.S. Patent 6,316,691 – Claim 1: "a NOA atrichia mouse which has matured form an embryo, said embryo having all the identifying characteristics of deposit number ATCC 72022."
[95] *In re Bergy*, 563 F.2d 1031, 1035; CCPA (1977).
[96] *Ex parte Solomons*, 201 USPQ 42; POBA (1978).
[97] Chakrabarty Rec. 95.

The POBA relied, in part, on the argument that Congress had found it necessary to enact a special plant patent act and, therefore, had implicitly excluded other living organisms as patentable subject matter. The CCPA reversed the POBA's decision in the *Chakrabarty* appeal, relying on the *Bergy* decisions.[98]

The defining moment occurred in 1980 when the Supreme Court considered this question raised in *In re Chakrabarty*. In a 5-4 decision, the court found Chakrabarty's engineered organism a patentable subject. The majority opinion, written by Justice Burger, concisely resolved the question by deciding that "everything under the sun made by man is potentially patentable."[99]

Justice Burger explained that Congress had recognized that the relevant distinction for patentability is not between living and non-living, but between products of nature (living or not) and human-made inventions. It is this opinion that clearly defines living matter as patentable if the invention satisfies all statutory patent criteria.[100]

The Supreme Court decision of biological patentability was followed in 1985 by a POBA decision that higher plants produced by crossbreeding techniques fall within the scope of the Patent Act (*Ex parte Hibberd*[101]) and in 1987 (*Ex parte Allen*[102]) when it upheld the first patent on a method for making a higher organism.[103] In that same year, the Patent Office issued rules of whole-organism patentability, announcing that "non-naturally occurring, non-human, multicellular living organisms (including animals) are patentable subject matter."

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[98] *In re Chakrabarty*, 571 F.2d 40; CCPA (1978).
[99] *Diamond v. Chakrabarty*, 447 U.S. 303 (1980).
[100] In that same year, in a related event with tremendous future implications, U.S. Patent No. 4,237,224 (i.e., the "Cohen-Boyen Patent") was issued on the nucleic acid chemistry method of "genetic engineering."
[101] 227 USPQ 173; BPAI (1985).
[102] 2 USPQ 2d. 1425, 1427; BPAI (1987).
[103] That is, a polyploid oyster made via hydrostatic pressurization of eggs.

Underscoring this principle in 1988, the Patent Office issued U.S. Patent No. 4,736,866 to Harvard University on the "Harvard Mouse," the first patent on a transgenic, higher organism.

2.5 The Current Status of the Patentability of Biological Subject Matter

Since the Supreme Court's establishment of animate subject matter as patentable, questions of patentability have centered on the key statutory criteria: novelty, nonobviousness, enablement, and utility. Whether biological subject matter satisfies these criteria can be seen as a tension between forces that favor private property in invention and those that resist privatization in favor of the public domain. The cases that form the legal milieu of biological patentability criteria reflect this private right/public good dichotomy. The case law described below demonstrates judiciary resistance to the granting of private rights in subject matter that ought to be public domain and implies that when such rights are granted, they are balanced by a larger public good. Legal patentability tests of enablement, nonobviousness, utility, best mode, and the others that underlie these cases can be seen in this light.

The Section 112 enablement requirement ensures that the inventor fully and accurately teaches the invention to the public, enabling the public to reproduce the invention. Enablement allows other, would-be inventors to "design around" the invention, thus motivating general technological advancement for the public good. In 1949, the U.S. Patent Office allowed patent applicants to make publicly available deposits of organisms as satisfaction of enablement. This is necessary when a written description is not sufficient to allow others to reproduce the invention.[104] In cases where molecular inventions are questioned on the basis of enablement, courts have held the scope of patentability to be circumscribed by the ability of the application to

[104] *In re Wands*, 858 F.2d 731; US App. (1988).

teach how to make and use the full scope of the invention without "undue experimentation."[105]

Dispute over biological subject matter patentability has often revolved around the nature of the "conception" and "reduction to practice" of biotechnological inventions. The "conception of invention" is complete when an inventor's idea is "definite and permanent enough" for someone with "ordinary skill-in-the-art" to understand and make the invention.[106] Reduction to practice is the "physical act of producing the desired results by the means conceived by the inventor."[107] Reduction to practice of a composition of matter occurs when the composition is made.[108] Conception is the completion of the mental part of an invention.[109] The test is whether one with ordinary skill in the art could understand and make the invention based on the written description without undue experimentation.[110] Much of the legal writing on gene patentability requires genes to be "isolated." What are "isolated" genes? Are they merely purified, or is sequencing required? In *Colbert v. Lofdahl*,[111] the POBA interpreted the word "isolated" to mean disclosure of the nucleotide sequence and ruled that purification of a cloned gene is insufficient. In *Amgen v. Chugai* (1991), the CCPA upheld the patentability of DNA sequences isolated and purified, with the result that genes, if sequenced, are patentable regardless of whether they would have been obvious or how difficult they would have been to sequence.[112] The flip-side of *Amgen v. Chugai* is that a gene invention is not "reduced to practice" unless and until the gene has been isolated and sequenced, and that knowing only the amino acid sequence of a

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[105] *In re Vaeck*, 947 F.2d 488 (U.S. App. 1991); *In re Goodman*, 11F 3d 1046 (U.S. App. 1993); *In re Wright*, 999 F.2d 1557, (Fed. Cir. 1993).
[106] *Merganthaler v. Scudder* 11 App. D.C. 264, 276; D.C. Cir. (1897).
[107] *Boyce v. Anderson*, 451 F.2d 818, 9th Cir. (1971).
[108] *Standard Oil Co. v. Montedison*, 494 F. Supp. 370; D.Rel (1980).
[109] *Sewall v. Walters*, 21 F.3d. 411, 415; US App. (1994).
[110] *Burroughs Wellcome Co. v. Barr Lab., Inc.*, 40 F.3d 1223, 1228; Fed. Cir. (1994).
[111] *Colbert v. Lofdahl*, 21 USPQ 2d. (BNA) 1068, 1071; Bd. Pat. App. & Interf. (1991).
[112] *Alpert v. Slatin*, 305 F.2d 891; CCPA (1962).

gene's product does not rise to a level sufficient for invention of the gene.[113] *In re Bell*[114] confirmed in 1965 that knowledge of an amino acid sequence is insufficient to reduce a gene to practice. For some inventions, the unpredictability of results is so high that conception and reduction to practice must occur simultaneously.[115] In 1993, the Federal Circuit Court applied this doctrine of simultaneous conception and reduction to practice to gene inventions, establishing a new standard of patentability for DNA inventions—a test the Federal Circuit applied in *Amgen, Inc. v. Chugai* and later in the 1997 case *Regents of the University of California v. Eli Lilly*.[116] The present standard for gene patentability requires isolation and sequencing.

Courts have found that the doctrine of simultaneous conception and reduction to practice should be applied only to those cases where the alleged conception was followed by "extensive research characterized by perplexing intricate difficulties arising every step of the way."[117]

The first paragraph of Section 112 requires a written description of the invention "in such a full, clear, concise and exact terms as to enable any person skilled in the art . . . to make and use . . . [the invention] . . . and shall set forth the best mode contemplated by the inventor . . . ."

In *Amgen v. Chugai*, defendants Chugai and Genetics Institute counter-claimed that Amgen was not the first to invent erhythropoeitin (EPO) because Chugai scientists had first developed a method to clone the EPO gene, even though Amgen had first reduced to practice by sequencing the cloned DNA of the EPO gene. The district court defined conception to be when "one has a mental picture of the structure

[113] *Amgen v. Chugai*, 927 F.2d 1200; Fed. Cir. (1991).
[114] *In re Bell*, 991 F.2d 781; Fed. Cir. (1993).
[115] *Smith v. Bousquet*, 111 F.2d 157, 159; C.C. P.A. (1940).
[116] *Regents of the U of California v. Eli Lilly & Co.* 119 F.3d 1559, 1566-67; Fed Cir. (1997).
[117] *Alpert v. Slatin*, 305 F.2d 891, 894; CCPA (1962).

of the chemical or is able to define it by its method of preparation, its physical or chemical properties, or whatever characteristics sufficiently distinguish it."[118]

The court held that merely describing a method for cloning the gene was insufficient for conception because at the time the description was made, the EPO protein sequence was uncertain and the cloning method was unpredictable. In *Fiers v. Revel* (1993), the Federal Circuit Court found that conception requires definition of the inventive substance other than by its functionality and that the DNA sequence *per se* is required for conception. In *Chiron v. Abbott Laboratories*,[119] the Northern California District Court further narrowed conception to require knowledge of the sequence *per se*. In *Regents of University of California v. Eli Lilly*, the court held that conception has not occurred until the gene has been isolated, defining the "written description" requirement: "an adequate written description of DNA requires a precise definition such as by structure, formula, chemical name or physical properties, not a mere wish or a plan for obtaining the claimed chemical invention; a description of rat insulin cDNA is not a description of the broad class of vertebrate or mammalian insulin cDNA."[120]

The *University of California v. Eli Lilly* case seems to argue that allelic or splice variants are not covered by claims to a single DNA sequence.

Lucas (1998) points out that in biotechnology, the "state of the art" at the time of invention can change rapidly, which affects the standards of invention over time. For example, in the past, knowing an amino acid sequence was sufficient to discern the encoding gene sequences, but now, knowledge of introns and complexities of regulatory sequence regions disrupt this causal linkage. By the *Merganthaler* standard, patentability of a gene sequence depends on the test of whether "the applicant [is] able

[118] *Amgen, Inc. v. Chugai Pharmaceutical Co*., 706 F. Supp. 94 (D. Mass. 1989).
[119] *Chiron v. Abbott Laboratories*, 902 F. Supp. 1103; N.D. Cal. (1995).
[120] *Regents of University of California v. Eli Lilly,* 39 USPQ 2d 1225; S.D. Ind. (1995).

to distinguish the claimed DNA from all other DNA and [whether one] can . . . understand, make and use the invention."[121]

Since *Chakrabarty*, the general trend of court decisions on gene patentability has been to limit broad patent claims by requiring sequence data and to tighten the requirements of enablement and written description. *Amgen v. Chugai*[122] limits inventors from claiming all species variants of a DNA sequence unless the effect of variants can be reliably predicted. *In re Vaeck*[123] limits the patentability of genetic recombinants to that which is clearly supported by existing data. Similarly, *In re Goodman*[124] and *In re Wright*[125] limit the scope of patentability to the species in which the invention was actually enabled. In *Genentech, Inc. v. Novo Nordisk*,[126] the court examined the patentability of "fusion proteins" and determined that although a written description of the invention had been made, it was not enabling because another five years of work (i.e., "undue experimentation") was required to reduce it to practice. In *Enzo Biochem Inc. v. Calgene, Inc.*,[127] the court used a similar "undue experimentation" test in rejecting the validity of patents broadly claiming any antisense DNA in prokaryotic or eukaryotic organisms because the patent enabled only *E. coli*.

The combination of *Amgen v. Chugai, Fiers v. Revel*, and *Regents of the U. of Calif. v. Eli Lilly* produces a situation in which an invention disclosure may render an invention obvious but still be insufficient to satisfy the written description and enablement requirements.

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[121] *Merganthaler v. Scudder* 11 App. D.C. 264, 276; D.C. Cir. (1897).
[122] *Amgen v. Chugai*, 927 F.2d 1200; Fed. Cir. (1991), 106.
[123] *In re Vaeck*, 947 F.2d 488; US App. (1991).
[124] *In re Goodman*, 11 F.3d 1046, 1048-49; Fed. Cir. (1993).
[125] *In re Wright*, 999 F.2d 1557, 1559; Fed. Cir. (1993).
[126] *Genentech, Inc. v. Novo Nordisk*, 108 F.3d 1361; Fed. Cir. (1997).
[127] *Enzo Biochem, Inc. v. Calgene, Inc.*, 188 F.3d 1362; Fed. Cir. (1999).

Sampson (2000) argues that the court's limitation of broad claiming maintains an appropriate balance between the public domain of innovation and private rights in real discovery. However, such limitation might also discourage investment for revolutionary breakthroughs and encourage a plethora of narrow patents.

Lucas (1998) points out inconsistency in circuit court decisions concerning conception and reduction to practice of gene versus other biomolecule inventions. Whereas DNA must be claimed by its sequence rather than its function,[128] antibodies are claimed by their function, not their structure.

The most recent statement on the patentability of biological subject matter is the U.S. Patent and Trademark Office *Utility Examination Guidelines* (*Guidelines*), published in the Federal Register and made effective on January 5, 2001,[129] which superseded the *Revised Interim Utility Examination Guidelines* of December 21, 1999.[130] The *Guidelines* respond to a variety of public comments concerning the patentability of genes and take a strict constructionist approach. They confirm that genes are patentable inventions. The *Guidelines* make it clear that a gene's genetic composition, isolated from nature and processed to achieve purification, is the basis for a patent.

The *Guidelines* also clarify the utility requirement for a gene patent, stating that patentability criteria include a specific and credible use for the gene.

Public comments that a gene is not a novel composition of matter because it pre-exists the invention in nature and is an unpatentable "product of nature" are refuted in the *Guidelines* because purified genes do not exist in nature.

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[128] *Fiers v. Sugano,* 984 F.2d 1164; US App. (1993).
[129] Fed. Reg./Vol. 66, No. 4, Jan. 5, 2001/Notices.
[130] Fed. Reg./Vol. 64.

The *Guidelines* refer to the Pasteur patent[131] and several cases[132] that support the purification-doctrine basis of these patentability premises. In an implicit rejection of vitalism, the *Guidelines* state that DNA molecules, like other chemical compounds, are eligible for patents when isolated from their natural state and purified or when synthesized in a laboratory from starting materials. The *Guidelines* also clarify that a patent on a purified gene sequence has no relation to and no force over the gene as it exists in nature. For example, patents issued on pure adrenaline are not infringed by normal bodily function. The *Guidelines* suggest that claims to a genus of DNA sequences could be allowable if a sufficient number of representative species are disclosed. The *Guidelines* also indicate that the current strict written-description requirements may be relaxed by stating that the specification must allow one to reasonably conclude that the inventor had possession of the claimed invention and that such possession is based on the interpretation of various factors.

The *Guidelines* reject a call for Congressional consideration of the gene-patentability issue, stating that Congress and the Supreme Court have already made their intentions clear.

2.6 The Scope of Patent Rights and the Patentability of Organisms *per se*

It is important to understand the nature of the rights granted by a patent. U.S. Code, Title 35, Section 154, Chapter 10(a)(1) provides that "Every patent shall . . . grant to the patentee, his heirs and assigns, of the right to exclude others from making, using, offering for sale, or selling the invention in the U.S. or importing into the U.S. . . . "

The *Guidelines* clarify that a patent does not grant the patent holder the right to use the invention; it grants the patentee the right to exclude others from making, using,

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[131] U.S. Patent No. 141,072.
[132] *Parke-Davis & Co. v. H.K. Mulford Co.*, 189 F. 95, 103; S.D.N.Y. (1911); *In re Bergstrom*, 427 F.2d 1394; C.C.P.A. (1970).

and selling the patented subject for a limited period of time. Furthermore, unlike with other forms of private property, it does not grant the right to possession, either exclusive or non-exclusive. There is a subtle but powerful distinction between a patent right and personal-property ownership. A patent grants limited exclusionary rights over a patented composition but does not grant ownership of the composition. For example, the owner of U.S. Patent No. 6,190,903, which claims a purified culture of bacteria designated “SH2B ATCC No. 202050,” has the right to stop others from making, using, or selling these bacteria as pure cultures but does not have the right to their exclusive possession. The propagation of pure cultures of the bacteria could be prohibited as “making,” but the patent holder cannot force a possessor to destroy the pure culture. However, the extraction of information on DNA sequences or novel proteins would be an infringing “use” and would be prohibitable. In this way, a patent holder could temporarily monopolize the genome and biological-discovery potential of a wild but purified organism. Patent claims to particular uses of an organism do not confer this broad right of wild genome “ownership”; nor do claims to organisms created by genetic engineers, because the original wild type is not claimed.

Since the patent right on organisms *per se* confers such potentially broad ownership rights, it is important to elucidate the basis for the patentability of purified—but otherwise unaltered—organisms *per se* and to understand the limits of such patentability.

The *Diamond v. Chakrabarty* rule that “anything under the sun made by man” is patentable excludes wild organisms. Except, under *Bergy I and II*, micro-organisms are patentable when made into a pure culture. This patentability is not limited to prokaryotes. Microbial eukaryotes (i.e., protists, algae, and fungi) are also patentable. For example, U.S. Patent No. 5,529,927 claims “a substantially pure culture of alga species Lobosphaera TM-33 deposited as ATCC 75630.”

Although patents on multicellular, more highly differentiated organisms are normally considered precluded by obviousness and novelty criteria (Rohrbaugh, 1997), Cooper (2000) argues for the patentability of such organisms, such as unique livestock made through selective breeding.

CHAPTER 3:
PROPERTY IN WILDLIFE

3.1 Introduction

Analyzing the relation of patents to wildlife conservation law requires an understanding of patent law and its applicability to invention. The previous chapter provides this understanding. Along with this, an understanding of biota property and wildlife property, in particular, is necessary. In the next two chapters, I describe biota property in two major parts. This chapter describes property rights in biota and wildlife, and the next chapter describes wildlife property as it derives from biological conservation law.

This chapter defines an overarching theme of property-regime types and the fundamental notion of ownership as a bundle of distinct property rights. This provides a lexicon to describe the evolution of the concept of property in wildlife in the United States from Roman and English roots. A discussion of the development of the federal–state balance of sovereignty over wildlife provides a basis for a larger appreciation of the wildlife-property situation.

A fundamental nexus of state versus personal property in wildlife is identified, which leads to an articulation of the rules of personal property in biota and its relation to government rights in wildlife. A discussion of obscure biota, ambiguous property definitions, and the complex patchwork of complicated and overlapping property in wildlife completes the discussion.

This framework, combined with the detailed analysis of biological conservation law in the next chapter, provides the basis for an analysis of the intersection of patent law and biological conservation law.

3.2 A Background in Property and Wildlife

Possession of wildlife is a prerequisite for creating a patent from it. Analyzing this connection between tangible and intangible property in wildlife requires an understanding of the fundamental relation between property and biota, generally.

The right to possess and use wildlife is the domain of property. Whether explicit or not, property in wildlife—its definition, enforcement, and use—is fundamental to the relationship of wildlife to human society. Lueck (1995, 1989, 1998) has described the basic role property plays in the legal, political, and economic milieu of wildlife. Property also provides an effective framework for analyzing the political economy of wildlife, but simple views of "owning" wildlife are not applicable. In one of the Supreme Court's most definitive statements on the issue, Chief Justice Holmes declared in *Missouri v. Holland* that "owning" wildlife is an oxymoron, and that although no one owns wildlife, the sovereign has an obligation to assert rights over a public good.

A sophisticated analysis of property in wildlife encompasses biota that are transient and fixed, free-roaming and captured, whole specimens (living and dead), their parts and by-products. Then, in order to understand the relation of such wildlife property and intellectual property, the dichotomy of tangible versus intangible property must be analyzed.

A comprehensive framework of property in wildlife is developed below. This framework is built on a taxonomy of the four archetypal property regimes, a definition of the "bundle" of distinct property rights, and the tangible/intangible property duality in biota.

A discussion of the evolution of the wildlife-property regime in the United States, including the dialectic of state versus federal sovereignty over wildlife from the colonial era to the present, provides context for the current relation of governmental control and private rights.

The nature of the governmental property interest in wildlife and the establishment of private property in wildlife are defined. Unique rules of biota property that play a role in the connection between wildlife and patents are also described.

3.3 Relevant Property Fundamentals

3.3.1 A Taxonomy of Property Regimes

A fundamental taxonomy of property regimes has emerged through a variety of analyses (Randall, 1987; Berkes, 1989; Ostrom, 1990; Tisdell, 1991). This taxonomy comprises four basic regimes:

Res nullius: null property (e.g., sunlight, air).

Res privatae: private property (e.g., private land).

Res publicae: governmental ("public") property (e.g., public roads).

Res communes: private property held by a group of owners (e.g., corporate assets, a condominium).

This taxonomy allows dissection of the mixture of property rights that exist in any particular resource scenario. For example, property rights in water may be non-existent (*res nullius*) as in clouds or the sea, private (*res privatae*) as in purchased bottled water, public (*res publicae*) as in a navigable river, or communal (*res communes*) as in a group-owned irrigation system.

Free-roaming, captured, living, and dead wildlife organisms and their parts in the United States fall into the following property regime categories:

Res nullius: all individuals, populations, and their parts not listed in federal or state law as controlled and not "fixed" (growing on or in soil) to private land.

Res privatae: all individuals fixed to private land; all legally-captured organisms and their parts.

Res publicae: all free-roaming individuals, populations, and their parts listed in federal or state law as controlled.

Res communes: all *res privatae* individuals managed by a group.

3.4 The Property-Rights Bundle

Close inspection of the property institution (Dukeminier and Krier, 1993) reveals that property "ownership" is defined by a "bundle" of distinct rights. For example, although one may own a car and hold, through title, the exclusive right of possession, the right to use is limited by public-safety law. If the car is leased, the possessor or user is not the owner. In usufruct rights, one has rights to use but not to own. If the car has a lien on its title, the owner's property rights are mitigated by the lien-holder's rights.

Becker (1977) describes the following distinct property rights and liabilities as first defined by Honoré (1961):

- The right to possess; exclusive physical control; the right to exclude others from use or benefits
- The right to use
- The right to manage (how and by whom a thing shall be used)
- The right to income
- The right to capital (the power to alienate the property; the right to consume, waste, modify or destroy)
- The right to security (immunity from expropriation)
- The right of transmission (the right to bequeath)
- The absence of term (indeterminate length of ownership)
- Prohibition against harmful use (to others)

- Liability to execution (liability to having the thing taken for repayment of a debt)
- Residuary character (existence of rules governing the reversion of lapsed ownership rights)

Complete or full ownership requires the holding of each of these separate rights and liabilities. It is rare that anyone holds all of these rights, unfettered, in any particular property. For example, holding title to land usually encompasses many of these rights, but zoning law constrains rights to use or manage. Even properties that appear to be unfettered (such as one's own body) have less than a full set of the bundle of these rights.

Combining the distinction of property right with the property-regime taxonomy provides a framework for categorizing property within the *res privatae–res publicae* continuum illustrated in Figure 3.1.

The property continuum ranges from "most" private (*res privatae*), on the left, to "most" public (*res publicae*), on the right. Between these extremes lie property blends. Some of the blends are primarily private with some public rights (e.g., a private home); others are primarily public with some private rights (e.g., national forest campgrounds). Note that *res nullius* is not on this scale. There is no property in *res nullius* until capture, when it becomes *res privatae.*

Wildlife property can be characterized according to this framework.

For example, in New York, a free-roaming bear is *res publicae,* and the state prohibits *res privatae* possession. State law allows possession of a captured (killed, not caged) bear under a license. The carcass now becomes mostly *res privatae.* Since the possessor may not sell and the state retains some minimal property rights in the carcass, the carcass is *res privatae*/*res publicae.*

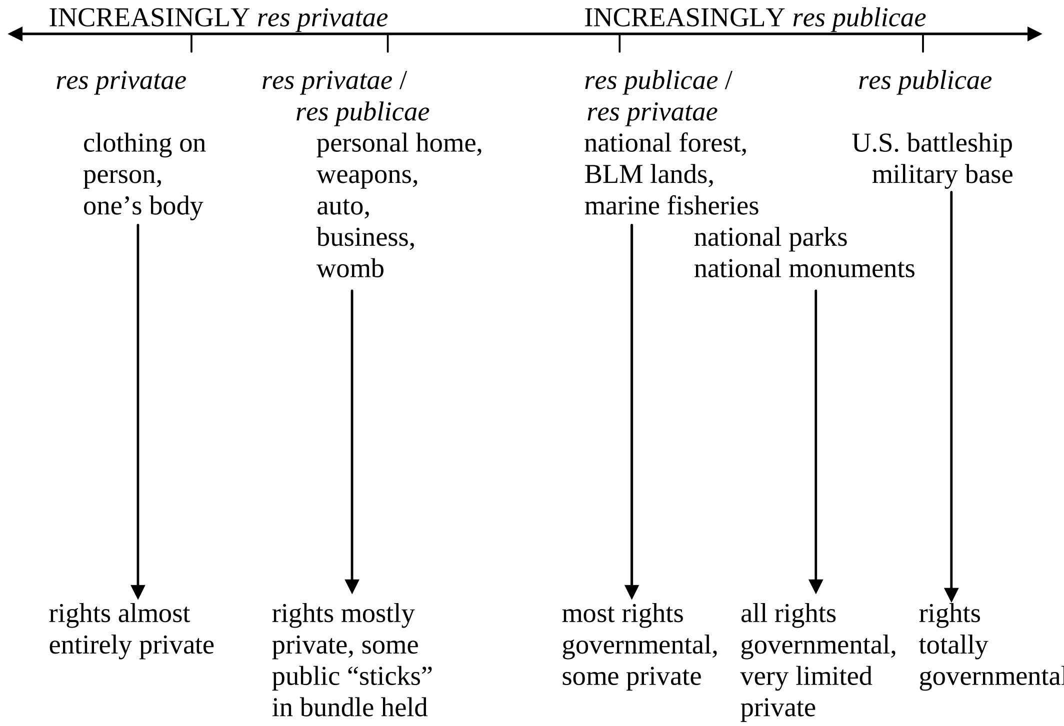

Figure 3.1. Examples of Property Types Across the Property-Taxonomy Continuum.

3.5 Antecedents of Sovereignty and Property in Wildlife in the United States

The control of wildlife has a long history. According to Lyster (1985), forestry conservation laws were in place in Babylon as early as 1900 BC. In 1370 BC, Akhenaten, an Egyptian pharaoh, established a protected nature reserve. In the third century BC, the Indian emperor Ashoka asserted sovereignty and protective control over all parrots, mynas, arunas, wild geese, cranes, bats, queen ants, terrapins, boneless fish, rhinos, and all quadrupeds not edible or useful within his kingdom.

Lafargue (1894) and Laveleye (1878) describe property concepts in early cultures. In many tribal cultures, private-property rights were limited to simple personal possessions (e.g., clothes, adornments). Less personal items (e.g., food, shelter) were generally available to all members of the tribe. Whereas intra-tribal property was typically communal, property rights between tribes were often vigorously defended—those associated with tribal hunting grounds, for example

(Johnson, 1986). In early hunter-gatherer cultures, wildlife was, like all natural resources, *res nullius.* The assertion of property rights in wildlife was not feasible except through the enforcement of hunting grounds and the control of hunting and fishing methods and seasons, which created a form of inter-tribal *res communes* (Lueck, 1995).

While wildlife was *res nullius* in early human societies, the process of biota domestication began. Dogs, chickens, goats, cows, and crops were variously converted from a wild to a domesticated state, and with that conversion, a transformation of property took place. Although issues of property in domesticated biota lie largely outside the scope of this work, it is useful to understand some of the unique domesticated biota-property rules and customs: in particular, where the conversion of wild to domesticated takes place through capture[1] and rules that pertain to property in animals, their parts, and progeny.

3.5.1 Roman Law and Biota

Roman law is the foundation for biota law in both England and the United States (Amos, 1883; Sohm, 1907). Lafargue (1894) claims that the concept of wildlife as a *res nullius*/*res communes* mix in early human tribal cultures was lost in the establishment of Roman law.

Property in domesticated animals has evolved over hundreds of years and is essentially a basic personal-property right. For centuries, flocks of poultry, herds of goats, cows, camels, oxen, yaks, and horses have been owned, bought, sold, traded, and rented. A key element in the ownership of domestic biota is the property's ability to reproduce. Typically, possession and contracts dictate ownership of domesticated biota. However, several common-law doctrines that hark back to Roman law also govern such ownership. For example, the owner of a mother animal normally owns the

[1] "Capture" is a legal term that includes caging, taming, and killing.

progeny, and the finder of stray domesticated animals is not the owner unless the owner cannot be found (St. Julian, 1995).

Roman law held that all wildlife was *ferae naturae*,[2] a *res nullius* resource, not owned by anyone but *res privatae*–ownable by first possession by capture, taming, or killing (Thomas, 1975). Roman law did not control what animals could be possessed or where (Favre, 1983), and once they were possessed, did not control their use. This doctrine of first possession as a basis of a property right in a *res nullius* wildlife, and the rules that apply to the conversion of wild *res nullius* to wild *res privatae,* are a critical theme.

Within Roman law, complex rules of property developed. Some of these rules apply only to biota property, while others are more general. Some of these rules may apply to property questions in biotechnological utilities. These include the following:

Per industrium hominis: Property in biota confined or killed by humans.

Per impotentium: Property in immature or disabled wildlife by virtue of their inability to escape.

Ratione soli: Property in transient wildlife by way of ownership of the land where the biota nests (defined property in bees).

Animus revertendi: Property in wildlife that, by its own volition, return to the control of an individual, and such property right is retained by that individual even when the biota is outside direct control.

Accretio: The act of growing to a thing (usually applies to very gradual increase such as in the accumulation of land through natural causes). Sometimes used to define the ownership of additional animals produced in herds as a result of reproduction.

[2] “Ferae” means wild or untamed, and “naturae” means of nature or natural.

Accessio: Personal property that is principally supplied by one party but altered and/or improved by the labor or materials of another, particularly when the alteration/improvement adds significantly to the value of the original materials. For example, the one who turns grass into hay owns the hay by *accessio.*

Plantatio: Property in seeds or plants implanted in soil belongs to the owner of the land.

Adjunctio: A species of *accessio* whereby two or more things belonging to different owners are bought into firm connection with each other: interweaving (*intertextura*), welded together (*adferruminatio*), soldering together (*plumbatura*), building (*inaedificio*), sewing (*satio*), or planting (*plantatio*).

Confusio: The inseparable intermixing of property belonging to different owners (typically relates to fluid mixing).

Commixtio: Similar to *confusio*, but a later separation can be made. Property in mixtures belongs to all owners of the starting materials.

Res nullius naturaliter fit primi occupantes: Anything that naturally has no owner belongs to the first possessor.

Bona vacantia: Property in stray biota belongs to the finder.

Roman law also established rules for biota progeny and by-products. Without an agreement to the contrary, the owner of the mother also owns her progeny; likewise, the owner of the producer owns the produce (e.g., the chicken owner owns the chicken's eggs).

3.5.2 English Wildlife Law

After the Norman Conquest of England in 1066 AD, the notion that the sovereign had exclusive authority to hunt or fish anything, anywhere, anytime was ascendant (Nelson, 1732; Murphy, 1968). Rights to take wildlife became an integral part of the patronage system in which the aristocracy acquired limited rights in fish and game through sovereign grants (Bean and Rowland, 1997). Rights to possess and use wildlife in England and the United Kingdom followed a set of rules summarized as follows:

Park: The rights to hunting "superior" game (e.g., deer, fox, martin) only on the grantee's land.

Chase: The right to hunt superior game across the lands of others.

Freewarren: The right to hunt "inferior" game (e.g., fowl, hares) only in defined areas if others are actively excluded.

Several fishery: The right to take fish in a particular body of water.

Common piscary: The non-exclusive right to fish in a particular river or body of water.

English wildlife law became a complex mix in which the sovereign and the landed aristocracy shared property rights in certain wildlife (Lund, 1980; Tober, 1981). However, the idea that wildlife in England was the sovereign's property was weakened by the fact that the king did not frequently or comprehensively assert a property interest in game (Lueck, 1989). English game laws from 1389 to 1831 were characterized as "qualification statutes" that restricted the possession of game to "qualified individuals" (landowners, aristocracy, and the wealthy) but did not supersede trespass law. By 1785, a hunting certificate was required. The qualification statutes were abolished in 1831, giving landowners explicit ownership of all wildlife on their land. The 1986 case of *Blade v. Higgs* firmly placed wildlife-property rights in the hands of the landowner in the United Kingdom (Lueck, 1989).

The philosophical contest of wildlife property occurred in England around the time of the American Revolution. This contest was manifest in a long-running debate between Sir William Blackstone and Professor Edward Christian and laid the foundation for the early roots of wildlife property in the new United States (Lund, 1980).

Blackstone, using Roman wildlife law as a basis, argued that wildlife is *res nullius* and that any property rights in land or biota are granted by the sovereign and are therefore *res publicae* (Blackstone, 1781). Christian held that property in wildlife was *res privatae,* flowing from the owner's property rights in the land. Blackstone was philosophically opposed to the privileges of the landed gentry bestowed by the English game laws and based his arguments for *res publicae* wildlife on several doctrines (Lund, 1980). First, under feudalism, the sovereign has full access to all lands and game in its domain, and any wildlife are stray goods (*bona vacantia*), which belong to the sovereign. The English history of granting royal game franchises to nobles also supported Blackstone's argument for the sovereign's rights in wildlife. Christian argued that the primacy of rights in land ownership superseded any sovereign's right in wildlife, pointing to the *Case of the Swans,* in which the judge, Lord Coke, implied that royal rights did not extend beyond a few explicitly stated game. Blackstone maintained that the sovereign's rights in wildlife were tacitly based on five hundred years of English game law. Christian countered that no prosecution had ever been based on Blackstone's theories of sovereign's property in biota (Lund, 1980). Christian's view eventually prevailed in the United Kingdom: landowners there hold a property interest in the wildlife on their land (Lueck, 1989).

Early jurisprudence in the United States diverged from the U.K. position, instead taking the Blackstone path. Lund (1980) posits that Blackstone's view became dominant in the new United States because it was more suited to frontier conditions and the philosophical bent of former colonists opposed to the power and privilege of landed aristocracy. The wildlife-property regime in the early United States was a frontier of *res nullius* in which anyone had free access to wild game and fish, regardless of land ownership, allowing acquisition of *res privatae* by capture or killing (Gabrielson, 1951; Sigler, 1972).

3.6 The Evolution of Sovereignty in Wildlife in the United States

The property regime in wildlife in the United States has evolved on several fronts. The first involves the symmetry between government and an individual's rights to useful wildlife. This has been a long undertaking of allocating wildlife property between the open access of *res nullius*, private rights in *res privatae,* and public control of *res publicae*—essentially, an evolution of the balance between the public good and the private right. This mix is partly defined by the distinction between transient and fixed biota. Another front is the dynamic of federal versus state sovereignty. As a result of two hundred years of evolving law, the federal/state balance of sovereignty in wildlife in the United States is a complexity of overlapping and interdigitated jurisdictions.

In summary, property in wildlife in the United States is a story of the development of wildlife from frontier *res nullius* to increasing state and/or federal control over wildlife, all within a balance of private and public rights, manifest through capture and use.

A basic distinction in the evolution of wildlife property is the criterion of mobile, transient animals versus plants fixed in place. The concept of *ferae naturae,* which is the basis of Roman *res nullius* and the root of U.S. law, refers to transient wild animals. Plants, being normally fixed, have fallen outside the traditional *res nullius* umbrella and have been considered a part of the land and its property milieu. Bean and Rowland (1997) note the historical conceptual distinction between animal wildlife and plants.

The evolution of fish and game wildlife law represents a large portion of the wildlife-property question. But it ignores plants and other less obvious organisms such as fungi, bacteria, algae, and viruses. Furthermore, U.S. wildlife law has encompassed only useful fish and game and has almost completely ignored other, traditionally less useful wild organisms such as arthropods and other invertebrates (Tober, 1981; Bean and Rowland, 1997). This inattention becomes relevant as biotechnology creates new utilities in such organisms.

3.6.1 Frontier Phase: Wildlife as *Res nullius*

In the early United States, an individual's access to wild fish and game was a matter of survival. The English notion that property in wildlife was tied to property rights in land was rejected. All roaming wildlife were *res nullius* and became *res privatae* on capture. In these early years, an individual's right to take and possess wildlife from the common *res nullius* pool was so strong it superseded a landowner's right of exclusive access (Lund, 1980; Tober, 1981). Bean and Rowland (1997) point out that in the general laissez-faire attitude toward wildlife property in the early United States, however, some landowners did assert ownership of wildlife on their lands.

The *res nullius* regime in the early United States was interspersed with a few early state laws regulating the taking of select wild game; for example, a 1710 Massachusetts law limited deer hunting, and a 1741 New York law limited the location of certain hunts (Matthieson, 1959). By the late 1700s, a number of state wildlife laws controlled the season, means of taking, and type of animal (Lund, 1980; Tober, 1981; Bean and Rowland, 1997). In this early period, all wildlife was *res nullius,* with first possession the means of acquiring *res privatae* property. The 1805 New York Supreme Court case *Pierson v. Post*[3] revolved on the question of when and how first possession provided an individual *res privatae* in otherwise free-roaming *res nullius* wildlife. The judges in this case invoked the *res nullius* nature of *ferae*

[3] *Pierson v. Post*, 3 Cai. R. 175; NY (1805).

naturae, stating that "property in such animals is acquired by occupancy only"[4] and that under Roman law, pursuit *per se* did not rise to possession. However, the judges decided that mortal wounding deprived the animal of its natural liberty and satisfied the rule of capture and perfection of a *res privatae* property right.

3.6.2 The Decline of Wildlife and the Rise of State Sovereignty in Wildlife

In the United States of the 1800s, the dominance of *res nullius* and *res privatae* via capture coupled with the rise of unfettered market-hunting led to precipitous declines in wildlife populations and even extinctions of some species, such as the heath hen, passenger pigeon, Carolina parakeet, and Audubon sheep (Matthieson, 1959; Tober, 1981; Lueck, 1989). Hanner (1981) describes how the lack of *res publicae* control of the bison was key to its near-extirpation. The pressure of obvious wildlife loss led to the beginnings of a conservation movement and the rise in the 1800s of state laws and regulations controlling the taking of wild game and fish (Lund, 1981; Tober, 1981; Bean and Rowland, 1997). For example, laws in Massachusetts (1855), Vermont (1850), and Connecticut (1850) provided year-round protection for song and insectivorous birds, although these laws did not apply to landowners (Tober, 1981). This dichotomy of private-property rights in land versus right in wildlife is pivotal in the evolution of the *res publicae* regime in wildlife.

State wildlife conservation laws began to appear in earnest in the 1870s. For example, New York passed a law controlling market-game hunting in 1871. Colorado (1872) and Oregon (1874) passed laws regulating the killing of big game. Maryland passed a law in 1872 controlling the taking of waterfowl and oysters, and in 1871, North Carolina passed a law mandating hunting methods and apparatus (Tober, 1981; Bean and Rowland, 1997). By the 1900s, most states had established strong

[4] Ibid.

proprietary interest in wildlife, especially by regulating hunting season period, bag limit, hunting methods, and access through licensing (Palmer, 1912).

The rise of state wildlife laws led to court tests of the states' rights to control the possession and use of wildlife. For example, in 1875, the New York Court of Appeals upheld the state's powers to regulate the taking, sale, and possession of game (Tober, 1981). In 1881, in upholding a state law forbidding the marketing of quail during the closed season, the Illinois State Court stated, "it is accurate to say that the ownership of the sovereign authority is in trust for all the people of the state."[5]

In 1894, the Supreme Court of Minnesota questioned the right of the state legislature to declare all wild game the property of the state and found that "to be the correct doctrine in this country that the ownership of wild animals, so far as they are capable of ownership, is in the state, not as proprietor but in its sovereign capacity as the representative and for the benefit of all its people in common."[6]

The rise of a state property interest in wildlife was a slow process as a result, in part, of resentment of England's oppressive game laws (Gabrielson, 1951; Matthieson, 1959). The gradual assertion of state *res publicae* created a tension of government authority over a public good, which later ultimately led to Supreme Court confirmation of *res publicae* of certain wildlife. Early tests of states' assertions of *res publicae* rights in wildlife that rose to the Supreme Court secured state sovereignty over wildlife.

The first wildlife case to come before the U.S. Supreme Court was *Martin v. Waddell,* in 1842.[7] This case, which involved property in oysters in tidal soils, confirmed the *res publicae* nature of these wildlife. The court[8] found that the British king's grant of land rights to a duke in New Jersey was superseded by the king's

[5] *Magner v. People,* 97 Ill. 320; Ill. (1881).
[6] *State of Minnesota v. Rodman,* 58 Minn, 393 (1894 Minn).
[7] *Martin v. Waddel,* 41 U.S. 367 (1842).
[8] Chief Justice, Roger Taney.

public-trust responsibility and that the duke's rights could not abrogate the "public common of piscary."[9] This ruling established the state's property right in this wildlife through the government's public-trust obligation. In a similar case (*Smith v. Maryland*) a few years later, the Supreme Court held that a state's ownership of the soil (tidal) of state-controlled land conferred to the state the right to regulate the taking of oysters from that soil.[10] The doctrine of state wildlife property as public trustee was substantiated in *McCready v. Virginia*, a related Supreme Court case in which the court found that the states owned tidewaters and the fish in them,[11] a finding that extended the doctrine of *ratione soli* to transient animals.

Any doubts that states had sovereignty over wildlife were laid to rest in 1896 by the Supreme Court, in *Geer v. Connecticut.*[12] With this decision, the Supreme Court clearly established that states held a property interest in wildlife. The court examined the nature of property in game and a state's authority therein. The case involved the legal taking of birds in a state and the subsequent interstate shipment of such birds against state law. *Geer v. Connecticut* firmly established state rights in wildlife. The court affirmed a state's right to control and regulate public property in game, a doctrine that would hold for the next 80 years. The court held that individual property rights in wildlife can only be acquired such as the sovereign may allow. Although this 1896 court decision solidified states' sovereignty in wildlife, it also hinted at ultimate federal authority in wildlife, a prescient decision. State sovereignty over wildlife was further confirmed in *Ward v. Racehorse* (1896),[13] *Patsone v. Pennsylvania* (1914),[14] and *New York ex rel. Kennedy v. Becker* (1916).[15]

[9] *Martin v. Waddel*, loc. cit.
[10] *Smith v. Maryland*, 59 U.S. 71 (1855).
[11] *McCready v. Virginia*, 94 U.S. 391 (1876).
[12] *Geer v. Connecticut*, 161 U.S. 519 (1896).
[13] 163. U.S. 504, 510 (1896).
[14] 232 U.S. 138, 143 (1914).
[15] 241 U.S. 556, 562 (1916).

3.6.3 The Rise of Federal Sovereignty in Wildlife

The beginning of federal sovereignty assertion over select wildlife was *Manchester v. Massachusetts*,[16] in which the 1891 Supreme Court upheld the right of states to regulate the possession of oysters. But the court was ambiguous about state ownership in wildlife and explicitly hinted at ultimate federal authority over wildlife. The court also differentiated between "sedentary fish" (e.g., oysters) and "swimming fish," using the long-held distinction between "fixed" and transient biota.

Before 1894, the federal government asserted little authority over wildlife on its lands. President Harrison's proclamation in 1882 reserving Alaska's Afognak Island "in order that salmon fisheries in the water of the Island and salmon and other fish and sea animals and birds . . . may be protected and preserved unimpaired"[17] asserted federal control over the wildlife in the first federal wildlife refuge. The Yellowstone National Park Act of 1894[18] prohibited hunting in the world's first national park. In 1906, the federal government prohibited the hunting of birds on "all lands of the U.S. which have been set apart or reserved as breeding grounds for birds by any law, proclamation or Executive Order."[19]

Bean and Rowland (1997) suggest that no legal challenges were mounted against these early assertions of federal property in wildlife on federal land since it was assumed that the government had the same right to control hunting on its land as any landowner of that time. However, states began to challenge federal authority over wildlife when federal activity impinged on state-controlled or private land or when such federal activity ran counter to state law.

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[16] 139 U.S. 240 (1891).
[17] Proclamation No. 39, 27 Stat. 1052.
[18] Yellowstone National Park Act of 1894, Ch 72, 28 stat. 73.
[19] Act of June 28, 1906, Ch 3565, 34 Stat. 536.

In 1900, the Lacey Act,[20] the first federal wildlife legislation, was passed. This law bolstered the states' regulatory authority over wildlife but gave the federal government the power to control interstate trade in wildlife and authorized the U.S. Department of Agriculture to pursue the conservation of birds.

The gradual shift of sovereignty in wildlife from states to the federal government was given impetus in the 1912 *Abby Dodge*[21] case, which involved the regulation of taking sponges in U.S. coastal waters. In *Abby Dodge*, the Supreme Court acknowledged the federal government as the ultimate authority over select wildlife.

The first statutory assertion of federal property in wildlife, the Migratory Bird Treaty Act of 1917, and the subsequent state challenge to such federal sovereignty in wild birds in *Missouri v. Holland* in 1920[22] together represent a watershed in the dialectic of state versus federal wildlife property.

Concern in Congress that migratory birds were in danger of extirpation and the realization that this transient resource could not be effectively managed by individual states led to the introduction of federal legislation in 1904. By 1913, a federal law protecting migratory birds had passed. There was significant opposition to this law, despite its basis in long-established state sovereignty over wildlife (Lofgren, 1975). The 1913 law was barely enforced by the Department of Agriculture (the responsible agency), and on the rare occasions on which the law was challenged, federal courts held that states, not the federal government, had sovereignty over game. Thus, in *U.S. v. Shauver*,[23] a district court relied on *Geer v. Connecticut* to find that sovereignty in game flowed from the original colonies to the states. Similarly, in *Silz v. Hesterberg*,[24]

[20] Lacey Act, Ch 553, 3, 31 Stat 188 (1900).
[21] *Abby Dodge*, 223 U.S. 166 (1912).
[22] *Missouri v. Holland*, 263 U.S. 49 (1918).
[23] *U.S. v. Shauver*, 214 F. 154 (E.D. Ark, 1914).
[24] *Silz v. Hesterberg*, 211 U.S. 311 (1908).

the court's decision was contrary to federal government arguments that migratory birds were the public property of the United States. The assertion of federal property interest in wildlife encountered strong philosophical resistance. So, supporters of federal control pursued a surer route to federal sovereignty—the exclusive federal treaty power (Bean and Rowland, 1997). Subsequently, the Convention with Great Britain (on behalf of Canada) for the Protection of Migratory Birds was negotiated and signed in 1916 and ratified by Congress later that year.[25] Lofgren (1975) describes the emergence of the two positions on state versus federal sovereignty in wildlife after ratification. The federal position argued that wild bird protection was a proper treaty subject; a treaty had supreme law status and constitutionally designated the federal government as the sovereign. States' rights advocates argued that a treaty cannot validate unconstitutional legislation and that the courts had long held wildlife as falling under the states' domain.

The treaty's implementing legislation, passed in 1918, declared all migratory birds listed in the U.S. Code and in the Protection of Migratory Birds Act "to be within the custody and protection of the government of the United States."[26] The act prohibited capturing or hunting without a federal permit. The stage was set for a constitutional battle, which began when the state of Missouri contended the act by filing a bill in equity restraining a federal game warden (Mr. Holland) from enforcing the federal regulations against a citizen of Missouri. By 1920, the case had reached the Supreme Court as *Missouri v. Holland.* The Supreme Court upheld the act and decided in a 5-4 decision that the constitutional treaty power gave the federal government sovereignty over this wildlife. Chief Justice Holmes wrote for the majority,

> The state . . . found its claim of exclusive authority upon an assertion of title . . . No doubt it is true that as between a State and its inhabitants, the State

[25] Protection of Migratory Birds Act, 39 Stat. 1702 (1916).
[26] 263 U.S. 49 (1918).

> may regulate the killing and sale of such birds but it does not follow that its authority is exclusive of paramount powers . . . wild birds are not in the possession of anyone and possession is the true beginning of ownership . . . But for the treaty and the statute, there soon might be no birds for any owners to deal with. We see nothing in the Constitution that compels the Government to sit by while a food supply is cut off and the protectors of our forests and our crops are destroyed . . . It is not sufficient to rely upon the states.[27]

This decision ended the doctrine of absolute state sovereignty in wildlife and affirmed federal rights in wildlife that Congress protects as a public good. This decision opened the door to federal wildlife regulation (Bean and Rowland, 1997) and defined the government's property interest in wildlife as *parens patriae,* a trustee for the public good, not as an owner *per se.*

The issue of state versus federal property in wildlife was raised again in 1928 in *Hunt v. United States.*[28] The U.S. Secretary of Agriculture directed that deer (controlled by Arizona game law) in Kaibab National Forest be harvested to avoid forest damage from over-browsing and that the harvest be done without regard to state hunting law. The state of Arizona arrested those carrying out the secretary's directive. Arizona relied on *Geer v. Connecticut* (1896) and other cases that supported a state's rights in wildlife within its borders even when that biota is on federal land. However, the Supreme Court ruled that "the power of the U.S. to thus protect its lands and property does not admit of doubt . . . the game laws or any other statute of the state notwithstanding."[29]

This decision clearly stated federal sovereignty over wildlife on federal land due to the federal-property power even if that wildlife is transient, not explicitly

[27] *Missouri v. Holland,* 252 U.S. 416 (1920).
[28] *Hunt v. United States,* 278 U.S. 96 (1928).
[29] *Geer v. Connecticut,* 161 U.S. 519 (1896).

covered by a federal law, and otherwise controlled by state law. In 1940, this ruling was extended to cover acquired national forest lands in *Chalk v. United States.*[30]

In 1940, Congress passed the Bald Eagle Protection Act,[31] the first assertion of federal sovereignty over a particular species of wildlife. The act, which prohibited the taking or possession of any bald eagle, its parts, eggs, or nests, was further amended in 1962 and 1972 to include golden eagles and exempt possession for Native American religious purposes.

Although the legal basis of federal sovereignty over wildlife selected by Congress was settled by 1940, the next twenty years were filled with disagreement on the issue of federal versus state sovereignty over wildlife controlled by state law but located on federal land.

In December of 1964, the Office of the Solicitor of the Department of the Interior issued a memorandum on federal authority to regulate hunting and fishing in the National Wildlife Refuge System: " . . . the United States government has constitutional power to enact laws and regulations controlling and protecting . . . [its] lands, including the . . . resident species of wildlife situated on such lands and that this authority is superior to that of a State."[32]

The first federal Endangered Species Act (ESA) was passed in 1966. This act did not control possession, leaving such regulation entirely to the states. This first ESA limited its definition of wildlife to vertebrates and did not include plants.

In 1969, the Supreme Court strengthened federal sovereignty over state-controlled biota on federal land in *New Mexico State Game Commission v. Udall.*[33]

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[30] *Chalk v. United States*, 114 F.2d 207 (4th Cir. 1940).
[31] Bald Eagle Protection Act, 16 U.S.C. §§ 668-668d (1940).
[32] "Quoted in G. Swanson, *Fish and Wildlife Resources in the Public Lands* 15 (1969)," cited in Bean and Rowland, 1997, p. 20.
[33] *New Mex. State Game Commission v. Hickel,* 396 U.S. 961 (1969).

The court held that the Secretary of the Interior could authorize the harvest of state-controlled game on federal land for research purposes regardless of state law.

In 1971, the Wild Free Roaming Horses and Burros Act[34] was enacted, providing federal control over the taking and possessing of these such animals on federal, state, and, to some extent, private land.

The passage of the Marine Mammal Protection Act (MMPA) in 1972[35] is a culmination of the shift to federal sovereignty over certain wildlife. The MMPA completely preempts states' authority over marine mammals listed in the act.[36] The MMPA is also noteworthy because it expands the meaning of the term "take" to include "harass and hunt," expanding government's property control of this biota.

In the 1981 case *Palila v. Hawaii Department of Land and Natural Resources,* the Ninth Circuit Court decided that "the importance of preserving such a national treasure (an endangered species) may be of such a magnitude as to rise to the level of a federal property interest,"[37] adding more substance to the federal government's claim of sovereignty over wildlife through the federal-property power. However, no decision was rendered because the parties settled out of court.

The 1976 case *Kleppe v. New Mexico*[38] further solidified federal sovereignty over wildlife explicitly covered in federal law. At the request of a federal grazing permittee, the state of New Mexico had caught (on federal land) and sold burros protected under the 1971 Wild Horse and Burro Act. The Bureau of Land Management demanded that the state recover and return the animals under this law. The state of New Mexico sued the Secretary of the Interior, declaring the law unconstitutional. A lower court decided that previous cases (e.g., *Hunt v. U.S.*,[39]

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[34] Wild Free Roaming Horses and Burros Act, 16 U.S.C. §§ 1331-1340 (1971).
[35] Marine Mammal Protection Act, 16 U.S.C. §§ 1361-1362, 1371-1384 and 1401-1407 (1972).
[36] However, a stringent mechanism for states to acquire some authority is provided.
[37] *Palila v. Hawaii Department of Land and Natural Resources,* 639 F. 2d 495 (9th Cir 1981).
[38] *Kleppe v. New Mexico,* 426 U.S. 529 (1976).
[39] *Hunt v. US,* 278 U.S. 96 (1928).

NMSGC v. Udall[40]) protected only lands, not biota, and that the Wild Horse and Burro Act therefore unlawfully protected animals.[41] "The Supreme Court unanimously reversed the lower court," stating that the federal government's power over governmental land "necessarily includes the power to regulate and protect wildlife living there. . . . it is far from clear . . . that Congress cannot assert a property interest in the regulated horses and burros superior to that of the State."[42]

Federal sovereignty over wild biota on federal land was challenged in the 1977 case *United States v. Brown.*[43] The court was to decide whether the National Park Service prohibition against hunting on state waters that are also within national park boundaries was a legal assertion of federal authority. The court found that the National Park Service had correctly exercised the property clause of the federal government in asserting federal sovereignty over wildlife on federal land and waters.

The cases described above, particularly *Kleppe v. New Mexico* and *Missouri v. Holland*, establish the federal-property power and treaty-making power as constitutional sources of federal sovereignty over wildlife. The federal power to regulate interstate and international commerce provides a third source of such federal sovereignty.

In the 1928 case of *Foster-Fountain Packing Co. v. Haydel,*[44] a lower court found that a state's control over wildlife terminates once part or all of such biota enters commerce. As with other cases involving the regulation of commerce, courts have found it unnecessary that an item be actually shipped across a state boundary for it to enter the stream of commerce. This issue may be relevant to the question of whether

[40] *NMSGC v. Udall*, 396 U.S. 961 (1969).
[41] *New Mexico v. Morton*, 406 F. Supp. 1237; D. New Mex. (1975).
[42] Bean and Rowland, 1997, p. 22, citing 426 U.S. at 537.
[43] 552 F. 2d 817 (8th Cir. 1977). Cert. Denied 431 U.S. 949 (1977), aff'g 431 F. Supp 56 (D. Minn. 1976).
[44] *Foster-Fountain Packing Co. v. Haydel*, 278 U.S. 1 (1928).

the filing of a patent on a biotechnological utility from *res publicae* wildlife is in the stream of commerce.

In the 1971 case *Douglas v. Seacoast Products, Inc.*, the Supreme Court held that the federal government had the power to regulate the taking of fish in state waters under the commerce clause of the constitution, stating, "at earlier times in our history there was some doubt whether Congress had power under the commerce clause to regulate the taking of fish in state waters, there can be no question today that such power exists where there is some effect on interstate commerce."[45] Although the fish in question in *Douglas v. Sea Coast Products* were migratory, the court did not use this as a basis for federal authority. However, a few years later, in *Andrus v. Allard,* the Supreme Court found the Migratory Bird Treaty Act an equally valid exercise of federal power under the commerce clause.[46]

The Ninth Circuit Court also cited the commerce clause as justification for federal authority over wildlife that does not move across state boundaries in *Palila v. Hawaii Department of Land and Natural Resources.*[47]

In the 1979 case *U.S. v. Helsey*, the Ninth Circuit Court upheld the federal government's right to control airborne hunting of wildlife under the commerce clause.

The 1991 case *Hawaii Audubon Society v. Lujan*[48] represents an interesting test of property in biota distinct from property in land. At issue was the conflict between *res publicae* property in the alala[49] and the property rights of a private landowner. The plaintiffs sought to compel the U.S. Fish and Wildlife Service to enter private land without the landowner's consent, if necessary, to assert the government's biota-property interest and to seize alala eggs and birds for the state's endangered-species

[45] *Douglas v. Seacoast Products, Inc.,* 431 U.S. 265 (1971).
[46] *Andrus v. Allard,* 444 U.S. 51 (1979).
[47] *Palila v. Hawaii Department of Land and Natural Resource,* 639 F. 2d 495 (9th Cir. 1938).
[48] No 91-00191 D. Hawaii.
[49] Hawaiian crow listed in the Endangered Species Act.

propagation facility. Removal of eggs/birds from the wild to the propagation facility had been proposed in a 1982 State of Hawaii Recovery Plan. The plaintiffs argued that non-consensual entry onto private lands was permitted under section 4(f) of the 1973 Endangered Species Act.

Federal sovereignty over Congressionally selected wildlife has been established. However, this does not divest the states of their role in the regulation of all other wildlife or imply any preference for a particular allocation of responsibilities between the states and the federal government (Bean and Rowland, 1997). In fact, the Code of Federal Regulations requires federal land managers to cooperate and coordinate their wildlife management activities with relevant state wildlife agencies.

3.7 The Current Status of *Res publicae* Wildlife—The Relation of Federal and State Jurisdiction

The federal government asserts property control over biota in two primary ways: as a landowner and by federal wildlife statute. As a landowner, the federal government has certain rights in the biota on federal land. However, the type of land dictates the extent and type of federal property control. For example, federal property in biota on national park land is different from that in biota on land managed by the Bureau of Land Management.

States may assert property control in all wildlife that is not federally controlled. A state has the power to impose restrictions or conditions on individuals regarding the taking or holding of wildlife in that state.[50] Ownership of *ferae naturae* not in actual possession by private persons is in the public in their collective sovereign capacity, or

[50] *Lacoste v. Department of Conservation*, 263 US 545 (1924); *Rogers v. State* (Ala App) 491 So 2d 987 (1986); *Ex parte* Kenneke, 136 Cal 527 (1902); *Harper v. Galloway*, 58 Fla 255 (1909); *People v. Bridges*, 142 Ill 30 (1892); *In re Schwartz*, 119 La 290 (1907); *State v. Snowman*, 94 Me 99 (1900); *Dapson v. Daly*, 257 Mass 195 (1926); *Ex parte* Fritz, 86 Miss 210 (1905); *State v. Wever*, 205 Mo 36 (1907); *Barrett v. State*, 220 NY 423 (1917); *Peple v. Bootman*, 180 NY 1 (1904); *State v. Jim*, 81 Ore. App. 189 (1986); *Peters v. State*, 96 Tenn 682 (1896); *State v. Niles*, 78 Vt 266 (1906); *Graves v. Dunlap*, 87 Wash 648 (1915).

in the state as representative of all the people.[51] Ownership of wild animals by the state is not that of proprietor but is rather that of trustee (*parens patriae*) for the sole purpose of regulation and preservation for the common use.[52] Migratory or transient animals have been held to be a public property, which the state can regulate to protect the common interest.[53] Because ownership of such animals is first within the people of the state, they may permit individuals to acquire ownership subject to conditions and limitations that the people through their legislative representatives may wish to improve.[54] For example, the private ownership of game may be limited to personal use, denying the individual who possesses the game the right to transport or sell it to another.[55]

In 25 states, statutes permit government to recover damages for the destruction or loss of government-controlled fish and wildlife (Halter and Thomas, 1982).

The current balance of federal versus state's rights in wildlife is articulated in CFR 43, Public Lands, subtitle A, Section 24.3 "General Jurisdictional Principles":

> In general, the states possess broad trustee and police powers over fish and wildlife within their borders including fish and wildlife found on Federal lands within a state . . . In the exercise of power under the Property Clause [of the Constitution] Congress may choose to pre-empt state management of fish and wildlife on Federal lands and in circumstances where the exercise of power and the Commerce Clause is available, Congress may choose to establish restrictions on the taking of fish and wildlife whether or not the activity occurs on Federal lands . . . State jurisdiction remains concurrent with Federal authority.

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[51] *North American Commercial Co. v. United States*, 171 US 110 (1898); *Ward v. Race Horce,* 163 US 504 (1896) (criticized but reluctantly followed by *Crow Tribe of Indians v. Repsis*, 866 F Supp 520 (1994)); *Ex parte* Bailey, 155 Cal 472 (1909); *State v. Lewis*, 134 Ind 250 (1893); In *re Schwartz*, 119 La 290 (1907); *L. Realty Co. v. Johnson,* 92 Minn 363 (1904); *Schultz v. Morgan Sash & Door Co.* (Okla) 344 P2d 253 (1959); *Acklen v. Thompson*, 122 Tenn 43 (1908); *Ex parte* Blardone, 55 Tex Crim 189 (As to ownership of fish and game, see 35 Am Ju 2d, Fish and Game §§ 1 et seq. Annotations: Governmental liability for failure to post highway deer crossing warning signs) (1909).
[52] *State v. Mallory* 73 Ark 236 (1904).
[53] *Bayside Fish Flour Co. v Gentry,* 297 U.S. 422 (1936).
[54] *Ex parte Kenneke,* 136 Cal. 527 (1902); *Herin v. Sotherland*, 74 Mont. 587 (1925).
[55] *Ex parte Keneke,* 136 Cal. 527 (1902); *American Express Co. v. People,* 133 Ill. 649 (1890).

3.7.1 The Nature of Government Property in Wildlife

There are significant differences between *res privatae* and *res publicae* property. *Res publicae* is not equivalent to private-property rights held by the government. Although the government's authority over the possession and use of *res publicae* property has many of the attributes of private property, there are key differences. Government may have the power to exercise most, if not all, of the several distinct bundles of rights described by Honoré (1961), but it does not hold these rights as a private-right holder. The two characteristics that fundamentally distinguish *res publicae* property are the *parens patriae* doctrine of public trust, and immunity from liability (Blum and Ritchie, 2005).

Numerous court cases that have defined the nature of *res publicae* in wildlife have tethered this definition to government's role as trustee of the public good.

The origin of the public-trust doctrine flows from English common law[56] and is a binding American legal principal.[57] Under English common law, the Crown held property in common resources by *jus privatium* (a right transferable by Crown or private persons) or *jus publicum,* a common public-trust right of the English people (Archer et al., 1994).

Concerning *res publicae* in wildlife, the public-trust doctrine holds government as the trustee, wildlife as the corpus, and citizens (present and future) as the beneficiaries (Favre, 1983). Government has the *parens patriae* right and obligation to conserve the corpus for the beneficiaries (Rogers, 1977).[58] A trustee is a fiduciary, held to a high standard of conduct and under a duty to administer the trust solely in the interest of the beneficiaries (Dukeminier and Krier, 1993).

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[56] See Environmental Law, 19, No. 3, 1989.
[57] *Phillips Petroleum Co. v. Mississippi,* 484 U.S. 469, 477 (1988).
[58] See also the Symposium: "The Public Trust Doctrine in Natural Resources Law and Management," 1980.

In the first Supreme Court wildlife case,[59] the court speaks of the states' public trust in oysters. Similarly, in *McCready v. Virginia* (1876), the court describes the appropriateness of state "regulation of the use by the people of their common property."[60] In *Manchester v. Commonwealth of Massachusetts,* the Supreme Court held that a state could regulate a natural resource for a valid "public purpose . . . for the common benefit."[61] In its definitive confirmation of the states' sovereignty over wildlife, the Supreme Court, in *Geer* (1896), held that "supervision of wildlife is exercised moreover as a trust for the people not as a prerogative for the advantage of the government as distinct from the people or for the benefit of private individuals as distinguished from public good."[62]

In *Smith v. Maryland,* the Supreme Court held that the state holds its public-trust properties "in trust for the enjoyment of certain public rights, and the state has the power to regulate the methods by which the public enjoys its rights."[63]

In *Toomer v. Witsell,* the Supreme Court wrote that the government's right and duty to protect wildlife does not derive from ownership but from its duty to the people, stating that "the ownership language . . . must be understood as no more than a 19th century legal fiction expressing the importance to its people that a state have power to preserve and regulate the exploitation of an important resource."[64] The opinion continues that states do not "own" wildlife but have a "substantial property interest" in it. Justice Frankfurter termed states' property in wildlife as "technical ownership."[65]

Dozens of lower court cases have similarly held that governmental ownership in wildlife is not that of proprietor but that of trustee and that the *res publicae* property

[59] *Martin v. Waddell,* 41 U.S. 367 (1842).
[60] 94 U.S. 391 (1877).
[61] *Manchester v. Commonwealth of Massachusetts,* 139 U.S. 240 (1891).
[62] *Geer v. Connecticut,* 161 U.S. 519 (1896).
[63] *Smith v. Maryland,* 59 U.S. 71, 74 (1855).
[64] *Toomer v. Witsell,* 384 U.S. 385 (1948).
[65] Ibid.

interest lies with the people in their collective sovereign capacity or in the state as representative of the people (Julian, 1997; Blum and Ritchie, 2005). Clearly, the *res publicae* is not a property interest that can be sold or for which special interests may be granted but is solely for preservation and regulation for common use.[66] Wilkinson (1980) points out that citizens have used the public-trust doctrine in court against the actions of the government. However, the state may prescribe the boundaries where *res publicae* ends and *res privatae* begins.[67]

When confronted with the issue of whether the state or a lower government (e.g., a municipality) holds the people's property interest, courts have confirmed the state's supremacy[68] as trustee and held that the doctrines of laches and estoppel, which mitigate *res privatae* property interests, do not apply to government.[69]

The other significant character that distinguishes *res publicae* from *res privatae* property is government's lack of liability. Courts have held that holding government liable for the conduct of *res publicae* wildlife would pose intractable problems for and intolerable risks to the government's ability to administer its *parens patriae* trust.[70]

3.7.2 Obscure Biota and Ambiguous Federal-Property Definition

The U.S. Code of Federal Regulation, Title 50, which implements the several federal laws covering wildlife, defines "fish or wildlife" as

> any wild animal, whether alive or dead, including without limitation any wild mammal, bird, reptile, amphibian, fish, mollusk, crustacean, arthropod, coelenterate, or other invertebrate, whether or not bred, hatched or born in captivity, and including any part, product, egg, or offspring thereof.

[66] *Mallory v. State,* 73 Ark. 236 (1904); *State v. Rodman,* 58 Minn. 393 (1894).
[67] *Kellogg v. King,* 114 Cal. 378 (1896).
[68] *Ex parte* Bailey, 155 Cal 472, 101, p. 441 (1909).
[69] *U.S. v. California* and *Utah Power & Light v. United States,* 243. U.S. 389, 409 (1917).
[70] *Metier v. Cooper Transport Co.,* 378 N.W.2nd 907 (1985).

Except for those species specifically listed as protected under federal law, federal law is silent on the sovereignty over non–fish or game wildlife except in the cases of interstate or international commerce.

It is unclear whether unicellular eukaryotes or prokaryotic organisms (e.g., protozoans, bacteria) are wildlife under this definition, although they could be defined as "other invertebrates." Considering viruses, mycoplasmas, and prions would seem to be an especially expansive definition of "invertebrate."

3.8 U.S. Indian Nations and Wildlife Property

The relation of an Indian nation's rights in wildlife on its lands to *res publicae* biota has two aspects. First, an Indian nation has the rights of a landowner. Second, and more significant, these "domesticated dependent nations," as defined by Supreme Court Chief Justice Marshall, have a unique relationship to the states, the federal government, and individuals. Because of their special trust status, Indian lands are not federal public lands or part of the public domain and are not subject to federal public land law. In *Cherokee Nation v. Georgia,*[71] the Supreme Court described Indian nations as distinct, independent political communities self-governed under a trustee relationship with the federal government.

It is interesting to note that the 1874 failure to form a state out of the Indian Territory (i.e., now Oklahoma) was due, in large part, to the Indians' refusal to provide for the division of land from communal lands to private property (Deloria and Lytle, 1984).

Bean and Rowland (1997) describe the wildlife rights Indian nations have *vis à vis* the federal government by virtue of their protected sovereign status. In the 1896 case *Ward v. Race Horse*, the Supreme Court determined that a state (Wyoming) had

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[71] *Cherokee Nation v. Georgia,* 30 U.S. 1, 20 (1831).

the right to assert federal sovereignty over wildlife on Indian lands.[72] However, in *United States v. Winans* (1905), the court decided that Indian treaty rights gave Indians certain sovereignty over fish and game on Indian lands.[73] In 1942, the court decided in *Tulee v. Washington* that Indians did not need to obtain state fishing licenses to take fish on Indian lands.[74]

The several Puyallup decisions involving the disposition of salmon in Northwest waters have resulted in a complicated patchwork of laws, regulations, and case law that affirm the federal government as the sovereign responsible for balancing the rights of Indians and non-Indian citizens with regard to wildlife that Indians have some claim in (Bean and Rowland, 1997).

Several federal wildlife acts explicitly distinguish the rights of Native Americans in federal wildlife. The MMPA and the Eagle Protection Act provide exemptions for Native Americans. Under MMPA, federal control is supreme, but certain takings without permit are allowed by Aleuts, Eskimos, and coastal tribes for subsistence use or for creating authentic native articles of handcraft and clothing. According to the Eagle Protection Act, Native Americans may possess eagle parts for religious purposes.

Under the federal Endangered Species Act, the federal government has blanket and absolute sovereignty over all listed species, including those on Indian lands. However, Indian nations have had a modicum of decision-making input in the implementation of the ESA on Indian lands.[75]

Regarding the relation of Indian nations' versus states' rights in biota, the courts have decidedly found that the states' governments retain sovereignty over

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[72] *Ward v. Race Horse,* 163 U.S. 504 (1896).
[73] *States v. Winans,* 198 U.S. 371 (1905).
[74] *Tulee v. Washington,* 315 U.S. 681 (1942).
[75] U.S. Department of the Interior Secretarial Order 3206.

wildlife, even on Indian lands. For example, in *Crow Tribe of Indians v. Repsis,*[76] a federal court found that an Indian nation does not retain treaty-based rights to hunt and fish on its lands, free of state regulation. Each state has its own definition of the scope and extent to which states have given rights to access and control of wildlife on Indian nation lands. In New York State, Indians are required to obey all state wildlife regulations.[77]

3.9 Capture and Domestication: Converting *Res nullius* Wildlife to *Res privatae* Property

The primary means of acquiring a *res privatae* right in *res nullius* is through first possession (Epstein, 1979; Blum and Ritchie, 2005). Obtaining ownership by being the first to possess, occupy, or capture something previously unowned is a widespread institution historically applied in many cultures in such varied resources as wildlife, satellite orbits, oil, gas and minerals, land, water rights, intellectual property, and the electromagnetic spectrum (Lueck, 1995).

The capture or killing of wild animals has long been considered the paradigm of first possession as the source of a property right in an unowned thing. In fact, other fugitive resources such as minerals have been defined as *ferae naturae* for the purpose of property rules (Brown, 1978). Romans clearly defined the capturer or killer of wild game as the owner of that game animal (Lund, 1980).

The classic New York Supreme Court case of *Pierson v. Post,*[78] in 1805, defined the rules of capture that prescribed property in a hunted fox. The court held that ownership required acts that bring the fugitive animal under certain control (Dukeminier and Krier, 1993). The act that reduces a *res nullius* wildlife to *res privatae* is that which reduces the liberty of the wildlife and places it under the control

[76] *Crow Tribe of Indians v. Repsis,* 73 F.3rd 782 (10th Cir. 1995).
[77] NY State Law ECL-90.
[78] *Pierson v. Post,* 3 Cai. R. 175 (1805).

of the property holder. The killing of a wild animal *ferae naturae* gives a property right in the carcass to the killer (Arnold, 1921), except where the government may have an overriding police power. Less permanent reduction of the animal's liberty results from capture, taming, or other means to bring the living animal more or less under human control. A related rule of caging is *per impotentium,* in which one may hold property in *ferae naturae* that are unable to run, fly, or swim away as a result of their youth or infirmity (Arnold, 1921).

Although killing a *ferae naturae* creature yields a static property right in possession, the control of a living creature is a qualified right. That is, the property right created by possession evaporates upon the restoration of the wild creature's natural liberty. This is clearly the case of a wild animal briefly caged and never tamed that returns to its natural state of liberty. A previously caged wild sea lion is *res nullius* once it has escaped to the sea (*Mullet v. Bradley*[79]).

Degrees of qualified property can continue in *ferae naturae* that have been partly tamed or brought under some measure of control. For example, under the doctrine of *animus revertendi,* a qualified property interest can exist in a wild animal that, although periodically not under immediate control, returns on its own to the owner's control (e.g., to a pen or land). In *Hughes v. Reese*[80] the court found that the taming of a wild fox to the point where the fox would return to the tamer created a property right in the fox that was not diminished by temporary departure of the fox from the control of the owner. If the biota does not return, the right is lost. In the case of loose bees, the court held in *Goff v. Kilts*[81] that the possession of bees required keeping the bees in sight and having the power to pursue them.

[79] *Mullet v. Bradley*, 24 Misc 695 (NY, 1898).
[80] *Hughes v. Reese*, 144 Miss. 304 (1926).
[81] *Goff v. Kilts*, 15 Wend 550 (NY, 1836).

Courts have held that property rights in captive wildlife are strengthened by the acts of routine physical caging, earmarking, branding, and use in commerce (Hogan, 1955).

Despite this long history of ownership by capture, some question whether this rule may be antiquated. For example, McLaughlin (2003) argues that the rule of capture does not support the sustainable use of a natural resource. McLaughlin believes that a more cooperative approach among several interested parties is preferable to a single owner-by-capture approach.

3.10 Personal Property and Biological Chattel

Private property in biota follows rules of property in chattel. The word “chattel” means “personal property in tangible things other than land.” It derives from “cattle,” one of the most significant personal property items of early cultures (Dukeminier and Krier, 1993). Animals have always been handled slightly differently from inanimate objects with regard to property. However, several court cases have countered this view (Hannah, 2001).

Personal-property rules are defined by custom and common law. Biota chattel or personal property in biota follow under these rules, generally with some unique variation caused by the unique characters of biota property (Hannah, 2001). A cow may be owned as chattel, just as a chair may be owned. But a chair and a cow are fundamentally different because of the cow’s biotic characters. That is, biota chattel is often “alive” with powers of auto-locomotion and auto-reproducibility.

To understand the institution of biota personal property, it is necessary to define the general property rules of chattel and then, within that framework, to articulate the rules of biotic chattel.

3.10.1 Personal-Property Rules

Movable items that are not the property of anyone may be converted into chattel by the act of first possession described earlier. This requires a level of physical possession and, in some cases, marking. In fact, the paradigm for assertion of property rights in something previously unowned is the capture of a wild animal (Rose, 1985).

Tangible personal property is movable by nature. It may or may not have value *per se* (e.g., jewelry). Personal property that is affixed to realty is realty until it is severed from the land (Webb and Bianco, 1970). Ownership is normally confined to the person in actual possession. Upon the death of the owner, transfer of ownership is controlled by the location of the domicile of the deceased, unlike realty, for which the location of the property is controlling. There are two type of personal property, or personalty: "choses in possession" and "choses in action." Choses in possession are properties in which rights are obtained by mere possession. Choses in action require some action such as accessing a bank savings account or a patent right. The focus here is on choses in possession.

Unlike the possession of real property, the possession of personal property does not require a written title or contract for conveyance. The possession of personal property creates *prima facie* evidence of a property right. In the sale of personal property there is normally an implied warrant of title that is conveyed. The possessor is considered to hold title unless the possessor is not the true or original owner. Such instances occur in lost, mislaid, or abandoned property, and in conversions, bailments, accessions, and adverse possessions.

Conversions refer to a wrongful taking of possession. No possessor of personal property can have rights in that property that rise higher than those of the one who transferred the property (Burke, 1983). Courts in the United States generally protect the first possessor's title in order to maintain an effective economy through fungible and negotiable transfer of title (Burke, 1983).

Prior possession refers to property rights in personalty that arise earlier than another's in the chain of possession. A prior possessor of a chattel has a right to the property as good as or superior to all but the true owner.

Finder's rights are qualified property rights held by those who find chattel. The "finding" of such chattel requires an intent to possess and a possessory act and must be done openly. A finder's property right is superior to that of all subsequent finders or possessors but inferior to that of prior finders or possessors and the true owner. Although lost chattel found in a public place is the property of the finder, if it is found in a private place, the owner of the place where the property is found has rights superior to those of the finder. There are four types of "lost" property:

Lost property involves an involuntary parting of the property from the true owner in which the owner is unlikely to find it through retracing his or her steps; the owner must intend to retrieve.

Mislaid property involves a voluntary parting of the property from the owner but a lack of ability to retrieve it, typically due to lack of specific memory. (e.g., a wallet on the floor of a public place is lost; a wallet on a desk in a public place is mislaid).

Abandoned property involves a voluntary parting of property from the owner and/or a voluntary failure to retrieve.

Treasure trove is buried treasure.

Finders have varying rights and obligations depending on the type of property loss. Finders have a general duty to find the true owner and are not entitled to compensation (except for those expenses caused by the finding and relocation). In the case of lost property, the finder must return the property to the true owner, if known, or be guilty of larceny or conversion. A finder who loses the property has superior rights to all subsequent finders.[82] A finder of lost property has the same rights and obligations of a gratuitous bailee, described below.

A finder of mislaid property has similar rights and obligations as with lost property unless the place where it is found is public, in which case it is likely that the true owner will retrace his or her steps and return to the place of mislaying the property; the owner of the place where the object is found (the owner of the *locus in quo*) has rights to the found property superior to those of the finder (he or she is more likely to find the true owner).

An overriding common law theme in rights of lost property is the public-policy goal that the true owner's rights be revered.

In the case of abandoned property, a finder is under an obligation to ascertain that the lost property has, in fact, been abandoned, after which the finder has superior rights against all.

Accession presents peculiar problems. Accession occurs when the personalty of different persons is inextricably combined to produce a new and distinct personalty. For example, if two owners of raw wheat have their wheat mixed and that mixture is ground into flour, the owners of the separate raw wheat are now "tenants in common" of the combined-wheat flour. The intent of the parties is normally immaterial. **Confusion** refers to a type of accession in which chattel is mixed such that there can be no distinguishing the original property in the new mixture. Owners are typically made by *pro rata*, sharing on the basis of their original property. However, if the confusion is intentional, the wrongdoer loses all rights and cannot convey title (i.e., the owner can completely recover from third parties).

[82] *Armory v. Delamire,* 1 str. 505 (1722).

If there is an increase in value of the combined property, ownership goes to the owner of the principal goods. However, the ownership of the combined property is normally apportioned according to the proportion of the mixing. If a valuable property is mixed with a relatively less valuable thing, ownership normally rests with the owner of the originally more valuable property. Similarly, if the value of the new mixed property is very much greater than that of the property added, the owner of the more valuable property is the owner of the new property. Conversely, original owners have no ownership if their property is so much less valuable than the new property created or if the identity of the old property is lost in the new property (the original owner may recover damages, however).

Although a trespasser (innocent or willful) has no cause of action against an owner in an accession, an innocent trespasser in an accession is given credit for his or her added increment of value. A willful trespasser may gain no rights in an accession.

A **bailment** is the transfer of possession of personal property from the owner (the bailor) to another (the bailee) without transfer of title.

The bailee has the right to possession and control over the bailed property for the term of the bailment, and these rights are superior to all including those of the bailor.

There are several types of bailment:

Gratuitous bailment: for bailor's sole benefit; requires only modest diligence of care by bailee.

Bailment for mutual benefit: requires a reasonable level of diligence of care by bailee.

Bailment for sole benefit of bailee: requires a high degree of diligence of care by bailee.

A bailee has an absolute duty to return the property at termination of the bailment. A bailment may be terminated by simple notice when it is for an undefined period.

Where the bailment is for a definite time, a bailor cannot maintain trover[83] or replevin[84] during the life of the bailment against a third party; if bailment is terminable at bailor's will, a bailor may bring trover or replevin if the bailed property is not returned by bailee on request by bailor.

A bailee is normally held to a reasonable standard of care but is absolutely liable for misdelivery of the bailed property to someone other than the bailor (misdelivery is a breach of bailment contract and, therefore, a conversion, and is not based on negligence).

If a bailee uses the property outside the scope of the bailment contract, it is a conversion for which the bailor may bring a trover action.

Negligent use of a bailor's property by a bailee creates no liability on the part of the bailor. The negligence of a bailor is not usually imputed to the bailor.

During the term of the bailment, the bailee has exclusive right of possession even against the bailor and may sue in trover or replevin to recover (even against bailor).

Unauthorized use by a bailee that results in loss or damage renders the bailee absolutely liable regardless of negligence.

The bailor's rights include suing for breach of contract for damages, bringing a tort action for damages, bringing an action in trover, and bringing an action in replevin.

[83] "Trover" means the recovery of value but not title or possession.
[84] "Replevin" means the recovery of possession and damages.

Where a third party has acquired the goods by an unauthorized act of the bailee, the bailor may maintain an action of conversion or replevin against the third party.

Adverse possession is a form of transfer of possessory rights and title in which actual possession is held by the non-owner, in an open, notorious, continuous, and hostile manner. Such possession, which runs for a statutorily defined period, will convey rights in the adversely held property from the original owner to the possessor.

Trespass in chattel is the unauthorized intentional interference with the rightful possession of a chattel by a rightful owner. The use of trespass has been largely replaced by conversion as a legal means of redressing wrongful possession (Burke, 1983).

Conversion is the wrongful exercise of dominion over personalty. There are two types of redress available to the owner of the wrongful act of conversion: replevin and trover.

Replevin is the legal act of the rightful owner to recover possession of the wrongfully converted personalty. Personalty that has been wrongfully taken through trespass conversion or distraint (described below) may be replieved by the rightful owner. Replevin requires that the chattel be identifiable, which means that most accession and all confusion cuts off rights of replevin. Replevin involves a recovery of property possession with attendant recovery of damages caused by the wrongful conversion and any interim value created during wrongful possession.

Recovery by act of trover is a very different matter. In trover, the rightful owner of the converted property obtains a court action to force a transfer of title from the original owner to the possessor by conversion. Thus, in this “forced sale” the possessor by conversion retains possession but is forced by the court to purchase the property and in so doing, to obtain title and the full value of the property to the original owner. Such title to property in a trover action transfers only an actual satisfaction of the court judgment; therefore, failure to so satisfy means the original owner retains title and can furthermore bring suit in replevin to gain possession.

Conversion includes both wrongful taking and wrongful holdings (i.e., a rightful possession followed by a wrongful failure to return).

3.10.2 Biological Chattel

Generally, property in biota falls under the rules of personal property. A few key characteristics distinguish biological chattel from non-biological chattel. First, living biological chattel is capable, if a whole organism, of auto-reproducibility. The reproductive capacity of an organism creates some unique property attributes. Also, whole organisms are frequently self-locomotive and capable of self-directive and related behaviors.

The first distinction is whether the biota is transient or fixed. In the instance of obtaining a property right in a transient wild animal, the first-possession doctrine first described in *Pierson v. Post* allows for the acquisition of a property right in a free-roaming, *res nullius* organism if and when a certain threshold level of control is asserted over the creature.[85] First possession requires actual or constructive control with an intention to possess.[86] Chasing is not a sufficient control; mortal wounding is.[87] A captured, living *res privatae* creature that was *res nullius* before capture becomes a *res nullius ferae naturae* upon escape.[88] However, by virtue of the doctrine of *animus revertendi*,[89] a captured wild animal that escapes and is conditioned (through training or otherwise) to return to the capturer is the property of the capturer even when it is out of the sphere of control of the original capturer.

[85] *State v. Shaw*, 65 NJ 875 (1902).
[86] *Kenon v. Cashman*, 33 A 1055 (1860).
[87] *Leisner v. Wamie*, 156 Wisc. (1914).
[88] *Muller v. Bradley*, 53 NY Supp. 781 (1898).
[89] *Ulery v. Jones*, 81 Ill., 403 (1876).

According to Hogan (1955), this assertion of *res privatae* property rights in a *res nullius* wild creature is affected by overarching public policy. In the early years of the United States, in which there was little or no industry in wild-animal husbandry, courts viewed the assertion of a property right in wildlife as strictly determined by physical control. Later, as such industry developed (e.g., mink and fox pelts), courts extended property rights to a looser definition of control. The term *mansuetae naturae* arose to define living wildlife that is rendered as commercial stock or merchandise through a variety of controls. Under *mansuetae naturae*, it is immaterial whether the free-roaming *ferae naturae* is *animus revertendi*, only that the creature has value to the original captor as stock or merchandise.[90]

Companion animals hold a unique place in the continuum of property in living matter. Unlike livestock and animals of commerce, these creatures are valued for their emotional connection with humans. Courts have generally held these animals to be treated as chattel. However, some courts have granted damages for loss due to suffering and anguish (on the part of the animal and owner), and some have argued for dropping the property rules on such animals altogether (Root, 2002).

At present, courts will generally support the biota-property rights of an original captor that has done all that can be reasonably expected to control the biota (Burke, 1983). Such rights are conversely true of liabilities. Wildlife that has been reduced to *res privatae* through capture and which then escapes to another's property and causes damage remains the property and liability of the original captor. The owner of damaged property may distrain the wild animal until such damages are compensated for (Hogan, 1955). In a related scenario, if a trespasser kills or captures a *ferae naturae* specimen on another's property, the *ferae naturae* is the property of the landowner (Webb and Bianco, 1970).

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[90] *Stephens v. Albers*, 81 Colo. 488 (1927).

Fixed-biota property, including trees, shrubs, and herbaceous plants, follows different rules. Wild plants are *fructus naturales* and are fixtures on the land and part of realty property rules unless severed from the land. *Fructus industriales* are cultivated plants, and their ownership is dictated by separate rules.

In lieu of a contract otherwise, ripened fruit is generally personalty. However, fruit growing on *fructus naturales* is the property of the landowner. Fruit on *fructus industriales* is personal property that may be owned by the sower. Such property rights in the "fruits" of such sowing are termed "enablements" (Burby, 1961). Enablements require a tenancy of uncertain duration, a crop maturation after termination of the tenancy, and a termination not caused by the tenant.

Nursery stock is always considered tangible personal property, and property rights in that stock are typically not coincident with rights in the land. In Georgia, owners of land on which pecan trees grow are the owners of all the pecans produced, regardless of where they fall.[91]

Fructus industriales planted and harvested by an adverse possessor are the property of the adverse possessor even if such possessor owes the landowner rent.

Property rights in domesticated animals also fall under personal-property rules. Domesticated animals are defined as animals raised generation after generation by the owner(s), generally of docile and manageable temperament or bait, and typically requiring human intervention for survival.[92]

An excellent review of property in animals can be found in St. Julian (1995), the key points of which can be summarized here. Domestic animals are personal property.[93] A bailee of an animal is not entitled to property rights in the progeny. However, the holder of a life estate is entitled to such offspring during the period of

[91] GA Code §§ 85-2101-2103 (1973).
[92] American Jurisprudence.
[93] *Oppenheimer Indus v. Johnson Cattle* Co., 112 Idaho 423 (1987).

the estate. In general, the owner of the mother is the owner of all progeny, regardless of whether the owner is in possession of the mother.[94] If contracts dictate ownership of progeny, the courts tend to follow. In the absence of a contract to the contrary, the owner of an animal also owns the animal's by-products (e.g., milk, eggs). Pigs, cows, horses, oxen, mules, burros, yaks, and other large animals are typically owned/sold through contract. A registration or certificate may act as title (e.g., Simmental registered cattle, Arabian horses, Holstein dairy cows). Both herds and individual animals are typically owned through contracts. A brand is used to mark and assert ownership. Poultry is typically owned as personal property and exchanged via contract.

3.11 Biota Property Plurality

Geisler (2000) describes property systems as a complex mix of varied use rights and jurisdictions. Rather than a clear and clean matrix of mutually exclusive property boundaries, property in land is complicated by "ownership hybrids, mutants and . . . mixed-use, transboundary systems" (p. 80). Property in wildlife is similarly complex, and combining the property complexity of land and biota yields a particularly rich property stew.

The "bundle" of property rights and liabilities provides a first layer of complexity. The uncoupling of rights of possession from rights of use, for example, or the separating of right of possession and use from right to alienate demonstrate the potential rights mosaic in a single object.

In the state of New York, a wild, free-roaming bear is absolutely the property of the state. An individual may not acquire any property right in the bear except under a license from the state and may render the bear *res privatae* only in a licensed killing. However, the state retains certain property control over parts of the bear carcass by

[94] *Arkansas Valley Land & Cattle Co. v. Mann,* 130 U.S.S. 69 (1888).

prohibiting the sale of the bear flesh[95] by the licensed carcass possessor. Similarly, in New York, the bodies of dead birds may be possessed but not sold. A second layer of complexity arises in the connection of property rights in land and property in biota.

Under trespass law, landowners may assert a type of biota-property right by controlling others' access to their land and therefore controlling access to the wildlife on that land. So, although a landowner has no property in a deer controlled by the state, he or she can keep others from accessing that deer.

Nothing in the language of the ESA or the CFR 50 explicitly describes the control over a patent application on biotechnological utility obtained from an endangered species from private land. It is questionable, therefore, whether a landowner may collect tissues of an endangered plant species on his or her land, discover/invent a biotechnological utility therefrom, and file a patent application: Does the landowner have a right to undertake such intellectual-property activity? Does the government have any control over the intellectual property?

[95] Hide, organs, and teeth of the bear are exempt from this prohibition and may be sold.

CHAPTER 4:
FEDERAL AND STATE WILDLIFE LAW

4.1 Introduction

In order to characterize the relation of patent law to biological conservation law, it is essential to analyze relevant federal and state laws.

In the following sections, I break federal biological conservation law down into three basic types: 1) law that springs from the federal government's regulation of interstate commerce, 2) law designed to protect individual species, and 3) law governing the management of federal lands and waters. Within each type, I describe the federal laws in terms of their relevance to the possession and use of relevant wildlife.

Analyzing relevant state law presents a problem given the fifty distinct bodies of law that exist. To make this analysis tractable, I have conducted a general overview of all relevant state laws and drill deeper into the detail of New York State's statute.

In both sections of federal and state law, I focus on conservation law and not on law that is designed to control noxious, invasive, or other pest species (e.g., Federal Noxious Weed Act; Non-Indigenous Aquatic Nuisance Prevention and Control Act).

4.2 Federal *Res publicae* Biota

Although there is a complex balance of federal and state rights in wildlife, the federal government has ultimate sovereignty (Roth and Boynton, 1993). Federal *res publicae* in wildlife is statutorily asserted through laws that regulate commerce, conserve species, or manage federal lands. Each of these approaches, and the laws they comprise, are defined below.

4.2.1 Regulation of Commerce

Lacey Act

Anderson (1995) provides a comprehensive review of the Lacey Act,[1] the first federal wildlife law. The Lacey Act began as a domestic anti-poaching law and has become the primary tool in the control of international trade in wildlife.

The act, passed in 1900, was originally intended to protect birds. It was motivated by the damage done to crops by insects that would otherwise be eaten by birds. The Lacey Act is the original assertion of federal sovereignty over wildlife. Its provision to make a federal crime of introducing wildlife taken against state law into interstate commerce frames the finely balanced relationship between federal and state sovereignty. The Lacey Act strengthens states' right to control the biota within their borders by putting the power of federal law behind state law and regulation. As originally written, it empowered the U.S. Department of Agriculture to authorize the introduction and preservation of game, song, and insectivorous wild birds; to prevent the "unwise" introduction of foreign birds and animals; and to supplement state laws that protect game and birds.

The ineffectiveness of state laws in controlling interstate commercial trafficking in game resulted from the *Geer vs. Connecticut* doctrine of state wildlife ownership.[2]

The Lacey Act was not designed to be a federal wildlife law but rather to augment and support state wildlife law. The author and sponsor, Lacey himself, believed that the authority of the national government was to begin where the state's authority ended. The Lacey Act did not assert any federal control over "state-owned" wildlife. Furthermore, the act distinguished between state and federal sovereignty in wildlife by removing federal restrictions on the states' regulation of the sale of wildlife

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[1] 18 U.S.C. § 42-44 (1981).
[2] 161 U.S.C. § 519 (1896).

within their borders and by placing all game animals and birds entering a state under the jurisdiction of that state's laws. It was directed at interstate traffickers in the game trade, particularly the market hunting of game birds and animals. It criminalized the delivery and shipment of parts or bodies of "wild animals or birds" killed in violation of state law. Utilizing the federal Commerce Clause power, the Lacey Act required the marking and labeling of wildlife shipments.

The original Lacey Act did not cover fish. The Black Bass Act was passed in 1926 and amended in 1930 and 1947. In 1981, the Black Bass Act was repealed and an expanded Lacey enacted, which covered all fish and wildlife, including migratory birds.

The 1981 Lacey Act established a comprehensive federal law controlling trade in wildlife. The act covers captive-bred wild animals and certain wild plants,[3] including wildlife taken in contradiction of Indian laws or federal treaties. The act defines "taking" to include any possession or trafficking in illegally obtained wildlife. Under the act, where the wildlife was originally obtained is irrelevant. In *New York ex rel Silz v. Hesterberg*,[4] the Supreme Court held that to bring plover and grouse killed in another country into a state with laws against possessing such animals was a violation of state law and therefore of the Lacey Act.

The Amendment of 1935 extended the act to include wild animals, birds, and parts or eggs captured or killed contrary not only to state and federal U.S. law but also to foreign law. Related to this power, the Tariff Act of 1930[5] provides that if any foreign law restricts the taking or exportation of any wild mammal, bird, or part or product thereof, it may not be imported into the U.S. without certification from the U.S. consul in the country of origin where it was taken legally. The Tariff Act is

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[3] That is, those indigenous to any state that are listed in CITES (Convention on International Trade in Endangered Species) or in a state or federal Endangered Species Act.
[4] *New York ex rel Silz v. Hesterberg*, 211 U.S. 31 (1908).
[5] 19 U.S.C. § 1527(a) (1976).

limited to mammals and birds and provides exemptions for scientific and educational purposes. The Lacey Act, on the other hand, covers any foreign wildlife or fish as well as "injurious" wildlife. In 1993 and 1994, some 700 Lacey Act violations were filed in U.S. federal courts. Examples include: *United States v. Hansen-Sturm,*[6] in which the defendants were convicted of violations stemming from the sale of caviar illegally harvested from Columbia River Sturgeon; *United States v. Borden,*[7] in which the defendants were convicted of harvesting mussels in violation of West Virginia state law for resale to commercial oyster producers; *United States v. Miller,*[8] in which the defendants were convicted of removing Arizona cactus for commercial resale[9]; and *United States v. Miranda,*[10] in which the defendants were convicted of selling undersize lobsters.

The Lacey Act covers wildlife, defined as

> any wild animal, whether alive or dead, including without limitation any wild mammal, bird, reptile, amphibian, fish, mollusk, crustacean, arthropod, coelenterate, or other invertebrate, whether or not bred, hatched, or born in captivity, and includes any part, product, egg or offspring thereof. Any wild member of the plant kingdom, including roots, seeds and other parts thereof (but excluding common food crops and cultivars) which is indigenous to any State and which is either (a) listed on an appendix to the CITES, or (b) listed pursuant to any State law that provides for the conservation of species threatened with extinction.[11]

Acts prohibited under the Lacey Act include the following:

> 3372. Prohibited acts
>
> (a) Offenses other than marking offenses. It is unlawful for any person—

[6] *United States v. Hansen-Sturm*, 44 F.3rd 793, 793-794 (9th Cir 1995).
[7] *United States v. Borden*, 10 F.3rd 1058, 1060-61 (4th Cir 1993).
[8] *United States v. Miller*, 981 F.2d 439, 440-41 (9th Cir 1992).
[9] cert denied 113 S.Ct. 1644 (1993).
[10] *United States v. Miranda*, 835 F. 2d 830, 831 (11th Cir 1988).
[11] U.S. Code Title 16, Chapter 53, section 3371.

(1) to import, export, transport, sell, receive, acquire, or purchase any fish or wildlife or plant taken, possessed, transported, or sold in violation of any law, treaty, or regulation of the United States or in violation of any Indian tribal law;

(2) to import, export, transport, sell, receive, acquire, or purchase in interstate or foreign commerce—

(A) any fish or wildlife taken, possessed, transported, or sold in violation of any law or regulation of any State or in violation of any foreign law;

(B) any plant taken, possessed, transported, or sold in violation of any law or regulation of any State; or

(C) any prohibited wildlife species (subject to subsection (e));

(3) within the special maritime and territorial jurisdiction of the United States (as defined in section 7 of title 18, United States Code)—

(A) to possess any fish or wildlife taken, possessed, transported, or sold in violation of any law or regulation of any State or in violation of any foreign law or Indian tribal law, or

(B) to possess any plant taken, possessed, transported, or sold in violation of any law or regulation of any State; or

(4) to attempt to commit any act described in paragraphs (1) through (3).

(b) Marking offenses. It is unlawful for any person to import, export, or transport in interstate commerce any container or package containing any fish or wildlife unless the container or package has previously been plainly marked, labeled, or tagged in accordance with the regulations issued pursuant to paragraph (2) of subsection 7(a) of this Act [16 USCS § 3376(a)(2)].

(c) Sale and purchase of guiding and outfitting services and invalid licenses and permits.

(1) Sale. It is deemed to be a sale of fish or wildlife in violation of this Act [16 USCS §§ 3371 et seq.] for a person for money or other consideration to offer or provide—

(A) guiding, outfitting, or other services; or

(B) a hunting or fishing license or permit; for the illegal taking, acquiring, receiving, transporting, or possessing of fish or wildlife.

(2) Purchase. It is deemed to be a purchase of fish or wildlife in violation of this Act [16 USCS §§ 3371 et seq.] for a person to obtain for money or other consideration—

(A) guiding, outfitting, or other services; or

(B) a hunting or fishing license or permit;

for the illegal taking, acquiring, receiving, transporting, or possessing of fish or wildlife.

(d) False labeling offenses. It is unlawful for any person to make or submit any false record, account, or label for, or any false identification of any fish, wildlife, or plant which has been, or is intended to be—

(1) imported, exported, transported, sold, purchased, or received from any foreign country; or

(2) transported in interstate or foreign commerce.[12]

Penalties for Lacey Act violations include the following:

> $200 fine for shipping violations maximum civil fine of $10,000. A bifurcated felony/misdemeanor scheme. Felony violations require knowingly violating the Act. Misdemeanor violations require only negligence. Maximum felony penalty of $250,000 for individuals and $500,000 for organizations and/or five years in prison; misdemeanor maximum penalty of $100,000 and/or 1 year in prison. Forfeiture of contraband, vessels, vehicles, aircraft and equipment. Loss of permits, licenses, stamps. Civil fines of up to $10,000. Authorized enforcement officers to carry firearms.[13]

An open question is the relation of the Lacey Act to intellectual property from wildlife covered by the act: If a wildlife specimen is obtained illegally and is used to

[12] U.S. Code Title 16, Chapter 53, section 3372.
[13] U.S. Code Title 16, Chapter 53, Section 3373.

obtain a patentable biotechnological utility, does the act of filing a patent application constitute a violation of the Lacey Act?

Other federal laws control certain wildlife in the United States. The Federal Noxious Weed Act provides federal control over "noxious weeds," defined as:

> a living plant of foreign origin that is either new to or not widely prevalent in the United States and that "can directly or indirectly injure crops, other useful plants, livestock or poultry or other interests of agriculture."[14]

The Non-Indigenous Aquatic Nuisance Prevention and Control Act grants powers to control listed species to the Secretaries of the Departments of Commerce and Interior.

4.2.2 Conservation of Species

Migratory Bird Treaty Act

The Convention with Great Britain (on behalf of Canada) for the Protection of Migratory Birds was ratified in 1916. The Migratory Bird Treaty Act,[15] enacted in 1918, provided protection of three types of migratory birds, each with different levels of federal control:

Migratory game birds can be taken (i.e., hunted) by permit only during an open season (September 2–March 9). There is no restriction on what can be done with a bird or its parts taken under permit. Permits that prescribe the particular manner and period for taking are authorized for birds listed.

Migratory insectivorous birds can be taken by permit only, and then only for a justifiable scientific, educational, or propagational purpose.

Migratory non-game, non-insectivorous birds can be taken by permit only, and then only for a justifiable scientific, educational, or propagational purpose.

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[14] 7 U.S.C. § 2802(c), cited in Bean and Rowland, 1997, p. 56.
[15] 16 U.S.C. § 703-712 (1981); US & UK Treaty signed 1916 (39 Stat. 1702, T.S. No 628); US & Mexico Treaty signed 1936 (50 Stat. 1311, T.S. No 912); US Japan signed 1972 (25 U.S.T 3329); US & USSR signed 1976 (29 U.S.T 4647, T.I.A.S. No. 9073).

For birds in the last two categories, no taking is allowed at any time unless by permit for scientific or propagation purposes. For birds in the first category, there is no taking during the closed season, and taking is allowed in the open season only by permit.

Similar migratory bird treaties were signed between the U.S. and Mexico (1936), Japan (1972), and the USSR (1976). Each of the treaties is slightly different. The treaties with Canada and Mexico allow taking for scientific and propagation purposes, and the latter treaty provides exceptions for museums. The Japanese and USSR Conventions allow taking for educational and other specific purposes that are consistent with the conventions' objectives. Each of the treaties or conventions provides for hunting seasons. Overlap of the several migratory bird treaties creates varying control for the same species. However, the Migratory Bird Treaty Act itself and Title 50 of the U.S. Code resolve these inconsistencies. The act is primarily administered by the United States Fish and Wildlife Service (USFWS).

Biota covered by the Migratory Bird Treaty Act include all living and dead whole specimens, parts, eggs, and nests of any species listed in Title 50 of the U.S. Code of Federal Regulations (CFR).

Under the act, no person may take, possess, import, export, transport, sell, purchase, or barter any listed migratory bird or the parts, nests, or eggs of such bird except as permitted under CFR 50 or as permitted by special regulation of the secretary (Agriculture or Interior). The act also prohibits disturbing nests and interstate commerce in listed birds, parts, eggs, or nests

> or any product whether or not manufactured which consists, or is composed in whole or part, of any such bird or any part nest or egg thereof.[16]

[16] U.S. Code, Title 16, Chapter 7.

Lawfully possessed wildlife may not be exported, purchased, sold, bartered, or offered for purchase, sale, or barter. Shipments are allowed but must be in marked containers.[17]

The Migratory Bird Treaty Act provides for exceptions. Listed species may be taken by permit if

> under extraordinary conditions, [birds] may become seriously injurious to agricultural or other interests in any particular community.[18]

The Mexican and Japanese Conventions exempt game farms and subsistence hunting by indigenous peoples. Permits for taking listed birds may be obtained from the USFWS for "public" purposes. State game departments, municipal game parks or farms, public zoological parks, accredited members of the American Association of Zoological Parks and Aquariums, and public or educational institutions may acquire by gift or purchase, possess, transport, and, by gift or sale, dispose of lawfully taken wildlife without a permit.[19] Wildlife lawfully bred in captivity may be acquired without a permit. Carcasses of birds killed during legal banding may be donated to public, scientific, or educational institutions. Scientific-collection permits are available for accredited scientific or educational institutions. Falconry permits allow for the highly controlled possession of live animals. Raptor propagation permits are required in order to take, possess, transport, import, purchase, barter, or offer to sell, purchase, or barter any raptor, egg, or semen for propagation purposes. Falconry permits require detailed record-keeping of each bird. Non-permittees may possess a permitted bird for no longer than 30 days. A dead raptor must be immediately destroyed and its marker returned to the USFWS unless written approval to retain the carcass is obtained.

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[17] CFR 50, Part 21, Subpart A, Section 21.2.
[18] U.S. Code, Title 16, Chapter 7.
[19] Record-keeping is required.

Approval from the USFWS is required in order to return a possessed raptor to the wild.

Penalties for violations include a fine of not more than $500 and/or imprisonment of not more than six months. If violations involve a sale, offer for sale, barter, or offer to barter a bird, the fine is not more than $2,000 and/or imprisonment of not more than two years. All equipment used in the violation is subject to forfeiture.

A banding permit allows temporary capture of animals and acquisition of blood or tissue samples. Possession and use of these samples are not controlled by the government; therefore, they become *res privatae* upon collection. It is unclear what disposition of whole specimens or parts may be permitted for listed non-game birds.

Eagle Protection Act

The original Eagle Protection Act[20] was passed by Congress for the purpose of protecting the bald eagle only. This act contained numerous exceptions, including for scientific or exhibition purposes and for all of Alaska. Two substantial amendments modified the original act. The 1962 amendment extended coverage to golden eagles and allowed taking and possessing for Native American religious purposes and for protection against depredation of domestic animals. The 1972 amendment tightened restrictions on the killing of eagles and substantially increased penalties for violations. It also provided exceptions for falconry and for the authorized taking of golden eagle nests if those nests "interfere with resource development."

Wildlife covered by the Eagle Protection Act include any living or dead whole specimen, or any part, nest, or egg of a bald eagle (*Haliaeetus leucocephalus*) or golden eagle (*Aquila chrysaetos*). The act applies to "specimens" of eagles, whereas the CFR refers to parts, eggs nests, and eagles themselves.

[20] 16 U.S.C. § 668(a) (1981).

Prohibited acts include the taking, possessing, transporting, selling, purchasing, bartering, trading, offering to sell, purchase, or barter, exporting, or importing of any bald eagle or golden eagle, alive or dead, or any part, nest, or egg.

Exceptions include the use of eagle parts in religious ceremonies of Native Americans or the non-commercial use of eagle parts by Native Americans under several treaties between Indian nations and the United States. Some seasonal taking to protect domestic herds or flocks may be authorized. Other takings for scientific purposes, exhibition by public institutions, or falconry may be permitted by the USFWS.

The Eagle Protection Act provides felonies for commercial transactions (buying, selling, bartering) or misdemeanors for simple negligent taking and/or possession. Each taking (of an animal or part) is a separate violation. First violations are fined a maximum of $5,000 and/or imprisonment of a maximum of one year. Subsequent violations are fined a maximum of $10,000 and/or imprisonment of a maximum of two years. Civil penalties include a maximum of $5,000 for each violation. Violations may also result in cancellation of any lease, license, permit, or other authorization for grazing on federal lands.

Marine Mammal Protection Act

The Marine Mammal Protection Act[21] (MMPA) was enacted in 1972 in response to the public outcry against the killing of dolphins by tuna fishing, the slaughter of baby harp seals, and the general public affection for cetaceans and pinnipeds. The MMPA plays a role in the federal- versus state-sovereignty dialectic described in Chapter 3. It exemplifies the shift of state to federal sovereignty in select wildlife. Although the MMPA provides a protocol whereby a state may attempt to

[21] 16 U.S.C. §§ 1361-1407 (1994).

eventually assume a modicum of control, it allows no state involvement in the control of listed species.

Wildlife covered include

> any mammal which a) is morphologically adapted to the marine environment (including sea otters and members of the orders Sirenia, Pinnipedia and Cetacea), or b) primarily inhabits the marine environment (such as the polar bear); and . . . includes any part of any such marine mammal, including its raw, dressed, or dyed fur or skin.[22]

The MMPA prohibits taking,[23] hunting, capturing, or killing, or attempting to harass, hunt, capture, or kill any marine mammal. It also prohibits the transport, purchase, sale, or export of, or the offer to purchase, sell, or export any marine mammal or marine-mammal product taken in violation of the act or for any purpose other than public display, scientific research, or enhancing the survival of a species or stock. Importing listed species is also prohibited.

The MMPA allows taking for authorized scientific purposes,[24] for appropriate public display, or for the purposes of enhancing the survival or recovery of a protected species. Exceptions also include taking by Alaska Natives for subsistence and for handicraft manufacture; select taking or importing is allowed by the Secretary of the Interior: taking for *bona fide* scientific purposes, taking necessary for enhancing the survival or recovery of a species or stock, taking for public display, or incidental taking by commercial fishing operations.

[22] Ibid.

[23] The term "take" means to harass ("the term harassment means any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild or has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including but not limited to migration, breathing, nursing, breeding, feeding or sheltering"). U.S. Code Title 16, Chapter 31, Section 1362, pp. 711, 712.

[24] "requires that the taking is required to further a bona fide scientific purpose . . . a non-lethal method . . . is not feasible . . . unless the Secretary determines . . . such research will directly benefit that species . . ." U.S. Code Chapter 35, Section 1539, p. 91.

Penalties include the revocation of permits and the assessment of civil penalties by the Secretary of the Interior of not more than $10,000 for each violation. Convictions may involve fines of not more than $20,000 and/or imprisonment for not more than one year.

The Secretary of the Interior may be petitioned to allow for the acquisition of tissues and cells if it can be argued that such taking is a *bona fide* scientific purpose or in furtherance of the survival or recovery of the species.

Wild Horse and Burro Act of 1971

The Wild Horse and Burro Act[25] was intended to protect a symbol of the nation's heritage and to control the abusive exploitation of these animals. The act covers wild horses or burros on federal land and relies on the property clause of the Constitution to pre-empt states from jurisdiction over wild horses and burros on federal land under the auspices of the U.S. Forest Service (USFS) or Bureau of Land Management (BLM). The act asserts federal control of unbranded and unclaimed horses or burros on federal land but allows states to determine whether such animals are unclaimed, especially if they are on private land. Other than this allowance for state determination of the status of such animals, the act has primacy over any state law.

The act prohibits the malicious causing of death or harassment, the willful removal or attempts to remove protected animals from public lands, and the processing of protected animals or their remains into commercial products. Penalties include $2,000 and/or one year in prison per violation.

The act provides some exceptions for protected animals that voluntarily stray onto private land; they may become the property of the private landowner.

[25] 16 U.S.C. §§ 1331-1340 (1981).

Endangered Species Act

The Endangered Species Act[26] (ESA) is the most comprehensive extension of federal sovereignty over wildlife under U.S. law. The prohibition against taking a specimen of a listed species is absolute, although certain exceptions may be permitted.

Beginning in 1966, Congress enacted a series of three laws, each building upon the previous, designed to prevent the extinction of certain threatened wildlife species. The ESA utilizes the major wildlife regulatory tools available to accomplish its objectives. The initial ESA of 1966 encouraged protection but did not prohibit possession, leaving this power to the states, and did not restrict interstate commerce in listed species. The 1966 law was limited to “fish and wildlife” and “vertebrate animals.” Some of these deficiencies were rectified in the act of 1969, which expanded its prohibitions on interstate and foreign commerce in unlawfully taken wild birds and mammals to include reptiles, amphibians, mollusks, and crustaceans. The international treaty known as the Convention on International Trade in Endangered Species of Wild Fauna and Fora (CITES) was ratified by the United States in 1973, which motivated a reevaluation of the 1969 ESA. The acts of 1966 and 1969 had left intact the traditional state authority to regulate the taking of wildlife. The federal obligations under CITES and Congressional willingness to supersede state authority in the wild demonstrated by the MMPA of 1972 provided a basis for more assertive federal authority over endangered species. The ESA of 1973 extended protection to any listed member of the animal or plant kingdoms. Further, it distinguished between “endangered” and “threatened” species. A critical modification was the “similarity of appearance” rule, an acknowledgment that certain species look so similar to endangered and threatened

[26] Endangered Species Conservation Act of 1966, Pub. L. No 89-669, §§ 1-3, 80 Stat. 926 (repealed); Endangered Species Conservation Act of 1969, Pub. L. No. 91-135, 83 Stat. 275; Endangered Species Conservation Act of 1973, Pub. L. No. 93-205, 87 Stat. 884 (current version at 16 U.S.C. §§ 1531-1543 (1976 and Supp. V. 1981)) amended by Nov.10, 1978, Pub. L. No. 95-632, §§ 1, 92 Stat. 3751.

species that they should be afforded protection to assure the protection of the endangered species they resemble.

The implications of listing a species as endangered were made clear by *Hill v. Tennessee Valley Authority,*[27] the famous "snail darter case."

The ESA amendment of 1978 vastly complicated the listing process by imposing a "social balancing" component on otherwise biological criteria. The 1978 listing process, further burdened by the Reagan administration's imposition of economic reviews beyond the act's requirements (Bean and Rowland, 1997), halted the listing of some 2,000 species.

The amendment of 1988[28] expanded the ESA to cover endangered plants, making it illegal to remove and reduce to possession any listed plant from federal lands or to maliciously damage or destroy any such plant

> on any other area in knowing violation of any law or regulation of any state or in the course of any violation of a state criminal trespass law.[29]

An endangered plant growing on private land is the property of the landowner. However, the landowner may not sell, offer for sale, deliver, receive, carry, transport, or ship, in interstate or foreign commerce, by any means whatsoever, and in the course of a commercial activity, such plant.

Wildlife covered by the ESA include all species listed as "endangered" or "threatened" in the U.S. CFR, Title 50, Section 17.11. This includes birds, crustacea, amphibians, fish, insects, mammals, reptiles, mollusks, and plants. The ESA defines "fish or wildlife" as

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[27] *Hill v. Tennessee Valley Authority*, 549 F.2d 1064 (6^{th} Cir 1977); aff'd 437 U.S. 153 (1978).
[28] ESA § 9(a)(2)(B), 16 U.S.C. § 1538 (a)(2)(B) (1988); Endangered Species Conservation Act of 1973 (Pub. L. No. 93-205, 87 Stat.884 (current version at 16 U.S.C. §§ 1531-1543 (1976 and Supp. V. 1981)) as amended by 1978 (Nov.10, 1978, Pub. L. No. 95-632, ss1, 92 Stat. 3751), 1982 amendments.
[29] Ibid.

> any member of the animal kingdom, including without limitation any mammal, fish, bird (including any migratory, nonmigratory, or endangered bird for which protection is also afforded by treaty of other international agreement), amphibian, reptile, mollusk, crustacean, arthropod or other invertebrate and includes any part, product, egg, or offspring thereof, or the dead body or parts thereof.[30]

The ESA covers listed species, specific populations, sometimes a species only in a portion of its geographic range, and sometimes "similarity of appearance" to listed species. Listing requires a petition to the Secretary of the Interior or his/her designate (the USFWS) and concurrence by the Secretary of Commerce. The listing determination is to be made solely on the basis of the best scientific and commercial data available.

Acts prohibited under the ESA include taking, harassing, harming,[31] pursuing, hunting, shooting, wounding, killing, trapping, capturing, collecting, or attempting to engage in any such conduct; and exporting, importing, possessing, selling, delivering, carrying, transporting, shipping, or engaging in interstate or foreign commerce of a listed species; and removing and reducing to possession any listed plant species from federal land.

ESA exceptions include authorized incidental taking, captive breeding, falconry, economic hardship, and scientific purposes. "Permits for Scientific Purposes"[32] require an application with details on the species to be taken: a statement that the species sought is still wild or already removed from the wild or born in captivity, location of the removed species, a complete description of the institution where the species will be used, and rationale for the taking. In evaluating the request for taking, the Secretary of the Interior will consider

[30] US Code Title 16, Chapter 35, Section 1532, p. 13.
[31] This includes significant habitat modification or degradation that actually kills or injures wildlife.
[32] 50 C.F.R. § 17.22 (2002).

> if the purpose is justifiable, what the direct or indirect affect on the wild population would be, the opinion of scientists, and the degree that the purpose would likely reduce the threat of extinction of the species.[33]

"Special Rules" eliminate normal permit requirements for designated threatened species in specific instances. For example, the San Marcos salamander may be taken without a permit in accordance with Texas state law. Loggerhead, green, and Olive Ridley sea turtles may be taken incidental to fishing operations.[34] Subsistence taking is permitted in certain cases. For example, green sea turtles may be taken in certain areas by select Pacific Islanders, although such turtles cannot be transferred to non-residents or sold.

Penalties under the ESA depend on the violation: a civil penalty of between $500 and $25,000 for each violation may be assessed by the Secretary of the Interior. Criminal violations may be assessed between $25,000 and $50,000 and between six months and one year in jail. Federal permits for grazing or wildlife importation may be revoked or suspended. Federal hunting, fishing, or other wildlife permits may be revoked or suspended. All equipment, vessels, aircraft, and other transportation used in taking and/or possessing may be forfeited.

The ESA is ambiguous on the extent to which federal sovereignty over listed species extends to such wildlife on state land. Gidari (1994) provides an overview of the balance of federal power in wildlife and a landowner's rights. Meltz (1994) also reviews the ESA reach over endangered species on private land.

Much of the tension between a private landowner's rights and federally controlled biota has centered on habitat modification that results from logging, construction, and development. The ESA permits some of this activity, and it is ambiguous as to the rights of the landowner. Although there is no case law to shed

[33] US Code Chapter 16, Section 1534, p. 91.
[34] Such taken turtles must be released to the sea if alive and handed over to USFWS if dead, or resuscitated and released, if possible.

light on the subject, it appears that, as with other wildlife law, the non-incidental possession of endangered-species specimens is prohibited on any lands, including private.

In the most recent Supreme Court case on the ESA, *Babbitt v. Sweet Home Chapter of Communities for a Greater Oregon*,[35] the court interpreted the taking prohibition to include significant habitat modification that kills or injures listed species. This decision extends federal sovereignty over listed species on private lands.

4.2.3 Wildlife on Federal Lands and Waters

The constitutional provision that any transfer of U.S. government property to any other entity requires the approval of Congress (through statutes that grant government agencies this right) provides a basis of federal *res publicae* in wildlife on federal lands and waters.

The federal government may not abandon U.S. government property without expressly stating its intention to do so.

The federal government asserts varying degrees of control of the wildlife on federal land. The type and extent of federal property control over that wildlife depends on the type of federal land. For example, governmental control of property in national parks is different from control of wildlife on BLM lands.

Forest Service Lands

The taking of any game or non-game animals, birds, or fish from any national forest lands or waters, including any overlap with military reservation or bird refuge, preserve sanctuary or reservation, requires a permit from the Forest Supervisor.[36] Title 50 of the CFR requires the U.S. Forest Service and the relevant state authority to cooperate to develop plans for wildlife protection on national forest land.

[35] *Babbitt v. Sweet Home Chapter of Communities for a Greater Oregon*, 515 U.S. 687 (1995).
[36] 36 C.F.R. § 241.3 (2002).

Bureau of Land Management (BLM) Lands

Management of wildlife on BLM lands is a cooperative effort between host states and the BLM. States are responsible for species management, and the BLM is responsible for habitat management (Bean and Rowland, 1997). The Classification and Multiple Use Act of 1964[37] authorized and directed the Secretary of the Interior to administer BLM lands under principles of multiple use and sustained yield. The Federal Land Policy and Management Act of 1976 directs the secretary to develop and maintain land-use plans for particular tracts that are coordinated with plans in proximate national forests and that

> use a systematic interdisciplinary approach to achieve integrated consideration of physical, biological, economic and other sciences.[38]

There are no requirements for a federal permit to hunt or fish on BLM lands, although areas may be designated in which no hunting, fishing, or trapping is allowed by the Secretary of the Interior and the Secretary of Agriculture. Decisions on BLM land-use plans are made by Resource Advisory Councils composed of commercial and environmental interests, public officials, the public at large, and academicians.

National Wildlife Refuges

The enabling statutes include the National Wildlife Refuge Administration Act (NWRAA) of 1966,[39] the Refuge Recreation Act of 1962,[40] and the Refuge Revenue Sharing Act of 1964.[41] The 1966 NWRAA combined various administrative units ("game ranges," "wildlife ranges," "wildlife management areas," "waterfowl production areas," and "wildlife refuges") into the National Wildlife Refuge System

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[37] 43 U.S.C. §§ 1411-1418, 373-75 (2002).
[38] Ibid.
[39] 16 U.S.C. §§ 668dd, 668ee (2002).
[40] 16 U.S.C. §§ L160K-460k-4 (2002).
[41] 16 U.S.C. §§ 715A (2002).

and allowed some hunting and fishing within the lands of the Refuge System under rules promulgated by the Secretary of Interior. The Refuge Recreation Act authorizes the secretary to permit public recreation (including taking wildlife) on refuge lands. Litigation[42] confirmed the jurisdiction of the USFWS over refuge properties and its primary role in controlling wildlife. The courts also confirmed the government's right to prevent trespassing (Bean and Rowland, 1997) and the secretary's right to allow regulated hunting.[43] The CFR states,

> Unauthorized removal of any natural objects from any national wildlife refuge is prohibited and disturbing . . . collecting or attempting to collect any plant or animal . . . is prohibited except by special permit.[44]

Combining this prohibition with the *Coupland vs. Morton*[45] decision, which gave the federal government authority to prohibit public access to refuge lands, defines a strong federal property right in biota on national refuge lands.

National Parks and Monuments

National parks are governed by several federal laws including the Yellowstone National Park Act of 1872[46] and the National Park Service Act of 1916[47] (the "Organic Act"). The Organic Act explicitly recognizes wildlife conservation as a primary purpose of national parks:

> the fundamental purpose of . . . said parks . . . is to conserve . . . the wildlife therein . . . in such a manner and by such means as will leave them unimpaired for . . . future generations.[48]

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[42] *Schwenke v. Secretary of Interior*, 720 F.2d 571 (9th Cir. 1983).
[43] *Humane Society of the U.S. v. Lujan*, 768 F. Supp. 360 (D.D.C. 1991).
[44] 50 U.S.C. §§ 27e (2002).
[45] Envmntl. L. Rep. 20504; 4th Cir 1975.
[46] 16 U.S.C. § 821 (2002).
[47] 16 U.S.C. §§ 881, 2-3 (2002).
[48] Ibid.

The Secretary of the Interior has broad discretion to take any action necessary to conserve park wildlife unless Congressionally prohibited from doing so.[49] Litigation has confirmed the secretary's public-trust obligation to protect park resources.[50] The Redwood National Park Expansion Act of 1978[51] gave the secretary the comprehensive authority to enforce the government's public-trust obligation in all national parks, authorizing the "highest standards of protection and care." Hunting and trapping are not permitted in national park areas,[52] and the courts have upheld the secretary's right to enforce such prohibition.[53] Courts have also held that the secretary has authority over non-federal waters on national park lands.[54] The CRF (Title 36) prohibits the possession of dead or living wildlife, fish, plants, or their parts except as permitted by the secretary and the superintendent of the particular park land or water.

National Parkways/Rivers and Riverways, Water Gap Areas, National Recreation Areas, National Lakeshores, National Conservation Areas, and Seashore Recreation Areas

The U.S. Code Title 16 states that hunting and fishing in national parkways and related lands is to be cooperatively managed with state and federal agencies and provides that the Secretary of the Interior may, after consulting with state and federal agencies, issue regulations designating "no take" zones or periods. Except in emergencies, any regulations of the secretary pursuant to this section shall be put in effect only after consultation with appropriate fish and game departments. This federal regulation also provides that hunting, fishing, trapping, and collecting are controlled by the secretary during open season as prescribed by local, state, and federal law. The

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49 *Michigan United Conservation Clubs s. Lujan*, 949 F. 2nd 202 (6th Cir. 1991).
50 *Sierra Club v. Department of Interior*, 376 F. Supp. 93 (1974).
51 The Redwood National Park Expansion Act of 1978, Pub. L. No. 95 – 250 § 101,92 Stat 163 (1978).
52 51 Fed. Reg. 33263 (1986); 36 C.F.R. § 882.2(b)3 (1996).
53 *Michigan United Conservation Clubs v. Lujan*, 949 F.2d 202 (1991).
54 *U.S. v. Brown*, 552 F. 2d 817 (8th Cir) cert denied 431 U.S. 949 (1977), aff'g 431 F. Supp 56 (D. Minn 1976).

secretary is to administer the regulations and protect wildlife with the aim of conserving natural resources.

National Military Parks

U.S. Code Annotated USCA Title 16 Ch. 1, Section 413 prohibits the taking of wildlife from military parks. The removal of any tree, shrub, or plant is a misdemeanor.

Department of Defense

The Natural Resources Management Program[55] requires the heads of military services and directors of defense agencies with land-management responsibilities to "act as trustees for natural resources under their jurisdiction."[56] The policy states that "watersheds, natural landscapes soils, forests, fish and wildlife and protected species shall be conserved and managed or vital elements of D.O.D.'s natural resources program."[57]

"Integrated Natural Resources Management (INRM) Plans" are required for properties under Department of Defense (DOD) control. INRM plans include fish and wildlife management, and both game and non-game species. Such INRM plans are designed to conserve the wildlife benefit for the public. Under these plans, endangered and threatened species are managed according to ESA and USFWS regulations; the Sikes Act requires coordination and cooperation between the Departments of Defense (DOD) and Interior and the host states on management of fish and wildlife on DOD properties. Hunting, fishing, and trapping are allowed on DOD properties according to the fish and game laws of the host state. Enforcement of such laws is done in accordance with an INRM plan in coordination with a "wildlife manager." The

[55] 32 CFR § 190 (2002).
[56] 32 CFR § 190.5 (2002).
[57] 32 CFR § 190.4 (2002).

Assistant Secretary of Defense for Protection and Logistics (ASD P&L) has responsibility for these activities.

Department of Energy

The Secretaries of Energy, Interior, and Agriculture and state agencies cooperate to develop and implement wildlife conservation plans on specific Department of Energy properties.[58]

Army Corps of Engineers—Department of the Army

CFR 36 provides the Department of the Army jurisdiction over wildlife on all Army Corps of Engineering properties. The District Engineer has authority to prohibit the taking of any wild animal or bird. Where it is allowed, hunting, fishing, and trapping are to be done in accord with the laws of the host state.

Wilderness Lands

The Wilderness Act of 1964[59] adds certain management directives to federal lands that are in the public domain for other purposes and includes lands under the auspices of other agencies including the BLM, Forest Service, USFWS, and National Park Service. The only express mention of wildlife in the act is the statement that nothing in the act "shall be construed as affecting the jurisdiction or responsibilities of the several states with respect to wildlife and fish in the national forests."[60]

International Treaties

Treaties have power equivalent to that of federal laws enacted by Congress. They are also akin to contracts between the U.S. government and the other signatory nations. For a treaty to be effective within the United States, some implementation of

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[58] 16 U.S.C. § 670 (2002).
[59] 16 U.S.C. §§ 1131, 314-29 347-49, 374 (2002).
[60] The Wilderness Act. Public Law 99-577, Sept 3, 1964, Special Provisions (d), Section 8, p. 896.

federal legislation is required, and the treaty *per se* may or may not have enforceable rights in the United States over U.S. citizens. Treaties obligate the federal government to adhere to the treaty provisions and have primacy over any state law. The United States is a signatory to several international treaties that govern wildlife, including the following: **CITES** (the Convention on International Trade in Endangered Species); the **Convention on the Conservation of Migratory Species of Wild Animals** (the "Bonn" Convention); the **Interim Convention on Conservation of North Pacific Fur Seals**, which controls the taking of fur seals in the north Pacific; the **Convention for the Regulation of Whaling**, which was implemented by the Marine Mammal Protection Act and the Fishery Conservation and Management Act[61]; the **Agreement on the Conservation of Polar Bears**; and the **Antarctic Treaty**, which controls the taking of birds, marine mammals, and krill.

The ESA and the Lacey Act provide the implementation of these treaty obligations. The ESA listing of species includes those that have been designated as controlled under CITES. The Lacey Act extends federal protection to any species taken or possessed contrary to state, federal, or foreign law or treaty to which the United States is a signatory.

4.2.4 Federal Control of Pathogens and Pests

Federal control over human pathogens is asserted in a variety of laws and regulations, primarily by the Food and Drug Administration, but that is not the focus of this study. However, I do review control of agricultural and environmental pests.

Agricultural pests are controlled by the federal government under a variety of laws. Animal pests fall under the Lacey Act.[62] Plants fall under a variety of statutes.[63]

[61] 22 U.S.C. §1 (1978 Supp. V. 1981).
[62] 18 U.S.C. § 42 (2002).
[63] Federal Plant Pest Act (7 USC §§ 150aa-jj (2002); Organic Act (17 USC §§ 47a-e (2002); Plant Quarantine Act (7 USC §§ 151-64a, 167 (2002); Federal Noxious Weed Act (7 USC §§ 2801-13 (2002); Agricultural Quarantine Enforcement Act; Non-indigenous Aquatic Nuisance Prevention and

In addition, Executive Orders 11987 (1977) and 13112 directed federal agencies to restrict exotic species, to establish a National Invasive Species Council, and to establish a National Invasive Species Management Plan and an Invasive Species Advisory Committee.

Agricultural pests are defined and controlled by the federal government under U.S. Code Title 7 (Agriculture). Section 147 of Title 7 exemplifies the broad federal government powers for control of such organisms. The Secretary of Agriculture is directed to identify pests (Section 136w-3) and is authorized "to carry out operations or measure to detect, eradicate, suppress, control, or to prevent or retard the spread of plant pests." Section 148 extends these broad powers to insect pests and plant diseases. Under this Title (Section 150aa), a "plant pest" is defined as

> Any living stage of: any insects, mites, nematodes, slugs, snails, protozoa, or other invertebrate animals, bacteria, fungi, other parasitic plants or reproductive parts thereof, viruses, or any organism similar to or allied with any of the foregoing, or any infectious substances, which can directly or indirectly injure or cause disease or damage in any plant or parts thereof, or any processed, manufactured, or other products of plants. "Living stage" includes the egg, pupal, and larval stages.

Section 150bb of Title 7 U.S.C. prohibits importing or entering any plant pest into the United States, moving any plant pest interstate, or accepting delivery (unless the movement is made in accordance with regulations). Section 150dd also gives the Secretary of Agriculture broad emergency powers.[64]

Control Act of 1990 (17 USC §§ 4201, 4202, 4711, 4712, 4721-28, 4741, 4751 (2002); 18 USC § 42 (2002)).

[64] "The Secretary may, whenever he deems it necessary as an emergency measure in order to prevent the dissemination of any plant pest new to or not theretofore known to be widely prevalent or distributed within and throughout the United States, seize, quarantine, treat, apply other remedial measures to, destroy, or otherwise dispose of, any character whatsoever, or means of conveyance, which is moving into or through the United States, or interstate, and which he has reason to believe is infested or infected by or contains any such plant pest, or which has moved into the United States, or interstate, and which he has reason to believe was infested or infected by or contained any such plant pest at the time of such movement; and any plant pest, product, article, or means of conveyance which is moving into or through the United States, or interstate, or has moved into the United States, or interstate in violation of this chapter or any regulation thereunder: Provided that this subsection shall

Noxious weeds are controlled in Chapter 61 of U.S.C. Title 7. The Secretary of Agriculture is authorized to promulgate regulations that prohibit the import or entering of a noxious weed interstate and the sale, purchase, barter, exchange, receipt acceptance for delivery, or transport of any noxious weed. A list of noxious weed species is provided in Title 7 of the CFR, Chapter 3. These powers of the secretary are extended to predatory and other wild animals in Section 426 of Chapter 17 of Title 7 U.S.C. and to nuisance mammals, birds, and organisms constituting reservoirs of zoonotic diseases in Section 426, Chapter 17.

The control of pest and pathogen species is spread across several departments and agencies (see Table 4.1 for several examples).

Despite significant cross-agency responsibility, the Animal and Plant Health Inspection Service (APHIS) has the primary burden of controlling pest and pathogen species. The regulations by which APHIS controls federally controlled pests are contained in Title 9 of the CFR. These regulations are numerous and complex, and they cover a broad range of wildlife. For example, Title 9 authorizes APHIS to assert federal power over animal semen, cell cultures, livestock vaccines, hay/straw from tick-infested areas, sera, toxins, organisms, hedgehogs, tenrecs, dogs, ratites, elephants, hippos, rhinos, and tapirs. APHIS has the power to examine records (Section 2.126); to confiscate and destroy organisms and their products (2.129); to prohibit interstate movement of land tortoises (74.1); and to control marine mammals (3.100), non-human primates (subpart D), guinea pigs and hamsters, animal stomachs and extracts from ruminants and service (95.19), and glands, organs, ox gall, and bone marrow (95.17, 95.18).

not authorize such action with respect to any product, article, means of conveyance, or plant pest subject, at the time of the proposed action, to disposal under the Plant Quarantine Act" (7 U.S.C. § 151 (2002)).

Table 4.1. Federal Agencies and the Pest Species under their Control.

Department and agency	Controlled pest and pathogen species
Agriculture	
Animal and Plant Health Inspection Service	citrus canker, glassy-winged sharpshooter, Mediterranean fruit fly, Asian long-horned beetle, plum pox virus
Agricultural Research Service	glassy-winged sharpshooter, brown citrus aphid, citrus psylla, papaya mealybug, pink hibiscus mealybug
Forest Service	European gypsy moth, Asian long nosed beetle, hemlock woolly adelgid, Port-Orford-cedar disease, Miconia
Interior	
U.S. Fish and Wildlife Service	*Caulerpa taxifolia*, Asian swamp eel, zebra mussel, brown tree snake, round goby
Bureau of Indian Affairs	cogongrass, purple loosestrife, Russian knapweed
Bureau of Land Management	giant salvinia, yellow starthistle, purple loosestrife, dyers woad, squarrose knapweed
U.S. Geological Survey	Asian swamp eel, giant salvinia, garlic mustard, round goby, black, silver and bighead carp
Bureau of Reclamation	giant salvinia
Commerce	
National Oceanic and Atmospheric Administration	*Caulerpa taxifolia* (aquatic plant)

Marine Wildlife

The Fishery Conservation and Management Act of 1976[65] (also called the Magnuson–Stevens Act) asserts exclusive federal management authority over "fish . . . mollusks, crustaceans, and all other forms of marine and plant life other than marine mammals and birds."

Within 200 miles of the U.S. coast, and wherever the continental shelf extends beyond the 200-mile zone, the United States asserts a property interest in all sedentary species, including crabs, sponges, mollusks, and corals. This law also establishes eight Regional Fishery Management Councils, which are composed of federal and state officials. The councils develop management plans for each fishery, which are

[65] 16 U.S.C. 88 § 1802.11 (1811); Amendments of 1986, Pub. L. No. 99-659 88 101(a), 100 stat. 3706.

approved by the Secretary of Commerce.[66] A critical aspect of these plans is the determination of the “optimum yield” of a particular fishery. The secretary is responsible for implementing the final regulations of such plants. Bean and Rowland (1997) point out that these hybrid federal–state councils are unique in wildlife law. Unlike the MMPA, there is no preemptory federal power over ocean fisheries. Title 50 of the CFR provides a voluminous set of complex fishing regulations that define authorized taking in particular fisheries.

Curiously, despite a title that suggests otherwise, the Marine Protection Research and Sanctuaries Act of 1972[67] provides no federal or state control over wildlife. Chapter 20 of the U.S Code describes the jurisdiction over wildlife on “Submerged Lands.” Submerged lands are all lands within boundaries of each state covered by non-tidal waters (navigable at time of statehood) or those covered by tidal waters. Natural resources within those lands include corals and coral reefs, fish, shrimp, oysters, clams, crabs, lobsters, sponges, kelp, and other marine and plant life. The U.S. Code provides that “public interest and title to such lands and natural resources with such lands with rights to manage shall belong to the state.”[68] However, the federal government reserves the right to control the taking of wildlife in coastal fisheries under the commerce clause.[69] In U.S. Code Chapter 43, Subchapter III, the designation “outer continental shelf land” includes the subsoil and seabed.

4.3 State *Res publicae* Wildlife

4.3.1 General Overview

While capture historically formed the basis of property in wildlife, the “capture doctrine” is subordinate to state “ownership.” This flows from the “public trust”

[66] The secretary can develop such a plan if the council fails, but the council can review it in that event.
[67] Marine Protection Research and Sanctuaries Act of 1972, Pub. L. No. 92-532, tit. III, 86 Stat. 1061, 16 U.S.C. 88 §§ 1431-1445(a) (2002).
[68] U.S. Code Title 43, Chapter 29, Section 1301.
[69] *Douglas v. Seacoast Products, Inc.* Va., 431 U.S. 265 (1977).

doctrine in wildlife, with its roots in the "king's prerogative in England" (Blum and Ritchie, 2005).

Each state has extensive and complex laws and regulations that govern the possession and use of wildlife. The scope and extent of the state *res publicae* character must be determined state by state and taxon by taxon. Detailing this complexity is beyond the scope of this work. However, a general overview of the common elements of state wildlife law and regulation and a few descriptive examples provide a useful framework.

A synopsis of wildlife law in all fifty states is provided by Musgrave and Stein (1993). Thirty states explicitly claim ownership of wildlife within their borders (Blum and Ritchie, 2005). These authors describe the following nine elements that generally characterize state wildlife law: 1) statements of policy, 2) state agencies involved, 3) protected species, 4) exceptions to protection, 5) hunting regulations, 6) fishing and trapping regulations, 7) animal damage control, 8) habitat protection, and 9) Native American provisions.

States vary considerably in their definitions of "wildlife." Some include invertebrates and insects; others do not include reptiles or amphibians.[70] Similarly, definitions of "game" and "non-game" also vary significantly.

States typically designate "game" vs. "non-game" and "protected" vs. "non-protected" species. States typically control the taking of game and protected species but not non-game or non-protected species. Game are typically controlled by hunting regulations, which permit taking, but only under strict prescriptions including required licenses or permits, definitions of closed/open season, hours of taking, bag limits, and control over manner of taking. Non-game wildlife are not controlled unless they are

[70] New Mexico.

protected. Protected species are protected against various types of taking. Non-protected wildlife are typically uncontrolled by the state.

Nearly every state protects songbirds, insectivorous birds, and non-predacious wild birds (jays and crows are an exception), their eggs and nests. Of course, the federal MBTA has primacy over any state law, and each state has enacted laws and regulations that are in accordance with the federal control of all species listed in the federal act. New Mexico appears to have the most extensive listing of protected birds.

Although protection for various types of wildlife varies by state, most states protect birds, game animals, sport fish, and any species (including plants) that are protected by federal law. Other animals, such as reptiles, amphibians, crustaceans, mollusks, and arthropods, are covered under some state laws and not at all under others. “Lower” life forms such as protozoa, algae, bacteria, and fungi are not explicitly covered under any state wildlife law.

Some states exhibit anomalous or unique wildlife-control laws. New York and Utah have the only laws that protect aquatic insects, prohibiting the taking of any such species without a permit (Musgrave and Stein, 1993). Other states do not protect insects except those listed in the ESA. Most states have wildlife-in-captivity laws that vary greatly in their specifics but generally control this practice. Maryland protects all wild mammals in the state except nutria and woodchuck.

Nearly every state provides for the taking, under strictly regulated conditions and procedures, of endangered or threatened species for scientific, zoological, or educational purposes, for propagation in captivity, or when public health or welfare is involved. Good examples of states with explicit regulations for scientific taking include Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Texas, Washington, and Wisconsin. All states allow taking exceptions for virtually any species through a permit or license process. The states all vary greatly in the details of their season lengths and their fish-and-game-hunting and fishing-and-trapping laws and regulations. Many states issue free hunting licenses to landowners for hunting on their own land. Another area of great variation is in enforcement and penalties.

4.3.2 New York State *Res publicae* Wildlife Law

New York State wildlife law and regulations are embodied in the Environmental Conservation Law (ECL) enacted in 1972.[71] The ECL is implemented by the New York State Department of Environmental Conservation. The ECL states that

> The State of New York owns all fish, game wildlife, shellfish, crustacean and protected insects in the state, except those legally acquired and held in private ownership. Any person who kills, takes, or possesses such fish, game wildlife, shellfish, crustacean and protected insects thereby consents that title shall remain in the State for the purpose of regulating and controlling their use and disposition.[72]

Several New York state court cases have confirmed the state's assertion of a property interest in wildlife. In *People v. Doxtater,* the court stated that

> even a fee title of the land under the waters of the lake and the exclusive right of fishing therein does not confer upon the holder thereof the ownership of the fish in the lake.[73]

In *People v. Bootman,* the court stated that

> the game and fish within the boundaries of the state [belong]to the people in their unorganized capacity; there is no property in living wild animals and only as the law permits their capture is there a right of property in them after they are caught or killed.[74]

In *Rockefeller v. LaMora,* the court decided that

[71] The latest version may be found in *McKinney's Consolidated Laws of New York Annotated* published by WestGroup in 1997.
[72] N.Y. Env. Con. Law, art. 11 § 11-0105 (McKinney 1997).
[73] *People v. Doxtater*, 147 N.Y. 723 (1894).
[74] *People v. Bootman*, 180 N.Y. 1 (1904).

> fish and game are migratory and those which may now be on private lands may quickly change their location to public lands and public waters, no man owns wild game or fish even though they be on his land, unless he has reduced them to his possession by capture and if they wander from his premises to those of the public or another, he may not complain of their taking.[75]

According to *In re Fishway,*

> fish running at large are ferae naturae . . . [and] are the public property of all the people of the state in common and no person can acquire property therein . . . [76]

In *Barrett v. State,* the court declared that

> the general right of the government to protect wild animals is too well established now to be called in question; their ownership is in the state in its sovereign capacity, for the benefit of all the people.[77]

In *Sloup v. Town of Islip,* the court found that

> migratory marine fish are ferae naturae and are the property of the state.[78]

In the *People v. Chimbers* the court stated that

> ownership of fish and game within the state is in its sovereign capacity and the state has general right to protect fish and game.[79]

In 2000, a New York appellate court held that the state's interest in protecting its wild animals is a legitimate basis for rejecting a "takings" claim for endangered species.[80] The state's sovereignty over wildlife that is not federal *res publicae* dominates any rights in wildlife that Native American nations may have in the state. In *People v. Pierce*, the New York court held that

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[75] *Rockefeller v. LaMora*, 83 N.Y. 289 (1903).
[76] *In re Fishway*, 115 N.Y. 745 (1909).
[77] *Barrett v. State*, 220 N.Y. 423 (1917).
[78] *Sloup v. Town of Isli*, 356 N.Y.S.2d 742 (1974).
[79] *People v. Chimber*, 398 N.Y.S. 222 (1977).
[80] 714 N.Y.S. 2d 78 (2000).

the Indians of the state are bound to obey the [NY State] game laws . . . [81]

Definitions in state wildlife law are critical to definition and assertion of *res publicae* in wildlife. The New York ECL provides the following definitions:

> "**Fish**" means all varieties of the super-class Pisces.
>
> "**Fish protected by law**" means fish protected, by law or by regulations of the department, by restrictions on open seasons or on size of fish that may be taken.
>
> "**Game**" is classified as (a) game birds; (b) big game; (c) small game.
>
> "**Game birds**" are classified as (1) migratory game birds and (2) upland game birds.
>
> "**Migratory game birds**" means the Anatidae or waterfowl, commonly known as geese, brant swans and river and sea ducks; the Rallidae, commonly known as rails, American coots, mud hens and gallinules; the Limicolae or shore birds, commonly known as woodcock, snipe, plover, surfbirds, sandpipers, tattlers and curlews; the Corvidae, commonly known as jays, crows and magpies.
>
> "**Upland game birds**" (Gallinae) means wild turkeys, grouse, pheasant, Hungarian or European gray-legged partridge, and quail. Grouse means ruffed grouse and every member of the grouse family. Pheasant means the ring-necked, dark-necked, and mutant pheasants and all species and subspecies of the genus Phasianus . . .
>
> "**Big Game**" means deer, bear, moose, elk, except captive bred and raised North American elk (Cervus elaphus), caribou and antelope.
>
> "**Small Game**" means black, gray and fox squirrels, European hares, varying hares, cottontail rabbits, frogs, land turtles, box and wood turtles and the bog turtle (Clemmys muhlenbergi, coyotes, red fox (Vulpes vulpes) and gray fox (Urocyon cinereoargenteus) except captive bred red fox or gray fox, raccoon, opossum, or weasel, skunk, bobcat, lynx, muskrat, mink, except mink born in captivity, fisher, otter, beaver, sable, and marten but does not include coydogs.

[81] N.Y. Env. Con. Law, art. 11 § 11-0307 (McKinney 1997).

“**Wild game**” means all game, except (a) domestic game bird and domestic game animal as defined in Subdivision 4 (below); (b) carcasses of foreign game as defined in Section 11-1717, imported from outside the U.S. and tagged as provided in section 11-1721; (c) game propagated or kept alive in captivity as provided in section 11-1907; (d) game imported alive pursuant to license of the department, or artificially propagated, until such game is liberated; and (e) game so imported or propagated when liberated for the purpose of a field trial and taken during the field trial for which it was liberated.

“**Domestic game bird**” *means ducks, geese, brant, swans, pheasants, quail, wild* turkey, ruffed grouse, Chukar partridge and Hungarian or European gray-legged partridge, propagated under a domestic game bird breeder’s license pursuant to section 11-1901 or a shooting preserve license pursuant to section 11-1903 or propagated on a preserve or island outside the state under a law similar in principle to title 19 of this article.

“**Domestic game animal**” means white-tailed deer propagated under a domestic game animal breeder’s license . . .

“**Unprotected wild birds**” means the English sparrow and starling and also includes pigeons and psittacine existing in a wild state not domesticated.

“**Protected birds**” means all wild birds except those named in paragraph a of this subdivision.

“**Wildlife**” means wild game and all other animal life existing in a wild state except fish, shellfish and crustacea.

“**Wild bird**” means birds which are “wildlife.”

“**Protected wildlife**” means wild game, protected wild birds and endangered species of wildlife designated by the department pursuant to section 11-0535 hereof or species listed in section three hundred fifty-eight of the agriculture and markets law.

“**Unprotected wildlife**” means all wildlife which is not “protected wildlife.”

> "**Protected insect**" means any insect with respect to the taking of which restrictions are imposed by the Fish and Wildlife Law or regulations of the department pursuant thereto.[82]

Other sections of the NY ECL further define the state's scope of rights in wildlife.

The ECL exhibits federal sovereignty in wildlife in New York. The state will adopt rules and regulations in relation to migratory game birds consistent with the federal MBTA.[83] It provides for the designation of "endangered" and "threatened" species, including those listed in the federal ESA, and prohibits the taking, importation, transportation, possession, or sale of any such species without a license or permit.[84]

In addition, the ECL provides a mechanism for extending *res publicae* over select wildlife:

> the department shall have power to give to any wildlife or fish, other than migratory fish of the sea, protection or additional protection to that afforded by this article, if ten or more citizens file with the department a petition, a public hearing is held and the department determines that there is reason to adopt such protection, it may adopt such regulations.[85]

The state's rights are grantable to individuals. It may issue to any person a license revocable at its pleasure to collect or possess fish, wildlife, shellfish, crustacea, aquatic insects, bird's nests or eggs for purposes of propagation, banding, science, or exhibition. Such license may require a fee of as much as $10, testimonials from two well-known persons, filing of a bond of $200, and submission of an annual report. This section also provides that the department may issue a similar license to possess

[82] N.Y. Env. Con. Law, art. 11 § 11-0103 (McKinney 1997).
[83] N.Y. Env. Con. Law, art. 11 § 11-0307 (McKinney 1997).
[84] N.Y. Env. Con. Law, art. 11 § 11-0535 (McKinney 1997).
[85] N.Y. Env. Con. Law, art. 11 § 11-0311 (McKinney 1997).

and sell for the same purposes and that such license shall be in force for one year. Such wildlife may be sold at any time by the licensee.[86]

The state may, at its discretion, issue a license or permit to take, transport, sell, import, and/or possess endangered or threatened fish or wildlife for purposes it deems legitimate.[87]

The state follows federal CITES obligations by prohibiting the sale or offer for sale of the skin or body of a list of wild animals that includes several exotic species (e.g., snow leopard, crocodile, vicuna, kangaroo, Sumatran rhino, etc.).[88]

In New York, all wild birds are *res publicae* except the starling, English sparrow, pigeon, and psittacines. The robbing or willful destroying of *res publicae* nests is prohibited without a permit.

The state distinguishes between *res publicae* and *res nullius* biota in the ECL. Any unprotected wildlife may be taken, possessed, transported, bought, or sold without restriction at any time.[89] The ECL also prescribes numerous rules for the possession, sale, and transport of a variety of wildlife.

The state asserts a variety of interesting proprietary rights in somewhat obscure biota. For example, the ECL prohibits obstructing fish; setting bear or deer traps; preventing frogs access to water; robbing or willfully destroying nests of protected birds; disturbing beaver dams or muskrat houses without a permit; disturbing a nestbox or structure constructed to harbor wild birds; or taking, detaining, transporting, or possessing homing pigeons wearing a registration marker. Unprotected wildlife in New York include **mammals** (shrews, moles, bats [except the Indiana Bat], woodchuck, chipmunk, red squirrel, southern flying squirrel, northern

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[86] N.Y. Env. Con. Law, art. 11 § 11-0515 (McKinney 1997).
[87] N.Y. Env. Con. Law, art. 11 § 11-0535 (McKinney 1997).
[88] N.Y. Env. Con. Law, art. 11 § 11-0536 (McKinney 1997).
[89] N.Y. Env. Con. Law, art. 11 § 11-0917 (McKinney 1997).

flying squirrel, mice, rats, voles and porcupines); all **reptiles** (except wood and box turtles and all marine turtles); and all **amphibians (**except frogs).

Whole specimens of controlled wildlife lawfully taken may be possessed, transported, bought, or sold. However, no person may possess any live beaver, otter, mink, muskrat, raccoon, red fox, gray fox, skunk, coyote, fisher, bobcat, opossum, weasel, marten, or other protected species other than pursuant to a license to collect, possess, or sell for propagation, scientific, or exhibition purposes.[90] The head, skin or hide, fur, and feet of legally taken game and wildlife, except birds, may be bought, sold, imported, or transported without license or permit. No domestic duck, goose, brant, or swan killed by shooting shall be bought or sold unless marked by having had the hind toe of the right foot removed.[91]

However, the state's control over legally possessed *res publicae* wildlife is demonstrated in the prohibition of sale, offer for sale, or possession for sale for food purposes of any dead bodies of birds belonging to all species or subspecies native to the state.[92]

The state's rights in wildlife are confined by private-land property rights. The ECL provides that no license, permit, or stamp for the hunting, fishing, or collecting of fish, wildlife, or game authorizes the holder to trespass on private lands or water or to interfere with another's property, to take from Indian reservations, to enter upon or to take or disturb fish or wildlife on state lands/water without permit or order, or to take fish, wildlife, or game from any closed area.[93]

The state defines when, where, and how any of the state's wildlife may be possessed. The ECL prescribes the open hunting season, bag limits for all state

[90] N.Y. Env. Con. Law, art. 11 § 11-1705 (McKinney 1997).
[91] N.Y. Env. Con. Law, art. 11 § 11-1723 (McKinney 1997).
[92] N.Y. Env. Con. Law, art. 11 § 11-1707 (McKinney 1997).
[93] N.Y. Env. Con. Law, art. 11 §§ 11-0703, 11-0705 (McKinney 1997).

game,[94] and the scope of legal trapping.[95] This law also allows landowners to hunt wildlife on their land (except deer and bear) and to trap bobcat, coyote, fox, mink, muskrat, raccoon, opossum, weasel, skunk, and unprotected wildlife.[96]

The state governs the possession, transportation, and sale of all fish taken in the state. There are no restrictions on the disposition of fish taken legally. Fish taken illegally may not be possessed, sold, or transported. However, trout, Atlantic salmon, black bass, walleye, and muskellunge may not be bought or sold, even if taken legally.[97]

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[94] N.Y. Env. Con. Law, art. 11 §§11-0903, 11-0905, 11-0907, 11-0909, 11-0911 (McKinney 1997).
[95] N.Y. Env. Con. Law, art. 11 §§ 11-1101 thr. 11-1109 (McKinney 1997).
[96] N.Y. Env. Con. Law, art. 11 § 11-0713 (McKinney 1997).
[97] N.Y. Env. Con. Law, art. 11 § 11-1319 (McKinney 1997).

CHAPTER 5:
IDENTIFYING AND CHARACTERIZING THE RELATION BETWEEN PATENTS AND WILDLIFE CONSERVATION LAWS IN THE UNITED STATES

5.1 Analyzing the Relation between Patent and Wildlife Conservation Laws

The detailed reviews of patent and wildlife conservation laws in Chapters 2, 3, and 4 make it clear that these laws have been developed for entirely different purposes. Patent law fosters technological progress, whereas wildlife conservation law protects wildlife resources. Not surprisingly, these bodies of law evolved in entirely separate legal and policy realms. But are they parallel, or do they intersect at one or more meaningful points? That is, are they orthogonal?

Chapter 2 demonstrates that statutory patent law contains no reference to wildlife or wildlife law. Similarly, Chapters 3 and 4 show that federal and state wildlife conservation laws make no reference to inventions, patents, or patenting activity. Thus, at an explicit, superficial level, there is no intersection of these laws. However, the issued U.S. patents on inventions made from wildlife (some listed in Table 1.1) are evidence of an obvious, practical linkage: U.S. patent law accommodates the use of wildlife to acquire intellectual property. But, conversely, does U.S. patent law ignore wildlife conservation law?

Under U.S. patent law, as long as the statutory criteria of patentability are satisfied, "everything under the sun made by man is patentable."[1] These criteria—novelty, nonobviousness, and utility—have absolutely no relation, however, to wildlife law. Patents are strictly limited by the rules of patentability. Courts have held that a patent may be invalidated by reason of criminal acts, but only if through such acts the patent applicant fails to disclose information relevant to patentability or submits false information to the patent office with an intent to deceive, and only if

[1] *Chakrabarty v. Diamond*, 1005 ct.2204 (1980).

such information would have been material to patentability.[2] As long as the rules of patentability are met on an invention, a patent will be issued regardless of whether other laws are broken in the process of inventing and patenting (U.S. Code, Title 35). Thus, violating wildlife law in the course of inventing and patenting is irrelevant to patent issuance and validity as long as the criminal activity is not directly relevant to patentability.

Since the patent confers the right to stop others from use, a very direct linkage between patents and wildlife conservation law could exist if wild organisms *per se* were patentable. This would create overlapping and conflicting rights of possession and use in the same specimen—some arising from the patent, others from *res publicae* rights of conservation law. In this context, it is useful to examine the patentability of wildlife *per se*.

Patents have never been issued on whole creatures except for microbes. And there is no evidence that any attempt has ever been made to apply for a patent on a multicellular wildlife species. However, it is not legally impossible (Rohrbaugh, 1997; Cooper, 2000) that such patents could be issued in the future. This is unlikely, however, given the long history of the "product of nature" doctrine, difficulty in meeting the nonobviousness patent criterion, and the questionable market value of such patents. Microbes are clearly the exception.

In patent litigations, courts have considered pure cultures of single-celled organisms to be more akin to human-made chemicals than to wildlife.[3] Patent rights may be acquired on a pure culture of a microbial species that satisfies the patentability criteria. There are many U.S. patents on such cultures of prokaryotes and eukaryotes, including bacteria, yeast, fungi, and algae. While the issuing of such patents presents a

[2] *Regents of U. of Calif. v. Eli Lilly and Company*, U.S. Court of Appeals, Federal Circuit, 96-1175, 7/22/1997.
[3] *Ex parte Bergy* 197 USPQ. 78 (POBA 1976).

potential clash between private patents and public wildlife, this conflict is averted because species-based state and federal wildlife conservation law does not cover microbes (Bean and Rowland, 1997). However, the potential for conflict between private patents and *res publicae* biota does exist for microbes on governmental property. Unless the government controls the taking of soil and other wildlife-containing environmental samples from governmental property, a private intellectual-property right can be established on biota in those samples that would otherwise be *res publicae* by *ratione soli*. A patent holder in this situation would have the exclusive right to stop others (including the government) from making, using, or selling pure cultures of that organism. Of course, the patentee's rights extend only to pure cultures and not to the patented organism in its natural environment, as in a microbial mixture. Nonetheless, the public's rights in the *res publicae* biota will have been diminished, particularly with regard to shares of commercial return from the patent and access to technological use of the organism's genome. In addition to the problem of the uncompensated privatizing of the public domain, this scenario presents a market failure in which resource beneficiaries (patentees) do not pay for maintenance of the resource. Physical possession of a specimen is pivotal in this dynamic. The government could assert a public-property right in microbiota collected from governmental land or water property, and could preclude or regulate private patent rights to require a public sharing of the private benefits that flow from any technological value from such biota.

As described above, the direct conflict between private patents and public wildlife has been limited to microbes. However, because of their patentability, in theory there is no reason why a wild, higher organism could not meet the test for patentability (Cooper, 2000), and existing patents on naturally occurring mutant animals[4] support this premise. Rohrbaugh (1997) explores the legal theory of this possibility in a discussion of the patentability of extinct animals resurrected biotechnologically.

Patent law veers closer to an intersection with wildlife law in the "product of nature" doctrine. Cooper (2000) points out that courts have rejected patents on inventions that are "products of nature," although there is no basis for such a rejection in the patent statute. Cooper posits that there is no reason, *a priori*, that a newly discovered, non-microbial species that satisfies the statutory requirements of patentability could not be patented. Given the tenuous distinction between microbial and non-microbial in the Bergy cases, there seems to be a basis for such arguments. It is theoretically possible, then, that a patent could be issued on an organism *per se* and that the organism is also covered by wildlife law.

Patent law and the procedures for acquiring a patent are statutorily unfettered by wildlife law. Let us examine wildlife law and its relation to patents. Table 1.1 demonstrates that U.S. patent law allows the creation of intellectual property on inventions made from wildlife. Based on the species listed in the table, it appears that patents can be obtained from governmental (*res publicae*), non-controlled (*res nullius*), and privately held (*res privatae*) taxa. Do wildlife conservation laws provide control over a patent process that involves wildlife? It is logical to suspect that they might. After all, patenting is a market-related activity, and a primary purpose of wildlife conservation law is to control the use of wildlife, especially by the market.

Chapters 3 and 4 reveal that federal and state wildlife conservation laws contain no explicit control of the patent process or of the patents the process yields. Wildlife laws, on the other hand, are replete with strictures on wildlife possession and use. And these laws assert governmental control over possession of explicitly listed

[4] U.S. Patent No. 6,316,691 "Atrichia mouse," issued to Kondo et al.

protected wildlife specimens and of those on federal or state land (Bean and Rowland, 1997). However, this governmental authority does not extend to patents obtained from legally possessed biota. Under existing federal and state law, anyone possessing a specimen of public wildlife is free to invent patentable subject matter using that specimen. No federal or state law that I have examined explicitly prohibits or otherwise controls the act of filing for patents on a biotechnological utility from *res publicae* wildlife (Musgrave and Stein, 1993; Bean and Rowland, 1997). Once a governmentally controlled wildlife specimen is legally possessed under federal or state law, these laws provide no control of patent activity with that specimen. And because the patent process is unfettered by wildlife conservation law, this lack of control also applies to specimens that are illegally possessed. Thus, wildlife conservation laws provide no governmental rights in the ownership or financial benefits of any patents obtained from legally or illegally possessed wildlife (Bean and Rowland, 1997).

There is clearly a property firewall between patents and tangible property in wildlife.

The lack of a legal linkage between patents on inventions made from legally or illegally possessed wildlife confirms the parallel relation of patent and wildlife laws. This parallel configuration means, first, that wildlife conservation law does not provide governmental control over patent rights obtained from legally possessed public wildlife. But the lack of intersection between wildlife law and patents obtained from wildlife possessed in violation of wildlife law is even more serious.

Let us examine, in detail, how wildlife-law restrictions on the possession and use of specimens fails to link to patents obtained by breaking such laws. The Endangered Species Act (ESA), the most restrictive of the federal biological conversation laws, is a logical test.

The ESA prohibits the physical possession of public specimens except by permit.[5] Permits for legal specimen possession may be obtained for purposes of propagation for species survival, scientific research, and incidental taking. Any commercialization of a specimen, or a part thereof, of a listed species is a violation of the ESA. The ESA prohibition on possession without a permit precludes the acquisition of private property in tangible matter and thereby, to some extent, prevents patentable inventions. So, to the extent the ESA controls specimen possession, the law controls access to patentable inventions from ESA species. However, the ESA contains no explicit prohibition on filing patent applications on an invention made using a legally possessed specimen or its parts. Thus, if a specimen of an ESA species is legally possessed, the ESA does not control the acquisition of private intellectual property obtained through that possession. Why does this situation arise? It does so because although the ESA controls the commercialization of tangible specimens, a patent application and a patent contain only intangible information. That is, unless the act of inventing or filing a patent application can be considered a "commercialization" of a tangible specimen, anyone who obtains an ESA permit for possession of a public specimen can acquire private intellectual property in an invention from that specimen, without obligation to the public (i.e., the government).

Under the ESA, if a specimen is possessed illegally, the federal government is empowered to confiscate it and to levy significant penalties, demonstrating governmental control over tangible, biological material. But what if a patentable invention is made from the illegally held specimen before it is confiscated? As described earlier, violating the ESA in order to obtain a U.S. patent has no effect on the validity of that patent. The ESA does not clarify whether the government might have some rights in such a patent. Because such situations have not yet arisen, it is

[5] This includes the taking of tissue samples.

unclear how the U.S. Fish and Wildlife Service, the agency responsible for enforcing the ESA, might respond or how courts might decide. However, it is logical to conjecture that patent ownership could be clouded by the "inequitable conduct" rule of U.S. patent law. Therefore, while the filing of a patent application *per se* is not a violation of the ESA, the inequitable conduct rule could provide a basis for a court to confiscate the patent from the ESA violator.

A proposed change in European patent law would eliminate this kind of disconnect between laws governing wildlife and those governing intellectual property (Williams, 1997). The proposal would require European patent applicants to submit an affidavit that the subject matter of their application was obtained from biological material collected and possessed legally and with the consent of the rightful owner or an entity with legitimate rights of possession.

The Lacey Act represents another test of the relationship of patent and conservation law. The Lacey Act is a broad and powerful federal biological conservation law. It makes a federal crime of interstate commerce in wildlife (or its parts) taken or possessed in contradiction of any state or foreign law. Despite this sweeping power, the Lacey Act fails to provide control of patent rights obtained from illegally held wildlife, because the event that triggers the Lacey Act is the introduction into interstate commerce of something tangible: A patent application contains only intangible information. However, if a state or a foreign government were to enact a law prohibiting the use of its wildlife for inventing or patent filing, the Lacey Act would represent an important shift in the relation of patent and conservation laws. This shift would be toward a violation of wildlife law, not patent law. As with the violation of the ESA described earlier, violating the Lacey Act in the process of inventing and patenting would have no effect on patent validity but might cloud issues of ownership.

I have established that patent and wildlife conservation laws are orthogonal. That is, they are entirely independent but intersect at a point. That point of intersection is the physical possession of specimens. The physical possession of a specimen is necessary to make a patentable invention, and the control of the possession of specimens is a basic tenet of wildlife conservation law. A right in the possession of tangible property is the nexus of patents and conservation.

5.2 The Orthogonal Intersection of Patents and Wildlife: Tangible Property and Conservation Law

Tangible property in wildlife specimens, including individuals or groups (e.g., a hive of bees), whole organisms, or their parts and by-products, is the intersection of patent and wildlife biological conservation law. Svarstad et al. (2000) correctly point out that the focal issue is the right to possess and use tangible wildlife material, not the patent right. Wildlife conservation law defines the rules of possession for public (*res publicae*) wildlife. All other wildlife are either private property (*res privatae*) (e.g., wild plants rooted on private land or legally captured specimens) or *res nullius*. Private-property specimens produce private patent property. And, since *res nullius* wildlife may be readily converted into private property through capture, patent property made from that property is also private property.

The scope of the rules defining the possession and use of public wildlife varies significantly, from strict public-property assertions as in the federal ESA to more lax assertions found in state fish and game laws (Musgrave and Stein, 1993; Bean and Rowland, 1997). For example, while the ESA prohibits the private possession of an ESA-listed species except under rarely used and strict provisions, state fish-and-game laws encourage some types of possession, albeit with typical constraints on methods and timing of capture and use. However, regardless of the extent of a public-property assertion, all current federal and state wildlife conservation law asserts governmental control over tangible specimens only. The creation of intangible private patent property from wildlife specimens falls outside the purview of all existing federal and state wildlife law, even the most stringent. However, the doctrine of “unclean hands” could provide a bridge between patent and conservation law (Koopman, 2005).

There are important distinctions between patent and tangible (i.e., personal) property rights. Personal-property rights include the right to exclusive physical possession. Patent rights do not include this exclusive possessory right (U.S. Code, Title 35). The patent owner holds only the right to preclude others from making, selling, using, or importing the patented subject matter. The patent does not grant the right to preclude possession. For example, if Party A holds a patent on enzyme X, purified from a wildlife specimen, and Party B (legally or not) possesses a vial of pure enzyme X, Party A cannot compel Party B to relinquish possession of the vial; Party A can only stop Party B from making, selling, using, or importing enzyme X. Certainly, prohibiting the making, selling, or using of enzyme X effectively controls Party B’s privileges and benefits of possession, but it does not dominate pure possession. Conversely, if Party B transfers possession of its vial of enzyme X to Party A but not ownership (i.e., a bailment), Party B may legally compel Party A to relinquish this personal property on demand despite Party A’s patent right on the enzyme. So, in some instances, personal-property rights can dominate patent rights. This dominance is strengthened by the fact that personal-property rights are essentially perpetual, while patent rights are limited by time.

Even though there may be an overlap of private patent rights and public rights in a public species, this dichotomous relation of patent versus personal-property rights remains. Even if a microbe is patented, which is permissible as described in Chapter 2, the patent right does not dominate a personal-property right in a test tube of a pure culture of the organism. And the microbe-patent owner has no control over the organism in its natural habitat. Furthermore, holding a patent right on a material or method obtained from a wildlife specimen does not grant the patentee any personal-property rights in the intact organism *per se* (Bent et al., 1987; Cooper, 2000).

Since physical possession is the intersection of patent and wildlife conservation law and because physical possession of a wildlife specimen intersects with real estate law through trespass law, a landowner's right to control access to wildlife on his or her land creates an important link in the relationship between patents and wildlife conservation law.

5.3 The Special Case of Collections

A natural outcome of the fact that tangible property possession is the link between wildlife law and patents is the importance of collections. Parry (2004) has described the conservation and economic implications of collections of wildlife such as those in museums, zoos, and private menageries. She correctly points out the importance of the appropriate management of rights of possession and also how disconnects can arise between tangible property and the intangible intellectual property she terms "bio-information." Although Parry correctly notes the importance of collections in the patent-versus-wildlife dynamic, she does not understand that linkages can be made between the tangible and intangible domains.

Collections will present one of the most interesting and complicated areas for implementing the property links. Making such links may be easier in collections than in ecosystems and may provide the best opportunity to see effective use of property management to effect potential benefits for conservation.

5.4 The Linkage Between Trespass Law and Property Rights in Wildlife

Because physical possession is the nexus of patent and wildlife conservation law, the right to control a possessor's ability to possess is a salient factor. Trespass law empowers owners of real property to restrict others from access to their property (Dukeminier, 2002). This right of exclusive possession in private land confers a *de facto*, private-property right in wildlife located *in situ* on that land by the right to control access. This *de facto* property right created by access control is assertable over private, *res nullius*, and, to a large extent, public wildlife on a landowner's land.

Trespass law developed over many years, with traditional exceptions made for hunting, trapping, and fishing (Tober, 1981). Such exemptions for wildlife-takers have gradually disappeared. At present, real-property owners hold strongly enforceable rights of access by any party, including government.

It is an open question whether a property right in a wildlife specimen *in situ* on land is dominated by the landowner's right to preclude trespass (*Hawaii Audubon Society v. Lujan*, No 91-00191 D. Hawaii; Dukeminier, 2002). However, it is clear that breaking trespass law (and thus violating the landowner's rights) must occur prior to possession of a wildlife specimen located on that land. Without access to the land, there can be no possession, and without possession, creation of intellectual property from *in situ* wildlife is not possible. Such landowner rights can be used by a landowner to contractually bind those who are given right of access to the land and the wildlife found there. This can extend the landowner's control of such wildlife beyond the confines of the real property. However, a landowner's rights in wildlife on the property do not extend to wildlife that have left the premises voluntarily. So, for example, while a *res nullius* dragonfly is on the property, a landowner has the right to capture (unless it is public wildlife) and a trespass-related exclusory right to the dragonfly. However, once the dragonfly leaves the premises, these landowner rights extinguish. Also, the rights of a landowner in resident wildlife may be diminished by unauthorized possessions of wildlife taken from the land by others. For example, if Party A, which has, by contractual agreement with a landowner, taken certain wildlife specimens from the landowner’s property, then loses possession of that material to a third party unauthorized to possess by the landowner, the authority of the landowner and Party A to assert rights in the wildlife may be diminished. And while a landowner’s trespass-based, *de facto* personal property in wildlife probably dominates governmental rights of possession in public wildlife specimens on private land, governmental rights in the specimens dominate when the wildlife is physically possessed, whether on or off that land, by the landowner or anyone else.

The juxtaposition of private quasi-property right in specimens derived from trespass law and governmental rights in transient wildlife defines the dynamic tension between private right and public good. This tension is exemplified in the ESA treatment of endangered plant species growing on private land. Such plants rooted and growing on private land are private property, but with public-property attributes created through government-enforced restrictions on malicious destruction and entry into commerce. Similar examples of the juxtaposition of governmental rights in public wildlife and private land rights can be found in the cases *Sweet Home v. Babbit*[6] and *Hawaii Audubon Society v. Lujan.*[7] In *Sweet Home*, the U.S. Supreme Court held that governmental rights in federal *res publicae* wildlife (as defined in the ESA) supersede private land rights. In *Hawaii Audubon Society v. Lujan*, the plaintiffs sued the federal government to force it to assert a dominant public-property right in specimens of an endangered species over the private right to preclude trespass (Bean and Rowland, 1997). Unfortunately, the case was settled out of court, and the court did not resolve the dichotomy of rights in this case.

The interplay of property rights in wildlife creates a complex mosaic, described below.

[6] 115 S. Ct 2407, 132 L. Ed. 2d 597, 63 USLW 4665, 40 ERC 1897, 25.
[7] No 91-00191.

5.5 The Mosaic of Property Rights in Wildlife

Table 5.1 defines a property-regime framework for whole, free-roaming, and captured wildlife, their parts, and derived patents as a function of a property-regime type. The table defines the basic property type and shows that free-roaming, whole wildlife is encompassed by three property-regime types. The table also shows that once such wildlife has been captured, property in free-roaming wildlife shifts from simple categorization to more complex amalgams of the basic property regimes. While r*es nullius* wildlife becomes purely private on capture, within public wildlife, possession results in property mixtures. For example, under the ESA, Marine Mammal Protection Act (MMPA), and Eagle Protection Act, physical specimens of captured wildlife remain purely public. However, the Migratory Bird Treaty Act (MBTA) exhibits a commingling of public and private biota-property rights. This commingling arises from provisions that allow the private possession of whole organisms through permitted hunting, temporary possession via a bander's permit, and unfettered acquisition of private property in tissues from such legally possessed biota.

State fish and game law (as exemplified by New York State law ECL-90) creates similar mosaics of governmental and private rights in physical specimens of free and captured wildlife and their parts.

Once a free-roaming wildlife specimen is legally reduced to private possession, whether through a governmental permit or because there is no governmental control of the specimen, the private possessor has an unfettered right to acquire private intellectual property in a biotechnological utility obtained from that possessed specimen.

Table 5.1. Property Type in Free-Roaming and Captured Whole Organisms of Wildlife, Their Parts, and Derived Patents as a Function of Property-Regime Taxon.

Property regime type	Free-roaming, whole organism	Captured, whole organism	Parts of organism	Patent rights from organism
Res publicae–federal				
Endangered Species Act	*res publicae*	*res publicae*	*res publicae*	*res privatae*
Eagle Protection Act, Marine Mammal Protection Act	*res publicae*	*res publicae*	*res publicae*	*res privatae*
Migratory Bird Treaty Act	*res publicae*	*res publicae & res privatae*	*res publicae & res privatae*	*res privatae*
Res publicae–state				
NY State Fish & Game Law (ECL90)	*res publicae*	*res publicae & res privatae*	*res publicae & res privatae*	*res privatae*
Res nullius	*res nullius*	*res privatae*	*res privatae*	*res privatae*
Res privatae	*res privatae*	*res privatae*	*res privatae*	*res privatae*

The dynamic transformation of property rights in wildlife by the various relevant factors is exemplified in the following scenario: A free-roaming wild deer is controlled by the state government, which requires a hunting license to obtain possession. In this condition, the deer is publicly "owned" *parens patriae* by the government in trust for the public. If applicable law does not prohibit the acquisition of a tissue sample during legal and temporary possession, the sample is private, and potential biotechnology utilities from that sample are *res nullius* until captured (i.e., discovered). When a licensed, private hunter takes possession of the deer by killing,[8] the whole specimen is private.[9] However, states often place use restrictions on the privately owned carcass of the once free-roaming public wildlife. For example, sales of animal parts are often restricted.[10] So, although the carcass is mostly private, because of these restrictions it also remains partially public. The now-harvested,

[8] State fish and game law usually requires killing as a prerequisite to possession.
[9] There are minor rights still held by the government (i.e., government tags must be affixed).
[10] For example, see NY State law ECL-90, which prohibits the sale of bear "flesh" and game birds.

mostly *res privatae* deer carcass contains a biotechnological utility that, because it remains undiscovered, is *res nullius*. If the private possessor of the deer carcass discovers (or contractually allows another to discover) a tangible biotechnological utility (e.g., a useful cell line), that tangible property is private upon discovery. Similarly, if the carcass possessor obtains a patent on an invention made using the carcass, the intellectual property is private.

5.6 Private Versus Public Property Rights in Wildlife

Table 5.2 defines the complicated relation of governmental versus private property rights and liabilities in free-roaming and legally captured public wildlife. This table describes the several rights that encompass property ownership. In free-roaming governmental wildlife, there are no privately held rights or liabilities; the government holds most, but not all, of these rights. Except where stipulated by statute, the government does not hold the same right to consume, waste, or destroy as in private property. However, unlike private entities, the government has no liability connected to its *parens patriae* rights in wildlife. This lack of property-related liability is a defining characteristic of the *parens patriae* governmental right. For specimens of public wildlife that are legally captured by private individuals, most (but not all) of the personal-property rights are privately held. For example, the right to receive income from the captured property is not conveyed by the government in the transfer of rights of possession to the individual. Such prohibitions on market transactions are a hallmark of public wildlife (Lund, 1980; Tober, 1981; Bean and Rowland, 1997). Rights of use in many privately captured public wildlife are jointly held, because the private holder cannot sell the carcass or its parts, and the government retains the right to restrict use of the carcass. However, there is a domain of wildlife possession by private possessors in which the government retains no rights restriction. Once private possessors have physical possession, they have an unfettered right to invent with the carcass or its parts. The unfettered right to use privately possessed public wildlife for the discovery of biotechnological utilities is critical to the relation of intellectual property and wildlife law.

Table 5.2. Governmental and Private Property Rights in Free-Roaming and Legally Captured *Res Publicae* Wildlife.

	Res publicae wildlife			
	Free-roaming		Legally captured	
Property right	Government	Private	Government	Private
Physical possession	yes	no	no	yes
Use	yes	no	yes	yes
Manage	yes	no	yes	yes
Income	yes	no	no	no*
Consumption	no	no	no	yes
Waste, destroy	no	no	no	yes
Security	yes	no	no	yes
Transmission	yes	no	no	yes
Absence of term	yes	no	no	yes
Liability	no	no	no	yes

* Some state laws allow the sale of some portions of legally captured specimens.

5.7 Specific Patents from Wildlife

Table 1.1 lists some U.S. patents that claim inventions made using various wildlife species. These patents were uncovered by keyword searching of the U.S. Patent and Trademark Office Web-based database. Keywords used included common wildlife names and Latin binomials. The use of the wildlife specimen in the act of invention was confirmed by reading the body of the patent, which describes the invention-making protocol.

Given the methodology employed to identify these patents, Table 1.1 is neither comprehensive nor exhaustive. It serves only to confirm the existence of the linkage between the possession and use of wildlife and U.S. patent rights and exemplifies the range of types of inventions and wildlife involved.

The next level of analysis would be to determine, with each issued patent, the conditions under which the inventor possessed and used the wildlife specimen. For example, did possession require approval from a governmental body or a private entity? If approval was required, was it obtained, and under what terms and conditions? Did these terms and conditions create any linkage between the approving entity and patent rights?

This level of analysis is beyond the scope of this work but is contemplated as a logical next step in the analysis initiated here.

5.8 Detailed Characterization of the Orthogonal Relation of Biological Conservation Law and Patents

Now that the orthogonality of patent law and wildlife conservation law has been established, it is appropriate to characterize this intersection. Specific situations, either real or hypothetical, can be used to probe where these two bodies of law intersect. Such situations are used below to more fully characterize this orthogonal relationship.

A hypothetical situation in which patents are issued on inventions made by possessing a federal endangered species presents interesting questions. Under the ESA, the Secretary of the Interior has authority to grant permits for the private possession of specimens of listed species for scientific purposes and for enhancing the survival of the species. Would the filing of patents on biotechnological inventions made with an ESA creature possessed under a scientific permit be allowed by the U.S. Fish and Wildlife Service, or would it be considered a prohibited commercial purpose?

The ESA does not explicitly prohibit inventing nor the act of preparing a patent application. However, the filing of a patent application could easily be construed as a commercial purpose. But the ESA forbids the commercial use of tangible specimens, and a patent application contains only information. This would seem to weaken the argument that a patent filing is a commercial use of a specimen. On the other hand, the act of inventing, which does require a tangible specimen, is necessarily coupled to the act of patent-application filing, which could then be construed as a commercial use and thus prohibited. Of course, if a tangible specimen is publicly deposited, as is required for certain types of biotechnological inventions, this would much more clearly fall in the prohibited category. One may look to the intent of the ESA for some guidance in interpreting this ambiguity. Does the issuance of a patent on an invention made using an endangered species further the aims of the ESA? Would "bioprospecting" activities (Reid, 1993a) that include commercial returns for conservation purposes be permitted under the doctrine of "enhancement of species survival"? The ESA appears to grant the Secretary of the Interior the authority to allow the private possession of listed specimens by those whose intent could include the acquisition of patents from endangered species. This authorization would seem more justifiable if the commercial use of any such patents were to be linked, financially or otherwise, to "enhancement" (i.e., species survival). Without this linkage, such justification is lacking. The linkage and justification for allowing patent acquisition could be established if the Interior Secretary required that a royalty be paid on the commercial use of patents on inventions from listed species and if such monies were used for species conservation. Probing this potential link between patent and wildlife conservation law raises important policy questions. Should the federal or state governments take a proactive policy stance in which "inventing" rights in endangered species are licensed in exchange for financial consideration or some other obligation in keeping with the intent of the ESA?

The MBTA presents another useful situation to probe the intersection of wildlife law and potential patents. The MBTA prohibits the possession of specimens of all listed species, with limited exceptions for permitted possession for hunting or scientific purposes. Through capture, under a hunting license, a tangible MBTA specimen is transformed from public to private. However, the potentially patentable inventions of the specimen remain *res nullius*. As with the ESA, it is not clear whether the MBTA allows the acquisition of patents or their commercial use under scientific-use permits.

The MBTA exhibits an important lacuna in the governmental control of public wildlife. This particular biota-property loophole in the MBTA exemplifies the systemic failure of federal and state law to assert public rights in inventions from the nation's public wildlife. This loophole results from the MBTA allowance of the private possession of biota tissue samples legally obtained by a private collector under an MBTA bird-banding permit. The MBTA allows a permittee to acquire unfettered property rights in tissue samples from governmentally protected wild birds. By allowing the permittee to own the tangible sample, the government has lost control over tangible biotechnological utilities as well as future patentable inventions from these wild birds.

Like the ESA, the Marine Mammal and Eagle protection acts assert strict control over tangible specimens but also exhibit the ESA's lack of control over patents derived from those specimens. All other federal laws that govern public biota directly,[11] or through federal land management, exhibit even less stringent control over free-roaming public wildlife and, of course, any patents that would arise from that wildlife.

[11] For example, Magnuson Fisheries Act, Coastal Zone Act.

The little-known Lacey Act may play a critical role in the long-term management of the link between public wildlife and private patents. Certain provisions of the Lacey Act could act as an effective nexus of conservation and patent laws. This nexus is fundamental to the issue of governmental control over patentable biotechnological utilities from public wildlife. Depending on the interpretation of these critical provisions, the Lacey Act could serve as the essential legal instrument in regulating patents from public wildlife.

Under the Lacey Act, it is a federal crime to introduce into interstate commerce a tangible specimen or “part thereof” of any wildlife obtained and possessed in contravention of any state or foreign law. This provision of the Lacey Act (and similar clauses in the ESA) raises a fundamental question of the intersection between state (and foreign) and federal biological conservation law and patent property: Does the filing of a patent application containing information on a DNA sequence, protein, cell (but not the tangible matter), or some other biotechnological utility from a specimen of wildlife taken contrary to state or foreign law constitute an introduction of the wildlife specimen or “part thereof” into interstate commerce? If so, the Lacey Act would provide blanket control over patents from state, federal, or foreign governmentally controlled wildlife. However, when one files a patent application on a gene, for example, the gene *per se* (i.e., the actual DNA oligonucleotide molecule) does not leave the laboratory. Only an informational representation of the gene (i.e., a DNA sequence of molecular symbols representations: A,G,T,C) crosses interstate lines and is filed in the patent office. Strictly speaking, then, a patent application does not enter a “part thereof” of a controlled wildlife specimen into commerce. Furthermore, it is not clear whether a patent application filing constitutes an introduction into interstate commerce. If the Lacey Act does not apply to patent application filings, it is further evidence of the orthogonal relationship and represents a critical failure to couple patents and biological conservation law.

State law controls the possession of most of the nation's public wildlife. The overview of state wildlife law described in Chapter 4 indicates that state law is similar to federal law in its lack of governmental control over patents from public wildlife under state jurisdiction. The review of New York State wildlife conservation law ECL-90 in Chapter 4 confirms this.

New York's ECL-90 law demonstrates the essential orthogonality of state law to patent law. New York State law ECL-90 governs state-controlled wildlife. Under ECL-90, the state lists all species that are and that are not state-controlled. Controlled species include all fish and game and other species. Under ECL-90, the state controls the possession of all controlled species. ECL-90 contains a myriad of rules that constrain the use of privately possessed, state-controlled specimens. However, none of these rules constrain the acquisition of patentable subject matter.

Even where New York law provides state control of wildlife, the penalty provisions can be so weak as to render the law ineffective. Under ECL-90, the cost of permits and penalties for illegal possession of certain species are much too low to provide meaningful control, especially over potentially high-value patent activity.

5.9 Natural Resource Implications

What are the implications of the orthogonality of patents and biological conservation law to natural resource economies? Because national and state law—and the policies they embody—do not assert governmental control over patentable inventions from public wildlife at the level of the physical possession of a specimen, all potentially patentable inventions in any wildlife are *res nullius*. Such inventions are available to be owned by capture. And, by patent law, they are ownable by the first capturer.

In the next chapter we will see that natural resource economics dictates that a scarce, *res nullius* natural resource that has utilitarian value is susceptible to market failure and potential destruction through a "tragedy of the commons" (Hardin, 1977) or similar process. Are all potentially patentable inventions from wildlife scarce? That depends first on whether the source organism is scarce. If it is, any patentable inventions of utility would also be scarce. But what about patentable inventions from creatures that are not scarce, such as gnats or biting flies?

A basic premise of wildlife conservation law is that such law is generally designed to protect scarce wildlife. Thus, by extension, patentable inventions from scarce wildlife would also be scarce.

It seems apparent that private entities are acquiring the physical possession of wildlife and creating patents from that wildlife for private gain. And since the linkage of patents and the law controlling public wildlife is orthogonal, government (and thereby, the public) has no direct means of mitigating potential market failure and destruction.

Wild biodiversity continues to decline, by most measures (Perrings, 1995; Howe, 1997; Novacek, 2001). Conversely, the economic value of biotechnological inventions from wildlife is increasing. And because of the orthogonality that has been described, there is a failure to require beneficiaries of biotechnological inventions to pay their reasonable share of the cost of conservation. This is a failure of the market to develop the sustainable use of natural resources. In cases of past market failure, government has asserted *res publicae* control over a common resource in order to protect that resource for the public good. Given the existing situation with wildlife and patent law, it is logical to draw a parallel between Supreme Court Justice Holmes's statement about the necessity of governmental protection for wild birds for the public good and the current unfettered exploitation of wildlife for invention.[12]

In the next chapter, I examine the resource economics of patentable inventions from wildlife and the implications of the orthogonality of patent and wildlife law.

[12] *Missouri v. Holland, 25, U.S., 416, 1920*

CHAPTER 6:
THE ORTHOGONALITY OF PATENT AND WILDLIFE CONSERVATION LAW AND ITS IMPLICATION FOR THE POLITICAL ECONOMY OF THE WILDLIFE RESOURCE

6.1 Introduction

It is clear that wildlife is the source of huge economic value in useful discoveries and that intellectual-property and traditional wildlife-property rules present new problems in natural resource economics (McLaughlin, 2003). In this chapter, I examine the natural resource economic implications of the orthogonality of patent and wildlife law. But to do so requires understanding the larger context of inventions from wildlife.

Below, I summarize some fundamentals of wildlife economics and describe wildlife as a source of inventions. I elucidate the dual-property aspects of many such inventions (tangible and intellectual), which relate directly to the nexus of patent and wildlife law: the physical possession of specimens. This analysis also requires an understanding of the unique resource-economics character of wildlife inventions.

I present an argument for and evidence of a market failure in the resource of inventions from wildlife. I critique certain current methods of economic valuation of invention in wildlife and propose an alternative. The overview I present of the political economy of inventions from wildlife is a preface for a discussion of a tragedy of the commons in these kinds of inventions. I describe an efficient property regime for the resource of wildlife inventions that leads to a revisiting of the conclusion of patent and wildlife law orthogonality. Finally, I define the public-policy problem that embodies these findings and develop some policy prescriptions.

6.2 Economics of Wildlife

6.2.1 Historic Commerce in Wildlife

Harvest of and trade in wildlife and their products has a long and far-ranging history (Roth and Merz, 1997; Freese, 1998). Local, regional, national, and global trade in wildlife commodities has included fisheries, timber, non-timber forest products, meat, and by-products such as skins, oil, ivory, and caviar. Other goods have included horns, feathers, organs (e.g., bear gall bladder, tiger penis), shells, and natural compounds from plants and microbes. The legal and illegal trade in living specimens for private collectors, for zoos, and as pets has long been significant. In addition, the economic value of biodiversity (Pimentel et al., 1997) and ecosystems (Costanza et al., 1997) has also been estimated. The economic value of these goods is based on the direct consumption of the wildlife resource, and the economics of their exploitation is the domain of natural resource economics.

6.2.2 Some Fundamentals of Resource Economics

What is the domain of resource economics? Randall (1987) defines a resource as something that is useful and valuable in its natural condition. According to Randall, things that are unknown or for which no uses have been found are not resources because they have no value. And, if useful things are available in huge amounts relative to demand, they have no relative value and are, therefore, not resources. This is a traditional economic view that sidesteps questions of option value and uncertainty in resources and seems to fail to account for future discovery of value. For example, using Randall's definition, the naturally occurring rare-earth element germanium was not a resource until semiconductor technology created a use for it. Many a "future resource" could be lost through failure to consider future value as part of the economic equation. Randall (1987) also requires scarcity as a criterion of a natural resource. This scarcity stipulation also suffers from a failure to account for future uncertainty.

Neoclassical economic theory is built on the simple idea that individual economic entities seek to maximize their welfare through the buying and selling of economic goods in a freely competitive market. Natural resource economics is the search for the welfare of individuals and society through the efficient maintenance, allocation, and distribution of natural resources, particularly through the production and consumption of commodities and the provision of resource stocks and waste sinks. Natural resource economics attempts to rationally determine efficient allocation of natural resources in the present and future and the distributional outcomes of such allocation decisions (Randall, 1987). The goal is optimal economic welfare of the individual and society. The premise of neoclassical economics and liberal democracy is that the well-being of society is promoted by individuals, each working in his or her economic self-interest, without coercion from others or from the state.

Resource economics theory is anthropocentric utilitarianism (Randall, 1987; Common, 1996). The goal of classical Utilitarianism is to maximize the good (i.e., utility) for society, whereas neoclassical (Paretian) Utilitarianism seeks an economic equilibrium in which no act is sanctioned that renders someone worse off than before the act. Tisdell (1991) describes the basis of modern welfare resource economics as the Utilitarian notion that each individual obtains utility or measurable satisfaction from his or her consumption of commodities and that the use of society’s resources should maximize the sum of utility obtained by individuals. According to Tisdell (1991), modern resource economics is concerned with the social administration of scarce resources for the purpose of satisfying, to the maximum extent possible, human desire for commodities, whether necessities or not.

A fundamental tenet of neoclassical Utilitarianism is Paretian welfare economics, which relies on individual preferences but avoids interpersonal comparisons of utility (Blaug, 1985). It is based on a system for utilizing resources that is efficient in satisfying human wants. The “Pareto criterion” holds that human welfare is not at maximum if it is possible to make an individual better off without making another worse off. A “Pareto improvement” occurs when, as a result of a change in the use of resources, an individual is made better off without anyone being made worse off. A corollary to the Pareto welfare model is the “Kaldor-Hicks criterion” (Kaldor, 1939; Hicks, 1939), in which a potential Pareto improvement is sanctioned if “losers” can somehow be compensated. Randall (1987) describes a “Pareto-safety” situation in which the losers in a Kaldor-Hicks improvement obtain actual compensation.

Randall (1987) describes a related broad economic policy tool, the “maximum social well-being” (MSW) model, which posits that MSW may exist anywhere on a social aggregate “grand utility frontier.” There are a great many ways to achieve an MSW on that frontier, and economists can identify policies that eliminate waste but cannot evaluate alternative, efficient solutions.

The belief, championed by Adam Smith, that individual action by freely acting economic agents will result in a maximization of social well-being was challenged by Pigou (1940). Pigou held that some self-interested individuals will behave antagonistically toward the social good, particularly as a result of the negative externalities caused by these individuals’ actions, and that these externalities would violate “Pareto optimality” if uncontrolled. In large systems, government would intervene in the economy with fines or taxes that would bring the system into Pareto optimality. Coase (1960) responded by arguing that those negatively affected by externalities could alter the actions of externality producers via perfectly defined and enforced property rights and side payments and thus avoid the coercion and distortion of governmental intervention.

The following elements provide a basis for analyzing the economics of biotechnological utilities in wildlife.

Scarcity means the amount available is limited relative to demand. While Randall's (1987) premise that scarcity is a necessary characteristic of all resources is arguable, it is clear that non-scarcity renders economics superfluous. Intertemporal change in demand or supply can transform non-scarcity into a scarcity. For example, technical innovation can create demand where none existed, as with germanium. Conversely, supply may decrease below the level of demand, as occurred with the passenger pigeon and bison.

In a market economy, any resource with a positive price must be scarce (Randall, 1987). However, some scarce resources are unpriced because there is no market to trade them. Endangered species are scarce, unpriced wildlife.

Scarcity is fundamental to the model of a self-regulatory market efficiently rationing a resource. Underwood and King (1989) state that absolute economic scarcity will not exist because scarcity is relative and price signals will produce resource substitution. Substitutability is an economic answer to the extinction of wildlife (Solow, 1993), although this view is criticized on grounds of real biophysical/ecological constraints (Cleveland, 1991).

Efficiency, the optimization of economic well-being of the individual and society, is a goal of welfare economics. Pareto welfare efficiency seeks economic optimality centered on individual human well-being. A Pareto-optimal economic system is efficient when there are no opportunities for costless improvement of human well-being. A market in which supply and demand reach equilibrium through price is the preferred means of arriving at efficiency (Randall, 1987; Common 1996). Implicit in the efficiency criterion is the monetization of all components of the economic equation. At the efficient point, net monetary benefits produced will be maximized.

The difference of all benefits and all private and external costs will be as large as possible at the efficient point. Stroup and Baden (1983) believe that increasing the economic "pie" is the essence of economic efficiency and is the only way to make everyone better off in the use of natural resources. Sources of market imperfection (e.g., public goods, common-pool resources, monopolies, and transaction costs) produce inefficiency of economic well-being. However, reaching points of economic efficiency does not guarantee socially desirable results (Sagoff, 1988).

The intertemporal efficiency of resource allocation is fundamental to resource economics (Krutilla, 1967; Common, 1996). It is affected by the financial factors of saving, borrowing, interest rates, wealth, assets, capital, and discounting (Randall, 1987). Norgaard and Howarth (1992) question reliance on an efficiency standard in which questions of intertemporal efficiency are framed as though the present generation holds all rights to resources. They describe the conflict between efficiency optimization based solely on the economic needs of the current generation and the economics of sustainability, which must include the welfare of future generations.

Cost–benefit analysis (CBA) is a framework for determining economic efficiency for a particular action. It organizes information to evaluate whether an action is a Pareto improvement. CBA hinges on the Kaldor-Hicks criterion and the equal treatment of all individuals. Some argue that CBA is limited because relief of pain or suffering, for example, should take precedence over pleasure promotion when evaluating competing costs and benefits (Randall, 1987).

Intertemporal dynamics must be accommodated because economic systems change over time. Short-, medium-, and long-term change in supply and demand are affected by many factors, including those technological, ecological, and demographic. Intertemporal efficiency is particularly relevant to resource sustainability and intergenerational equity in resource allocation.

Individual preference, which is based on the classical Utilitarian philosophy of the maximization of individual well-being, is the desire of an economic agent to satisfy his or her well-being. Individual preference is fundamental to determining the economic efficiency point at which maximum well-being is achieved. Economists equate individual preference with individual utility; the willingness-to-pay model is a widely applied measure of such utility. But reliance on individual preference is confounded by complexities. For example, preference often deviates from utility-theory models (Shogren and Nowell, 1992). Page (1983) claims that individual-preference models are typically blind to complexity and that they incorrectly assume individuals have only one preference ordering. Tisdell (1991) believes such preferences are quite malleable and are strongly subject to societal institutions. Sagoff (1988) raises the confounding effects of external manipulation of preference by advertising. Kelso (1977) states that western institutions have channeled individual preference into consumption, production, and growth, and that this runs counter to resource sustainability in a world of finite resources and increasing population. Lehman (1995) points out fundamental flaws in the reliance on individual preferences, questioning the basic assumption that achieving one's desires equates to improving the individual's or society's welfare. For example, satisfying a preference for drugs, alcohol, and sex may not enhance welfare. In addition, individual preference fails to account for preferences of future generations.

Individual well-being and the Collective Good. Adam Smith's theories are a basis for the belief that the aggregation of individuals' economic well-being produces the greatest social good. In balance, Marshall and Marshall (1890) and Pigou (1912, 1920) describe individual actions that counter social good and that create social costs that are the cause of externalities.

Externalities are economic effects that are beneficial or negative to entities other than those that created the effects. Externality *per se* is a broad concept in which the utility of one economic agent is affected by activity under the control of a different economic agent (Randall, 1987). Also called “spillovers,” externalities are costs or benefits that fall outside the market exchange. When included in the exchange, they are “internalities,” accounted for in the *quid pro quo* equation of all participants. Many minor externalities occur, but no one cares because they are not Pareto-relevant. Externalities create economic inefficiency and market failure. Property rights can link externality producers to those affected, which can internalize costs in the market exchange and mitigate the externality (Stroup and Baden, 1983; Randall 1987; Bromley, 1991; Tisdell, 1991).

Natural-resource use has historically entailed significant negative externalities. Logging can create social cost as a result of stream-silting and habitat loss. Manufacturing creates pollution, and pesticide poisons aquifers. With biotechnological utilities, an externality will exist if a species is used up for a non-biotech utility use that would cost future biotechnological-utility discoveries. The Yellowstone–PCR case exemplifies such an externality. The cost of maintaining this wildlife is borne by the taxpayer, not by the beneficiaries (the inventors and exploiters of PCR). However, it could be argued that the externality is at least partially mitigated by the economic development enjoyed by the taxpayer.

Rivalry is a physical, intrinsic property of a resource. It has nothing to do with institutional choice. Rival resources are those in which an individual’s consumption diminishes another’s ability to consume that resource. A fishery is a classic example of a rival resource. If a fish is caught, no one else can catch that fish. Consumption of a non-rival resource, on the other hand, does not diminish another’s opportunity for consumption. Consumption of sunlight does not affect anyone’s ability to consume that sunshine. Examples of rival resources include groundwater, wildlife, oil, and timber. Non-rival resources include national defense and roads. Feeny et al. (1990) have pointed out that rivalry is the point of divergence between individual and collective economic rationality.

Exclusivity, an intrinsic resource characteristic, dictates whether individuals may feasibly be excluded from access. Non-exclusivity may result where exclusion is impossible (e.g., clouds) or highly infeasible or prohibitively costly (e.g., open-ocean fish, all insects). Unlike rivalry, exclusivity can be institutionally created. For example, although it is difficult to physically exclude individuals from access to free-roaming fish and wildlife, fish-and-game laws render this resource exclusive. When exclusivity is physically possible, specification of property rights in the resource becomes a political choice. For example, it is feasible to make exclusive a resource such as public education. However, in the United States, the political choice has been to make pre-college education a non-exclusive resource.

Property rights are the mechanism of institutionalizing exclusivity, and the primary and most basic form of exclusivity is physical possession. Resource exclusivity requires definition, maintenance, and enforcement of a property right. Without exclusion, users cannot be kept from access, making it impossible to collect a price for use. Without exclusivity, price cannot ration use or provide revenue for sustaining a resource. So, non-exclusive resources are under-provided by markets, resulting in under-investment and economic inefficiency (Randall, 1987).

In property-right terms, non-exclusivity is the *res nullius* regime, whereas exclusivity may be either *res privatae, res publicae*, or *res communes*. Economists tend to view *res privatae* as most conducive to efficient market dynamics and *res publicae* as a deviation from that ideal (Stroup and Baden, 1983). Randall (1987), Ciriacy-Wantrup (1975), Ostrom (1990), and Bromley (1991) all variously describe *res communes* as a middle ground in which a group has exclusivity in a resource. This "group private property" regime, based on institutionalized rules of membership and resource access or use, does not have all the characteristics of non-attenuated private-property rights but provides a workable system where *res privatae* is not feasible. Randall (1987) believes that even the most efficient *res communes* will not result in attainment of Pareto efficiency, but can produce "second best" solutions that will act to sustain long-term productivity, discourage waste, and also provide for satisfactory incomes.

The **Economic Taxonomy of Natural Resources** provides a framework from which to distinguish and analyze different types of resources as economic goods and to define the socioeconomic implications of those distinctions.

Renewable/Non-Renewable is a primary resource distinction. Non-renewable (or exhaustible) resources do not reproduce and can be used up. The theory of the mine (Tietenberg, 1988) exemplifies how potential exhaustion of non-renewable resources is a physical necessity that constrains resource use of this type. Potential exhaustion of renewable resources is not a physical necessity but is a function of a number of factors. Biological resources are a complex subset of renewable resources, characterized by their ability to auto-reproduce. Reproduction rate is a function of factors that can vary such that reproductivity may be great, small, or non-existent. Biological resources are renewable but destructible.

The natural-resource taxonomy is further characterized by combinations of rivalry and exclusivity.

Rival–Exclusive resources are readily provided by markets, and if suitable market dynamics exist, Pareto optimality is possible. Rival–*res privatae* resources ("private goods") fall clearly into this category. Rival–*res communes* resources ("communal goods") approach, but never reach, the capacity of rival–*res privatae* to achieve Pareto optimality. According to Stroup and Baden (1983), Pareto optimality is not attainable for rival–*res publicae* resources (governed by the state because of market-system distortions) as a result of government bureaucrats' lack of economic incentive, need for economic efficiency, and imperfect information, as well as politics, corruption, and inherent bureaucratic inefficiency.

Rival–Non-Exclusive resources cannot be provided by markets because exclusion is not possible, payments cannot be collected, price loses meaning, and the demand–supply/price dynamic collapses. Some of these resources are *res nullius,* in which no exclusivity can exist because of the physical nature of the resource (e.g., global atmosphere). Others are practically *res nullius* because property rights are technically difficult to define and enforce (e.g., satellite orbits). Technology and/or institutional mechanisms can alter this economic taxon. For example, technology may enable imposition of exclusivity (e.g., enclosing the open range with barbed wire). A political choice may impose *res publicae* exclusivity on a resource (e.g., prohibition on possessing endangered species). Technology may enable an institutional choice to impose *res publicae* exclusivity (e.g., electromagnetic spectrum, groundwater). Although markets cannot provide rival–non-exclusive goods, such goods can be supplied by the public sector or through philanthropy (Randall, 1987). If exclusion is physically and economically feasible and *res privatae* is politically acceptable, markets can provide these goods in a potentially Pareto-efficient manner (Randall, 1987). Where only *res publicae* is politically acceptable (e.g., radio frequency broadcast rights), government may offer these goods for fees, but this is only a facsimile of market-based, Pareto-optimal rationing.

All rival–non-exclusive resources are susceptible to a "tragedy of the commons" (TOC).

Non-Rival–Exclusive. Exclusivity allows these to be provided by the market, but non-rivalry precludes Pareto optimality unless perfect, discriminatory pricing can be achieved (Randall, 1987). Government may provide such goods through a user-fee structure. Biotechnological utilities may fall into this category since the use of such utilities does not affect another's ability to use the same material (Aylward, 1992).

Non-Rival–Non-Exclusive resources ("pure public goods") cannot be supplied by markets, only by philanthropy or government. Examples include national defense, roads, bridges, wilderness, and existence of wildlife. If exclusion becomes technically feasible, the resource may become non-rival–exclusive in which private markets (if politically acceptable) or government may provide, although with less than Pareto optimality. Baden (1998) points out exceptions to the non-rival–non-exclusive (public good) problem: in small groups, social pressure can compel self-imposed exclusivity and payments for use; if the private benefit of providing a public good exceeds the private cost, the public good will be provided privately.

Congestible resources are non-rival up to a threshold of use at which congestion by users renders the resource effectively rival. Examples of congestible resources include bridges, airports, restaurants, public toilets, and the Internet.

6.3 The Market: Supply, Demand, Price, and Equilibrium

A cornerstone of economics is market function. An ideal market exists when providers and consumers freely engage in an equilibration of provider's supply and consumer's demand in a two-dimensional domain of price and quantity. The elegantly simple "market diagram" describes a demand curve that relates the quantity of a commodity produced to its price. As price rises, demand decreases, and supply increases. As quantity increases, demand decreases, and price drops. Equilibrium occurs when the price–quantity point is such that production equals demand. Price is the "signal" that rations goods among consumers, motivates (or demotivates) producers, and directs the allocation of resources. Price is the mechanism that moves economies in the direction of efficiency. Baden (1998) extols the market as the ideal process for moving people voluntarily to coordinate their actions in allocating scarce resources efficiently since price effectively and efficiently coordinates rationing and is incentive-generating.

Common (1996) defines the ideal market as requiring the following: an absence of externalities, an absence of public goods (or bads), consumers and producers with complete information, and producers and consumers that respond to price. Randall (1987) describes market imperfections that produce inefficiency: attenuated property rights producing non-exclusivity in resources and goods, including "public goods"; non-rivalry in resource use; congestible resources; monopolies; and externalities.

The market diagram is anthropocentric, and market efficiency has little connection to inter- or intra-generational equity in resource allocation. Other limitations include failure to account for non-monetized values and future uncertainty.

Value is fundamental to the economic equation. Valuation of a resource is essential to making economic choices. It is an organizing principle but has limitations, particularly in some natural resources (Daily et al., 2000). Traditional economics relies on market price as a valid indicator of value. This reliance is confounded when there is no market for a resource and when determining monetized value is difficult or practically impossible. Valuation is also constrained by the long time horizons of sustainable resource methodologies, uncertainty, and inter-generational equity. Economists have developed various sophisticated resource-valuation methods in this complex environment (Anderson and Bishop, 1986; Costanza, 1991, 2000). Valuation models such as "Travel-Cost," "Hedonic-Price," "Willingness-to-pay" and "Contingency-Valuation" exhibit more or less utility depending on the resource. Other methods include “Bidding games,” “Payment Card,” “Duality/Cost Function,” “Producer-Optimization,” and “Household-Production.” These methods are intrinsically anthropocentric and intra-generation–limited, and, furthermore, externalities are frequently left out of such valuation models. Costanza (1991) describes an ecological dimension to resource valuation. Barbier (1992), Tisdell (1991), and Freese (1998) define a “Total Economic Value” of natural resources, composed of use and non-use values, with several components:

Use Values

- direct use (non-consumptive, such as access to genetic information; consumptive, such as fishing)
- indirect use (carbon storage, waste removal)
- option (future discoveries from wildlife)

Non-Use Values

- bequest (preserve for future generation)
- existence (wilderness, cultural, intrinsic)

Existing biotechnological utilities are direct, non-consumptive use values that can be quantified. Potential biotechnological utilities in wildlife are an option use value whose value presents a vexing economic problem.

In my opinion, option value is the closest economists come to valuing the potential of future technological discoveries. It is the present value placed on a resource in order to have the option to use the resource in the future. It is usually determined by valuing uses that would preclude future use. An option price is that price which present consumers will pay to forego other uses for this option. A limitation in determining option value is lack of information about the future. Technology, for example, may transform a present low-value resource to future high value.

If it is determined that there is risk of catastrophic or irreplaceable loss of a resource—for example, the irreplaceable loss of a species and its unique genetics by extinction—the "precautionary principle" may be invoked (Perrings, 1991). When such risks exist, the precautionary principle holds that standard methods of valuation are unacceptable. Common (1996) states that the precautionary principle represents a unique way to approach project assessment in relation to social goals and is different from the standard method of allocative efficiency and cost–benefit analysis.

Common (1996) advocates performance bonds to manage this dilemma. Ciriacy-Wantrup (1968) proposed a "Safe Minimum Standard" (SMS) policy approach to potential irretrievable loss resulting from gene resource extinction. The SMS uses a public-policy decision process that accounts for the economics of resource loss through extinction (Bishop, 1978). The SMS for a species is that viable population sufficient to sustain the species. The SMS cost is evaluated by the foregone economic benefits lost by foregoing projects that would have caused the population to drop below its SMS. Ciriacy-Wantrup (1968) proposed that a SMS be adopted for all species and adhered to unless the social cost of doing so is "unacceptably high." The difficulty is determining the "unacceptably high" cost at which the present generation is not willing to convey options to future generations. In the famous *Snail Darter v. Tennessee Valley Authority* test case of the Endangered Species Act, the decision involved a choice between quantifiable benefits of a dam versus the unquantifiable cost of species loss. Extinction creates potential for large future losses, small or no losses, or even gains by future generations.

Regarding valuation of endangered species, Brown and Goldstein (1984) developed a model that points out the necessity of determining the probability of discovering improved products from the species evaluated and of evaluating the value of such discoveries. This emphasizes the difficulty in valuing a resource with such high scientific uncertainty. The discovery of the polymerase chain reaction (PCR) in microbial thermophiles demonstrates the difficulty of such *a priori* valuation. Prior to the PCR discovery, no commercially valuable products had been derived from these organisms, and the idea of PCR could hardly have been predicted.

Property rights are essential for trade. Competitive, free markets require property rights (Randall, 1987). Coase (1960) argues that if non-attenuated property rights in a resource are clearly defined, enforceable, and held by involved parties in a market, Pareto-relevant externalities will be eliminated, resulting in economic efficiency. Efficient markets require property rights in which rights of use are specified, enforceable, and transferable (Randall, 1987).

Market failure occurs when markets do not produce allocative efficiency (Common, 1996). Non-exclusive, *res nullius* or free-access resources are a source of market failure caused by economic "free-riders" (Bator, 1958; Randall, 1987; Bromley, 1991). Stroup and Baden (1983) point to lack of property-right definition or enforceability as a prime source of market failure. Externalities are also a significant cause of market failure. Natural resources are highly susceptible to market failure because of their typical non-exclusive and public-good character. A market failure to supply a non-rival, non-exclusive good leads to temporary under-supply, whereas a market failure in an exhaustible or destructible common resource may lead to irretrievable loss of the resource (Baden, 1998). Bromley (1991) defines market failure as individualistic, wealth-maximizing behavior that results in outcomes that are less than socially optimal.

Excessive transaction costs (such as the cost of defining and enforcing property rights) can cause market failure. Market economists typically advocate establishing property rights and a market for a *res nullius* renewable resource as a preferred means to move market actors voluntarily (Baden, 1998) toward efficiency and recommend a perfect price-incentive mechanism rather than governmental regulation (Common, 1996). Randall (1987) cautions that an apparent market failure may actually be the absence of a market. Some markets are not worth the cost of their creation. Governmental interference in a market through distortions caused by taxation, subsidies, regulations, and so forth can create market failure. Randall (1987) suggests that the middle ground between market failure and governmental intervention is governmental assistance in market creation and maintenance through well-crafted regulations.

Tisdell (1991) describes a market failure in wildlife resources caused by their mixed-goods character. Wildlife harvested for a private good (e.g., as a trophy or pelt) may have existence, option, or other value. Economic optimality for the private good may be met while a market failure simultaneously exists for values of other parties.

Uncertainty presents a significant challenge to economic valuation. The extent to which uncertainty will affect an economic model is a function of the uncertainty that surrounds a particular resource scenario. Although the future is inherently uncertain, the degree of uncertainty is increased by long time horizons, technological change, demographic dynamics, changing demands, unexpected resource-stock changes, changing governmental regimes, and other factors. For example, the invention of the electric light had a profound effect on the economics of oil lamps and transmission lines, which could not have been evaluated *ex ante*. In the case of biotechnological utilities, technology has created utilities where none existed. PCR was not preconceived but has created entirely new markets.

When an action involves an irreversible transformation of the environment (as in the loss of a species), uncertainty should be included in a CBA (Arrow and Fisher, 1974). Hartwick and Olewiler (1986) construct a model in which it could be “socially optimal” to extinguish a renewable resource. However, this model ignores the uncertainty of potentially greater values discovered in the future. Randall (1987) sums up the effect of uncertainty by claiming that intertemporal problems that involve long time horizons, uncertainty and/or irreversibility may be best handled by the caution and risk aversion that conservationists often espouse.

Faber and Proops (1998) have developed economy/environment models that take uncertainty and the emergence of invention and innovation into consideration. They acknowledge that novelty is unpredictable, occurs frequently, and can produce significant economic effects particularly relevant to biotechnological utilities. To be patentable, a biological utility must be novel and not obvious. Inventions cannot be predicted. It is impossible to formulate a rational expectation of the value of an unpredictable invention. By the very nature of invention, patentable biotechnological utilities and their value cannot be predicted in an economic model.

Economic models of biological resources: The fishery and forest represent two bionomic model types that represent the property/resource dichotomy between fugitive and sedentary wildlife. The fishery has attributes of a fugitive and reproducible resource. It reproduces under density-dependent growth rates that are a function of various environmental and human-caused factors, it is subject to depletion through over-harvesting, it is destructible, it is fugitive and is *res nullius* (because of the infeasibility of property rights), and it is rival.

Economic models of a fishery take biological growth and reproduction into account in the stock calculation of “Maximum Sustainable Yield” (MSY). The MSY is the quantity of fish harvested per unit of time within which there is no net decrease in the fish stock. It is the maximum amount of harvest that equals growth in overall fish biomass over time. Gordon’s (1954) “bionomic equilibrium” is that point of harvest where MSY produces revenue that is just sufficient to cover the cost of harvest.

The fishery exemplifies a rival–non-exclusive resource subject to the TOC. Gordon (1954) preceded Hardin (1968) in a TOC analysis of the fishery model. The fishery represents the classic case of lack of property rights (*res nullius*) in a common resource destroyed by the combined actions of numerous individuals seeking to maximize their value through capture (Hartwick and Olewiler, 1986; Neher, 1990).

It is not surprising that the fishery is the subject of considerable thought and experiment concerning alternative property-right regimes. Ruddle (1989), Miller (1989), Acheson (2003), and Ostrom (1990) describe *res communes* management regimes of fisheries. An integrated *res communes* and *res publicae* regime has been described in which "individual tradable quotas" (ITQs), or access shares in the fishery, are granted to fishers by the government and in which the ITQs may be exchanged in a market (Townsend, 1998).

The forest is a different type of bionomic model. Although it shares characteristics with the fishery (rivalry, auto-reproducibility, destructibility), it is not fugitive and is feasibly exclusive. Property rights may be defined and enforced in the forest, which eliminates TOC problems. The forest model is dominated by a different type of resource economics problem: discounting. The central economic thesis of the forest can be illustrated by the following scenario. The owner of the resource (measured in board feet or tons of standing timber) has two choices: cut and sell the timber and put the monetary gain into an interest-bearing instrument, or leave the timber to grow and cut later after growth has increased the value (board feet or tons) of the timber sold. At any point in time, the key is determining when the return will be greater through interest on investment of the proceeds of sold timber versus growth rate of the trees. It is a straightforward calculation that argues for cutting all slow-growing trees now. It also suffers from a lack of consideration given to other values (habitat, clean streams, reduced flooding, water conservation, carbon sequestering, scenic beauty), and the attendant externalities this inconsideration produces.

6.3.1 Some Wildlife Economics

Traditional resource economics analyzes natural resources that are directly useful to humans. Fish and game are those wildlife that have traditionally been the economist's purview. Since biotechnology creates uses for wildlife outside of traditional wildlife economics, it is necessary to expand the economic analysis. But, before addressing an economics of biotechnological utilities, it is useful to review wildlife economics.

The application of appropriate economic models to wildlife depends on the physical character of the wildlife itself and the institutional milieu that governs its accessibility. All direct uses of wildlife are rival. However, the supply of some wildlife is so high or the demand for it so low that it is effectively non-rival. Gnats are rival but so plentiful and useless as to be practically non-rival. For this analysis, effective non-rivalry is ignored.

There is great variability in the exclusivity of wildlife. The fishery typifies non-exclusive wildlife, while the forest is feasibly exclusive. It can be assumed that transient wildlife are non-exclusive, although exceptions to this generalization could include populations that, because of their nesting or habitat patterns, are endemic to an area enclosed by property rights. Such species may be characterized as having an exclusivity character for certain periods of their lifecycle (e.g., during nesting). Despite exceptions (which require a case-by-case analysis), the useful working model is for non-transient wildlife to be rival–exclusive and for transient wildlife to be rival–non-exclusive.

The rival–non-exclusive character of transient wildlife creates a market inefficiency that becomes apparent if the wildlife is scarce. History is replete with the destruction of rival–non-exclusive wildlife populations by market forces (Garretson, 1933; Matthieson, 1987), and governmental control has played a key role in stopping this destruction (Tober, 1981). Emphasis has been on the prohibition of markets in scarce fish and game (Bean and Rowland, 1997). Such species have been made exclusive through *res publicae* mechanisms of law and regulation. In the case of regulated wildlife, in which species may be hunted, fished, trapped, or collected by permit, a governmentally controlled "market" of permits, licenses, and fees is presumably linked by governmental decision makers to some form of supply and demand. In other cases of *res publicae* wildlife, there is no "market," because of the absolute prohibition against taking, possessing, or trading (e.g., endangered species). Some argue that these prohibitions reduce market pressure on species viability, create perverse incentives in poaching and black markets, and limit economic options to incentivize conservation actions, and that some portion of wildlife could be made private goods as a conservation approach (Swanson, 1991, 1992, 1994; Anderson and Leal, 1997). Lueck (2001) suggests that the Endangered Species Act can act against species conservation by eliminating conservation incentives and creating conservation disincentives. The use of trespass laws has been advocated as a means of imposing a type of exclusivity over wildlife on private land. Innovative institutional structures that combine aspects of *res communes*, *res privatae*, and *res publicae* control of wildlife for purposes of conservation have been described by Freese (1998), Baden (1998), and Anderson and Leal (2001).

For many species of wildlife, there is no *res publicae* control. Most arthropods, mollusks, and microbes are *res nullius*. These species could be in danger of a TOC degradation if they were to become valuable and scarce. Biotechnology has the potential to create such value and scarcity.

Determining the usual economic values of wildlife such as meat and skin is a relatively simple calculation. But other, competing values are typically ignored in this calculation. For example, the existence value of a wild species will be lost if the species is harvested for tangible goods (Tisdell, 1991).

The *ex post* determination of the value of wildlife biotechnological utilities has been little studied, although some have made preliminary and narrow attempts (Principe, 1989; Artuso, 1994; Simpson and Sedjo, 1996). Even less studied is the *ex ante* evaluation of potential value of this resource.

A unique property of biota that impacts its exclusivity is autoreproducibility. Possession of a biota specimen often confers the ability to possess more through reproduction: Livestock have progeny, and plants may be vegetatively reproduced to create clones of a single sample. With biotechnology, one cell may be sufficient to reproduce the organism. This allows capture of value through possession of very small portions of the biota. The source of this value lies in two distinct but related types of property: tangible personal property and intangible intellectual property.

6.4 Wildlife as a Source of Proprietary Biological Material and Intellectual Property

Proprietary biological material is tangible personal property in an organism, groups of organisms, their parts, or by-products. Although one's dog or horse is not typically called proprietary biological material, such creatures are tangible personal property. A single wild chipmunk becomes proprietary biological material when caught and caged. The role of proprietary biological material in the resource economics of wildlife becomes more crucial when considering biotechnologically rendered parts. Cell and tissue cultures, plasmids, DNA constructs, proteins, and antibodies are proprietary biological material. They can be reproduced or subcultured and can contain genetic information. Proprietary biological material is the direct source of most biotechnological utilities. Although a wildlife specimen is the original source of any biotechnological utility, the biotechnologist invents by using a sample of tissue taken from the organism. The sample is proprietary biological material. Depending on the extent to which law controls the possession and use of the wildlife, the sample may be the private property of the possessor. If law controls the taking, possession, and use of the sample, then the biological material remains public property. The Endangered Species Act asserts public control of biological material from listed species. Other laws, including many state game laws and the federal Migratory Bird Treaty Act, do not extend state control to sampled biological material, thus allowing private-property rights in the sample.

Thus, within technical constraints, proprietary biological material can be created from any biota and, depending on the reach of the law, such material may be privately owned or public property.

6.5 Defining Biotechnological Inventions

The term "biotechnological invention" refers to those utilitarian materials and functions that are biotechnologically discovered in or invented using biota. It is an umbrella term that encompasses any biological matter or method that has utility. A biotechnological invention may or may not be patentable. A gene that conveys a trait on transgenic organisms is a biotechnological utility and may very well be patentable. So, too, is the transgenic organism *per se*. Less obvious, but no less utilitarian, biotechnological utilities include DNA sequences that code for gene regulation functions, such as "promoters," "translational enhancers," and "terminators" of gene expression. Many biotechnological utilities are not patentable because they do not satisfy the patent requirements of novelty, nonobviousness, and enablement or because they are "naturally occurring."

Biotechnological inventions also encompass functions such as honey-making by bees, demonstrating that the value of biotechnological inventions values is not limited to genes or to biochemicals.

Biotechnological inventions encompass DNA sequences in artificial "genetic constructs," "vectors" that facilitate insertion of foreign DNA sequences into a host cell genome, and intangible methods such as "parasite-derived resistance"[1] and "replicase-mediated" disease resistance in transgenic plants.[2] Biotechnological utilities also include cell lines, tissue cultures, plasmids, and biochemicals that are useful *per se* or that provide a template for further invention. For example, biological optics systems have inspired advanced photonics designs.

6.6 Dual-Property Aspects of Biotechnological Inventions

A biotechnological invention can exist simultaneously as biological material *per se* (for example, the actual DNA oligonucleotide molecule of a gene) and as intellectual property (such as a patent on the use of the DNA sequence as a technological entity). PCR technology exists as enzymes *per se* and as patents on the use of those enzymes. As matter, a biotechnological invention may be possessed and controlled as personal property. This property may exist in test tubes, in petri plates, as propagules (cells, tissues, seeds, etc.), or as whole organisms. Biotechnologically rendered genes typically exist in a genetic construct within an engineered host cell. These materials are valuable because of their utility and their alienability (i.e., they may be bought, sold, or exchanged). Ownership and control of these properties is secured through possession or contract. Once possessed, such property may be owned unfettered unless governmental rights extend from the biota to the derived biological material. Two aspects of such physical property obtained from wildlife are important:

[1] Embodied in U.S. Patent No. 5,580,710.
[2] U.S. Patent No. 5,596,132.

physical possession is a requisite to obtaining an invention (patentable or not), and the possession or use of such property may be constrained by federal or state law. In addition to constraints on the physical property, however, there is also the intellectual property aspect to consider.

The duality of tangible versus intellectual property rights is reminiscent of the dichotomy between usufruct rights and title in land law. Personal-property rights in the biological material are separate from the patent rights that convey the exclusive right to prohibit others from making, using, or selling. The use of the biotechnological invention may be covered by patent rights. Patents are granted by the federal government and are owned by the inventor or otherwise by contract between the inventor and another party (e.g., an employer). Like the personal property of tangible biological material, the patent may be exchanged in a market transaction. The following scenario illustrates this dichotomous property relation.

A test tube containing a cell line is possessed by an individual, and absent a contract or law that controls such possession, all the cells in that tube are the sole personal property of the possessor. Another individual holds a patent on a use of this same cell line. The patent owner has no right of possession in the tangible property of the cell line, only the right to stop anyone (including the owner of the cell line, and anyone the owner transfers the cells to) from making, using, or selling the cells for that use. Simply possessing these cells does not infringe on the patent owner's rights.

A biotechnological invention may be owned as tangible property only. For example, antibodies (proteins with immunological utility) are either unpatentable or their patentability is narrow to the point of uselessness in terms of market value. In some cases, the biotechnological invention is patentable, but doesn't exist as matter. Such inventions are inspired by something in a specimen. For example, the "parasite-derived resistance” method covered by U.S. Patent No. 5,580,710 can be embodied in any type of biological matter.

Thus, with biotechnological inventions, situations arise in which the owner of personal property in the biological material controls possession of that material while another simultaneously owns the use of that material via patent rights. Layered on this ownership quilt is the control of free-roaming wildlife *per se*. These attributes confound traditional natural resource economic models.

6.7 The Unique Resource Economic Characteristics of Inventions from Wildlife

Characteristics of inventions from wildlife produce a unique set of attributes that are relevant to the economic analysis of this natural resource.

Dual utilitarian value: the utilitarian value of inventions is based on physical matter and information derived from that matter (Parry, 2004).

Dual rival and non-rival character: The biotechnological invention is rival to the extent that the relevant biological material is rival. This rivalry is partially mitigated by reproducibility in which genetically identical clones can be created. Regarding the rivalry of the genome, DNA *per se* in rival biological material is also rival. But, since the same genome exists in any other specimen of the some species, the genome as a source of information is non-rival.

Mixed exclusivity/non-exclusivity: Wildlife fixed to the land (plants and soil microbes) on private property is exclusive; on public land it may or may not be exclusive. Fugitive wildlife is inherently non-exclusive (exceptions include small, endemic populations in circumscribed areas). Public property has been established over specimens of federal and state-controlled wildlife. The extension of such public rights over tangible biotechnological utility varies from species to species according to applicable federal or state law. In either case, property rights in the biotechnological invention will be exclusive by virtue of either *res privatae*, *res publicae*, or a mix of *res publicae* and *res privatae* (i.e., private ownership of legally taken specimens with some governmental control on disposition). However, the biotechnological invention will exist in all members of the taxon; therefore, possession of a biotechnological invention does not exclude others from accessing the same invention from other specimens of the taxon. The use of the invention may be patented, which would grant exclusivity over use, but not that matter, which is tangible biological property.

Mixed property-right character: Living wildlife are either private property (plants on private land), public property (federally controlled species including plants on public land, or free-roaming, state-controlled species), or *res nullius* (free-roaming and uncontrolled by federal or state law). Tangible biotechnological invention may be private property (matter obtained from *res nullius* species or plants on private land), public property (matter from species controlled by federal and state law that extends governmental control over parts of specimens), or public–private property (federal- or state-controlled specimens for which federal or state laws do not extend public control to either tangible personal biological property or intellectual property). In some cases, specimens of wildlife may be a combination of public property–private property and *res communes*,[3] which is a logical extension of the controlling regime of wildlife specimens.

Utility through consumption and non-consumption: Aside from aesthetic values, wildlife utility normally requires consumption of the wildlife. Such consumption is only marginally relevant to biotechnological inventions because such inventions are either information or are typically reproducible through cloning and sub-culture. Consumption of inventions is irrelevant given that only a negligible amount of biological material, relative to the population, is necessary to invent.

[3] For example, in the case of "Individual Tradeable Quotas," granted by government, managed by a community, rights and values belong to the individual on capture.

High uncertainty: Inventions are characterized by their high scientific uncertainty. Invention is inherently unpredictable. It is nearly impossible to determine, *a priori*, whether a species will yield value through invention. This is especially true with patentable inventions, which must be novel and not obvious. The impact of uncertainty is exacerbated by the irreversibility of species extinction. Once a species is extinct, its potential inventions are lost. The probability of obtaining an invention from a particular species may currently be low, while potential value may be very high—a lottery, in effect. This "lottery effect" means that each genetically unique organism is a lottery ticket in the risky search for useful, valuable invention.[4] Each unique species taxon has a high option value created by two factors: the high scientific uncertainty that a valuable invention may eventually be found in it, and the catastrophic effect of irretrievable genetic loss caused by extinction.

6.8 An Economic Taxonomy of Inventions in the Wildlife Resource

The economic taxonomy of inventions in the wildlife resource may be divided into two property types: tangible and intangible. Tangible invention is rival, but that rivalry is mitigated by its potential to be reproduced. So, if a tangible invention is possessed as personal property, that matter is rival. However, to the extent someone else can obtain and possess the same tangible invention from another specimen of the same species, it is not rival.

Intangible inventions are not rival because possession does not diminish supply.

Tangible inventions from wildlife will be exclusive, with a mix of private-property and public-property characteristics, depending on the extent to which governmental control extends to the tangible biological matter. For example, a

[4] In some cases, organisms may exhibit a unique utility that may not be directly represented in the genome *per se*. For example, some populations of Monarch butterfly exhibit incredible migratory feats, while other, genetically identical Monarchs do not.

tangible invention from most insects would be private personal property because most insects are a *res nullius* resource (honeybees can be an exception). The possessor of that insect matter would own it as personal property by right of first possession. However, others could obtain identical matter from another *res nullius* specimen of the same species. A tangible invention from an endangered species would be exclusively public property because the whole, living specimen is public property, as are samples taken from it.

The intangible patent right is exclusive by the nature of the right of a patent holder to exclude others from use. The patent does not, however, prohibit the physical possession of a tangible invention, only the making, using, and selling of the patented invention.

Where a wildlife specimen is exclusively possessed, it will be controlled by the government,[5] privately (through individual possession of a specimen of a *res nullius* species), or through a mixture of public and private ownership. These public–private mixtures take a variety of forms. For example, in the state of New York, bears are public property when free-roaming in the wild, and no private individual may possess a living, free-roaming, New York bear. However, wild bears can be possessed by individuals by killing under a valid permit issued by the state government. Once possessed, the bear carcass becomes private property with an exception: the flesh cannot be sold; therefore, public control over select uses of some parts of the bear remains even after reduction of the free-roaming public bear to a dead, private specimen.

Tangible inventions and intangible property rights from wildlife can be categorized using the resource economics taxonomy illustrated in Table 6.1.

[5] Federal for endangered species, migratory birds, or other species listed in federal law; state for other fish and game; other species controlled by state law.

Table 6.1. Property Type in Tangible and Intangible Inventions from Wildlife.

Invention	Undiscovered	Discovered
Tangible	Common-pool resources	Mixed private–public goods
Intangible	Pure public goods	Pure private goods

6.9 Is there a Market Failure in Inventions from Wildlife?

6.9.1 Contributing Factors

Ideal markets provide a mechanism in which the costs of maintaining and supplying a resource and the benefits from its use are efficiently allocated between maintainers or suppliers and beneficiaries. Is the current market use of inventions from wildlife a market failure?

Sources of failure of a market to efficiently allocate costs and benefits of a natural resource include ambiguous property rights and exploitation of a valuable, *res nullius* resource. Property rights must be defined and enforceable if a market is to function. Markets should provide a direct link between the cost of a resource and the financial return from that resource. Externalities exist when the costs of maintaining and supplying a resource are not borne by the beneficiaries. A corollary is the free-rider problem: Do all of those who benefit from exploitation of the resource participate in the cost of its maintenance and supply? Is there governmental "interference" in the market mechanism? Is there an equitable allocation of costs and benefits over all participants and stakeholders, including future generations? Does the mixed-goods problem described by Tisdell (1991) yield a "mixed market failure" in wildlife inventions? Let us examine each of these components of potential market failure in the context of wildlife inventions.

Property rights: Property rights in specimens of wildlife, their carcasses, and parts are defined for public species (species listed in federal laws, state wildlife laws) and plants (owned by the real estate property owner). The many species that do not fall under these umbrellas are *res nullius*. For example, most arthropod species are *res nullius* and are subject to market failure. Property in tangible inventions from public wildlife is confused but appears to be private. Thus, the governmental entity responsible for managing a wildlife population has no rights to benefits that arise from an invention obtained from that wildlife; the beneficiaries are free-riders since they are not obligated to share the costs of wildlife maintenance. For the many wild species that are currently *res nullius* (in fact, the vast majority of species), it seems only a matter of time before technology renders some of them scarce, thus creating conditions for market failure.

Allocative efficiency: The condition of nonexistent or ineffectively defined property rights in wildlife inventions yields a disconnect between financial returns from commercialization of such inventions and the cost of wildlife maintenance. An intergenerational allocation inefficiency arises from the uncertainty of future value of undiscovered inventions in wildlife. Regardless of efforts to connect present beneficiaries of wildlife invention exploitation to investment in the wildlife resource, unless future inventions are maintained for future generations by maintaining wildlife species, a serious intergenerational allocative efficiency exists.

Mixed-good character: A resource with mixed-good character may have a market in some of its goods and a failure in others (Tisdell, 1991). Trophy hunters who pay for taxidermy goods participate in a market in big-game “hunting goods” but simultaneously participate in a failure to supply existence or option values. The inventions from wildlife are highly susceptible to the mixed-goods problem.

These several factors suggest that wildlife invention systems are inherently prone to a market failure. This failure seems intuitive, since the increasing value of wildlife inventions are paralleled by decline in many wildlife populations. In the next section, I present specific cases that substantiate a market failure.

6.9.2 Evidence of Market Failure in Wildlife Inventions

In the summer of 1966, Dr. Thomas Brock, a professor at the University of Wisconsin, and his student H. Freeye collected microbial samples at Mushroom Spring in Yellowstone Park under a park collection permit. The permit placed few restrictions on the collector's use of collected samples. The researchers isolated an unknown, thermophilic microbe from the sample, published a paper describing the species they named *Thermus aquaticus,* and deposited an axenic culture of the species in the American Type Culture Collection (the ATCC is a public biological repository) as culture "25104." ATCC restrictions to access 25104 were simply the required nominal fee and standard "hold harmless" clauses for liability. Kary Mullis, an employee of Cetus Corporation, obtained a sample of 25104 from ATCC (Cetus paid a $35 fee) and used it to invent the polymerase chain reaction (PCR) method. Cetus filed its first U.S. patent application on the PCR technology with K. Mullis as sole inventor, on October 25, 1985. A subsequent U.S. patent application was filed by Cetus (with Mullis and five others as inventors) on February 7, 1986. The October 1985 and February 1986 applications ultimately were issued on July 28, 1987, as U.S. Patent Nos. 4,683,202 and 4,683,195, respectively.

U.S. Patent No. 4,683,202 (K. Mullis inventor; Cetus Corp Assignee), titled "Process for Amplifying Nucleic Acid," was issued with twenty-one claims that cover "a process for amplifying any desired specific nucleic acid sequence contained in a nucleic acid mixture thereof . . . ."[6] U.S. Patent No. 4,683,195 (Mullis et al.; Cetus

[6] **Claim 1 reads as follows:** "A process for amplifying at least one specific nucleic acid sequence contained in a nucleic acid or a mixture of nucleic acids wherein each nucleic acid consists of two separate complementary strands, of equal or unequal length, which process comprises: (a) treating the strands with two oligonucleotide primers, for each different specific sequence being amplified, under conditions such that for each different sequence being amplified an extension product of each primer is

assignee), titled “Process for Amplifying, Detecting and/or Cloning Nucleic Acid Sequences,” was issued with twenty-six claims.[7]

With these two patents, Cetus controlled the making, using, and selling of PCR technology. In the late 1980s, Cetus and Perkin Elmer commercialized PCR through licenses and sales of PCR reagents and thermal cycle equipment. Hoffman-Laroche purchased the Cetus PCR patent estate for $300 million. Since this transaction, PCR has produced significant commercial activity, including large intellectual-property costs.

Neither Yellowstone National Park, the National Park Service, nor the Department of the Interior has received any direct share of the revenue resulting from the PCR property (Lindstrom, 1997). This demonstrates a market externality produced by lack of a market connection (other than normal business taxes) between the financial beneficiaries of the PCR (Cetus and Hoffman-LaRoche and their investors) and those who invested (the federal government, trustee for the people of the United

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synthesized which is complementary to each nucleic acid strand, wherein said primers are selected so as to be sufficiently complementary to different strands of each specific sequence to hybridize therewith such that the extension products synthesized from one primer, when it is separated form its complement, can serve as a template for synthesis of the extension product of the other primer; (b) separating the primer extension products from the templates on which they were synthesized to produce single-stranded molecules; and (c) treating the single-stranded molecules generated from step (b) with the primers of step (a) under conditions that a primer extension product is synthesized using each of the single strands produced in step (b) as a template.”

[7] **Claim 1 reads as follows:** “A process detecting the presence or absence of at least one specific nucleic acid sequence in a sample containing a nucleic acid or mixture of nucleic acids, or distinguishing between two different sequences in said sample, wherein the sample is suspected of containing said sequence or sequences, which process comprises: (a) treating the sample with one oligonucleotide primer for each strand of each different specific sequence, under hybridizing conditions such that for each strand of each different sequence to which an oligonucleotide primer is hybridized an extension product of each primer is synthesized which is complementary to each nucleic acid strand, wherein said primer or primers are selected so as to be sufficiently complementary to each strand of each specific sequence to hybridize therewith such that the extension product synthesized from one primer, when it is separated from its complement, can serve as a template for synthesis of the extension product of the other primer; (b) treating the sample under denaturing conditions to separate the primer extension products from their templates if the sequence or sequences to be detected are present; and (c) treating the sample with oligonucleotide primers such that a primer extension product is synthesized using each of the single strands produced in step (b) as a template, resulting in amplification of the specific nucleic acid sequence or sequences if present; (d) adding to the product of stop (c) a labeled oligonucleotide probe for each sequence being detected capable of hybridizing to said sequence or a mutation thereof; and (e) determining whether said hybridization has occurred.”

States) in the resource (pristine hot springs and their biota). This externality arose from the failure of park management to define and assert property rights in its wildlife and, specifically, its failure to assert its property right in collected samples of biota through its collection permit.

Identifying patents on biotechnological utilities from wildlife is *prima facie* evidence of an externality-produced market failure that is much broader than the Yellowstone thermophile–PCR case. A search for such patents is summarized below.

Reptiles and amphibians are well-known sources of biologically active venom compounds. Reviewing U.S. patents reveals numerous examples of intellectual property on biotechnological utilities from snakes and amphibians. A number of patents claim rights in purified “ajoene” (and its manufacture or use), a venom enzyme from the snake genus *Bothrops* (vipers). U.S. Patent 5,968,988 claims ajoene for shock treatment. Other patented uses of ajoene include contraceptive (U.S. Patent 5,863,954), antithrombotic (U.S. Patent 5,744,584); lupus diagnostics (U.S. Patent 5,705,198), and eye-disease treatment (U.S. Patent 3,869,548).

Novel cytotoxic polypeptides from the western diamondback rattlesnake (*Crotalus atrox*) are claimed in U.S. Patent 4,731,439 owned by Oncogen, Inc., of Seattle. A tumor treatment based on “crotoxin” obtained from the Cascavel (*Crotalus durissus terrificus*), a rattlesnake relative native to Bolivia, Paraguay, Uruguay, and Brazil, is the subject of U.S. Patent 5,164,196, owned by Ventech Research, Inc., of Cambridge, Massachusetts. A metalloproteinase pain treatment from the Mexican West Coast rattlesnake (*Crotalus basilicus basilicus*) is the basis of U.S. Patent 5,314,899, owned by the U.S. Department of Health and Human Services. A prothrombin-activator enzyme, useful for disease diagnosis and obtained from the Australian brown snake (*Pseudonaja textilis*), is claimed in U.S. Patent 5,922,587, owned by Pentapharm AG of Switzerland. A fibrinolase, useful in thrombosis treatment, obtained from the Southern copperhead snake (*Agkistrodon contortrix contortrix*), is the subject of U.S. Patent 5,260,60, owned by the University of Southern California. Similar thrombolytic materials and methods from *Agkistrodon contortrix contortrix* are the subject of U.S. Patent 5,951,981, owned by Diatide, Inc., of Londonderry, New Hampshire. *Agkistrodon contortrix contortrix* is an endangered species in Iowa and Massachusetts (Levell, 1995). A phospholipase isolated from the Mozambique red spitting cobra (*Naja mozzambica pullida*) is the subject of U.S. Patent No. 5,045,462.

It is not clear whether these patents have generated commercial activity or whether the "appropriate" owner, if any, of the biota asserted property rights in the wildlife specimen. However, it is reasonable to assume investigation will evidence the same disconnect as Yellowstone and PCR. A number of other reptilian biotechnological utilities can be found in the scientific literature requiring further investigation of the property situation. For example, Coelho et al. (1999) report the effect of disintegrin "jarustatin" from *Bothrops jararaca* on neutrophil migration and actin skeleton dynamics. Danem et al. (1998) report that a venom component from the leaf-nosed viper (*Eristocophis macmahoni*) may have anti-cancer properties. A patentable utility from wildlife need not be complex or technically esoteric. U.S. Patent 5,866,160, owned by Hainan Life-Nourishing Pharmacy, Co., of Hainan Province, People's Republic of China, claims a precise composition of whole, ground, and dried turtle and tortoise for use as a nutriceutical. Similarly, U.S. Patent No. 5,912,018 covers the treatment of certain human medical conditions using secretions of the Arabian Gulf catfish. U.S. Patent No. 4,677,069, owned by Cornell Research Foundation, claims the industrial use of enzymes from clams.

Magainin Pharmaceuticals owns patents on the antimicrobial "Locilex," a diabetic–foot-ulcer treatment based on pexiganan from *Xenopus* (frog) skin. *Xenopus* is a widely available laboratory animal and, essentially, *res nullius*.

A number of U.S. patents have been issued on compounds and methods obtained from spiders. For example, Patent 5,196,204, owned by the University of Utah, claims compounds and methods derived from *Agelenopsis aperta* venom.

An animal repellant obtained from firefly (*Photinus*) is claimed in U.S. Patent 4,490,360, owned by Duke University.

The discovery of novel combinatorial chemistry of bioactive compounds obtained from the squash beetle (*Epilachna varivestris*; Schroeder et al., 1998) is the subject of U.S. Patent No. 6,384,026, owned by Cornell Research Foundation.

Birds are also a source of biotechnological utilities. U.S. Patent No. 4,112,074 claims the use of the ovomucoid egg fraction of Japanese quail (*Coturnix coturnix japonica*) for treatment of allergy.

In many instances it is not clear whether a technical discovery from wildlife has produced patented or valuable personal property. Often, the report of such discovery is difficult to link to an issued or pending patent. For example, Harborne (1986) has described a number of potentially useful utilities from insects including repellants from ladybird beetles and pheromones from butterflies, moths, flies, lacewings, and weevils. Harborne also describes a further complexity: the chemical defense of poison-dart frogs (*dendrobatids*) appears to result from the frog's ingestion of ants (*Solenopsis*), which contain alkaloids that yield a toxic exudate of the frog's skin. No patent information is available on the report that antibacterial peptides have been found in the hemipteran insect, *Palomena prasina* (Chernysh and Cociancich, 1996), or that discodermolide, a compound from a marine organism, appears to have anti-cancer potential (ter Haare et al., 1996).

Marine organisms are a particularly rich source of biotechnological utilities. Eleutherobin, a recent cancer-drug candidate obtained from the coral *Eleutherobia*, is covered by a U.S. patent owned by the University of California and licensed to Bristol-Myers Squibb (Mlot, 1997). Mlot also relates a statement by D. Newman of the National Cancer Institute that the AIDS drug AZT was developed from a basic structure found in a marine sponge. Halopyrroles with antiviral and antibacterial properties are obtained from the Caribbean sponge (*Agelas coniferin*) and claimed in U.S. Patent 4,737,510, owned by the University of Illinois.

An example of the disconnect between wildlife property, intellectual property commercialization, and conservation is the discovery and exploitation of pseudopterosin from Caribbean soft corals. In the early 1980s researchers at Scripps Institute of Oceanography (University of California) legally collected blue sea whip (*Pseudo pterogurgia*) specimens in coastal waters of the Bahamas (Look, 1983). As in the Yellowstone case, the researchers complied with Bahamian regulations that provided negligible constraints on use of the collected specimens. Later, in the Scripps laboratories, the researchers discovered “pseudopterosins,” complex heterocyclic compounds that exhibit anti-inflammatory, anti-cell-proliferation, and pain-reduction properties in mammals. Subsequently, the University of California filed U.S. patent applications on pseudopterosins and their uses. Eventually, U.S. Patents 4,745,104 and 4,849,410 were issued with claims on pseudopterosin-derivative molecules and their use as an anti-inflammatory, analgesic, and pain reducer. These patents contain a general reference to gorgonians in the “West Indian region” but no reference to Bahamas or to anything that links the patented subject matter to the biota source. After filing the patent applications, the University of California licensed its intellectual property to several companies. These licenses did not include any Bahamian party, nor was there any obligation on the part of the University of California to share any control or benefits arising from the discovery of these compounds from wildlife collected in Bahamian waters.

These examples evidence a property-based market failure in the exploitation of biotechnological utilities of wildlife. In these examples, property rights in the wildlife are either unclear, unperfected, or not asserted.

6.10 Economic Valuation of Inventions from Wildlife

Economic valuation is essential to the political economy of natural resources (Ciriacy-Wantrup, 1968; Ciriacy-Wantrup and Bishop, 1975; Daily et al., 2000). Effective natural resource management requires such valuation, but such resources are difficult to value. The importance and technical challenge of resource valuation has led to a variety of approaches (Costanza, 1991; Daily et al., 2000). Valuing wildlife is a particularly difficult problem (Swanson and Barbier, 1992; Barbier, Burgess, and Folke, 1994). Analysts have tackled the problem of determining wildlife value, including non-monetizable or difficult-to-quantify values such as existence, aesthetics, or ecosystem service (Costanza and Daly, 1987). Inventions are a significant valuation problem, and inventions from wildlife are even more so.

Wildlife inventions are a direct use of wildlife, and determining the value of such existing inventions is difficult, but straightforward. However, this is not true of inventions that have not yet been discovered. Patent law exacerbates this problem, since only unpredictable discoveries are patentable. It is intuitively obvious that many such utilities are yet to be found.

A fundamental limitation in determining values of wildlife inventions is the high uncertainty of discovery of a valuable utility in a particular specimen or species. It is extremely difficult to predict *ex ante* the value of inventions yet to be discovered in a wildlife specimen. Analysts have tried various approaches to dealing with this uncertainty, with varied success. Some are based on the simple assumption that the invention-value potential of a species is obtained by multiplying the probability (based on past discoveries of inventions) that a species will yield a commercial product by the average *ex post* value of such a commercial product. Such estimates require broad assumptions that can produce wide-ranging results. Principe (1989) uses this method to determine that a wild plant species is worth $23.7 million, while Aylward (1993) calculates the figure to be $44 per plant species. These values are based on the assumption that all plant biotechnological utilities will be human medicinals. Artuso (1994) uses an *ex post* analysis of a pharmaceutical company's willingness-to-pay and the statistical probability of discovering a drug from a set of tested samples within a known testing template. Mendelsohn and Balick (1995) determine the potential value of higher plants to yield drugs by estimating a probability of discovery of a drug by *ex post* estimates of net drug revenue, yielding an aggregate value of $48 per hectare of tropical forest. This narrow focus on medicinals from plants is also used by Pearce (1990) to quantify the value of tropical rainforest. Pearce determines an aggregate value of billions of dollars based on consumers' willingness-to-pay to preserve this resource. Pearce and Puroshothamon (1992) set a value of $420 billion for potential drugs from plants in tropical forests, and Gentry (1993) suggests a $900 billion aggregate value for the same resource.

Although these analyses may be useful in establishing some basis for a limited determination of potential value of drugs from plants or other well-studied species, they are too narrow to be generally useful in determining a comprehensive and accurate value of wildlife inventions. The first problem is that although such inventions encompass medicinals, they are much broader in scope, including fundamental methods (e.g., the PCR) and materials (e.g., DNA sequence traits and promoters) and even inventions outside of the life-science domain (Hamilton, 2004). Beyond this initial limitation lie more serious, conceptual flaws. Simpson and Sedjo

(1996) and Simpson (1997) point out some of these, including the failure to account for scarcity, pre-planned discoveries, or redundancy of useful discoveries. These authors describe such flaws in their earlier analyses and prescriptions to correct them. Despite their efforts to improve valuation, their own approaches are deeply flawed.

Simpson (1997), Simpson and Sedjo (1996), and Polasky and Solow (1995) conduct sophisticated statistical analyses of a process of identifying a drug candidate in a set of untested samples in a pre-planned screening protocol. They conclude that the willingness-to-pay value of a "marginal species" to a pharmaceutical researcher in their contrived drug discovery process is low. Simpson and Sedjo (1996) use a simple demand function for biological samples in pharmaceutical screening. They calculate a maximum possible value of any species at less than $10,000 based on an *ex post* evaluation of a pharmaceutical researcher's willingness-to-pay for a marginal species' contribution to a set of samples and on the sensitivity of the value of that species to an *ex post* probability of discovery with assumptions of drug discovery and value probability. This narrow approach leads Simpson and Wildavsky (1996) to conclude that the discovery of a drug product from wildlife is either so common in species as to be redundant or so rare as to make discovery unlikely.

These analyses are mathematically sophisticated statistical constructs. However, their conceptual framework is too limited for general application to valuation of the wildlife invention problem, given its tremendous technical breadth and the serendipitous path of discovery embodied in the patentability criteria of absolute novelty and nonobviousness. The models of Simpson and his colleagues do not account for the functional breadth of invention and rely on a ludicrously simple "litmus" model for discovery that is practically useless in evaluating the potential for discovery of unexpected inventions such as PCR.

Most important, Simpson and Wildavsky (1996) significantly overstate the applicability of their conclusions beyond the framework of their analysis. While they concede their model is narrow, they proceed to state the broad general value of biodiversity based on that narrow model. The danger of such broad generalizations may be the acceptance of such conclusions by others who will miss the narrow and simplistic conceptual basis of this analysis, further promulgating improper conclusions of biodiversity value. For example, Garrod and Willis (1999) parrot the conclusions of Simpson and Wildavsky (1996) without acknowledging any conceptual limits of the work that would temper even their narrow conclusions. The detailed critique of Simpson's work presented below is useful at this point.

Simpson's tenuous linkage of a narrow analytical base to the broad conclusions made can be seen in several examples. Simpson and Craft (1996) ask, "what is the value of preserving biodiversity?" and then proceed to limit their focus to the discovery of a commercial drug by a pharmaceutical firm. They refer to this conceptual limitation when they comment on the importance of saving yet-unknown species or obtaining genetic insurance against as-yet unidentified disease.

This analysis ignores the great complexity and variety of wildlife inventions that already include methods and materials found in wildlife. This ignorance of the practically limitless breadth of inventive methods and materials, and of the multitude of uses of wildlife invention, is evident in Simpson's constant focus: "chemical compounds produced by wild organisms" and a "commercially valuable substance" (Simpson and Wildavsky, 1996). This narrow focus ignores the discovery of a variety of enabling technologies that provide a platform for many products.

Simpson and Wildavsky (1996) argue that a "valuable substance" of a species is redundant. While such redundancy may be true for some discoveries (e.g., ubiquitous, conserved genes or common metabolites) in a broad range of taxa, it may be very wrong for others (e.g., flavor variety within a single species of wine grape, coffee varieties, or specific cheese-producing bacteria).

Simpson's model is based on a "need for a new product" that ignores innovation and invention. It is also based on "testing for a particular application," which ignores the real biological discovery process in which observation of experimental phenomena leads to insight, discovery, and invention. Simpson and Wildavsky (1996) generally rely on an *ex post* prediction of probability of discovery and value. Their conceptual blinders are obvious when they state their belief that one does not find something unless one is looking for it, a most telling statement that sums up their lack of knowledge of the discovery process and its significance in the value of wildlife. Their models are based on a simplistic process in which a known drug target is screened for, and when a "hit" is discovered, testing stops. Real discovery of biotechnological invention is much less systematic. In fact, in order to be patentable, an invention must be novel and unanticipated. Simpson's frequent use of the term "testing" belies a simplistic view of looking for a "substance" in some binary "litmus test," rather than the complex process of research, which follows serendipitous leads through unintended and multi-branched paths. Burke (1978, 1996) describes a more realistic perspective of technical discovery as a web of unintended connections in a "pinball effect." Simpson's model does not account for the process of inventing biotechnological inventions from wildlife. Using the Simpson model of "testing" for a discovery, the PCR would still lie undiscovered.

Simpson assumes that when a "substance" is found in a "test" of a collection, the process stops and the collection is discarded. *Au contraire*, the discovery of a drug lead is more likely to incentivize further research. Researchers continue to investigate a species after a discovery has been made and are often more motivated to look for other discoveries in such a biological "hot spot."

Simpson and Wildavsky (1996) also make numerous erroneous technical assumptions. They state that "genetic recipes" for "valuable chemicals" in wildlife can be exploited by "gene transplantation." Although this statement is in theory true, drugs are typically complex molecules made by the coordinated expression of multiple genes scattered across chromosomes and are not, at present, technically amenable to such "transplantation."

The simple Simpson model is also based on the assumption that every species is equally probable of yielding the commercial product for which it is being "tested." This assumption ignores the fact that species are heterogenous in harboring certain functions. For example, venomous spiders and snakes have a higher probability of yielding a cytoactive compound than do doves or butterflies. It is well known that certain families of plants (e.g., *Solanaceae*, *Apiaceae*), fungi (e.g., *Streptomycetes*), frogs (e.g., *Bufo*, dendrobatids), insects (e.g., ants, wasps, beetles), fish (e.g., puffers), coelenterates, and others exhibit a propensity for containing biologically active compounds.

Simpson and Wildavsky (1996) state that "genetic resources" are non-rival goods and then proceed to confuse intellectual- and personal-property rights in biological matter. Intellectual property is non-rival, whereas the DNA of a species is rival, especially considering restrictions on access to or possession and use of public specimens by government and of private specimens by private-rights holders or as a result of physical scarcity.

Simpson and Wildavsky (1996) postulate that species' redundancy results from geographical dispersion and the superfluity of specimens in excess of those needed for species viability. They also argue for drug redundancy, in which competing drugs will be available for the same condition. Such redundancy and value are atomistic, unecological, and reminiscent of hunters taking buffalo for their tongues (Hanner, 1981). Simpson's focus on "potential products" ignores the importance of biotechnological services. For example, calculating the economic value of PCR must include the services based on this method, including forensics, diagnostics, and research tools. Simpson and Wildavsky (1996) greatly overstate their findings when they claim that a marginal species' value in new product research is low. They neglect to reveal that their conclusion is derived from a simplistic chemical-screening model. Their assertion that the significant question is the value of the marginal species, rather than total value, may be supported by their narrowly construed statistical framework, but does not follow from the more complex real situation.

Simpson's narrowly construed view of the biotechnological value of wildlife is only one of many components of a comprehensive value equation. The Simpson models are devoid of any sense that species may, in some cases, have value only in their habitat or in connection with other species. They pay lip service to other species' values but do none of the intellectually demanding work necessary to tackle this problem. Their simple one species–one drug model is inadequate for complex situations such as the frog exudate that apparently depends on ingested ants (Harborne, 1986). The Simpson view can be summarized by this simplistic protocol: Biota is a collection of equal units; systematically screen the units for a known function, find the unit that yields the function, and you are done with the collection and the process.

Simpson and Wildavsky (1996) rhetorically ask why firms are not rushing to invest in biodiversity searching and then argue that this justifies their position. However, their position also emphasizes their myopic economic analysis. For-profit companies utilize a short time frame of profitability and usually limit their vision to exclude activities that are not profitable within this time frame. But this short-term view is not easily compatible with biotechnological discovery. Discovery of the PCR required over one hundred years of resource investment (maintaining Yellowstone

Park) before "profitability" was remotely possible. History is replete with accounts of many years of investment (often contrary to a profit-taking mentality) before commercial success was realized. It took more than two decades from the invention of xerography before the first sale of a copy machine (Mort, 1989). Similarly, it took many decades from the discovery of germanium before its economic value was made significant by semiconductor technology. Simpson's statement that lack of investment by for-profit firms means biodiversity has low value is short-sighted and woefully incomplete. Simpson's (1997) arguments are largely based on the wildlife redundancy argument, stating that

> losses in biological diversity may have little bearing on whether the next miracle drug is found. That's because there are so many wild plants and animals that can be used by researchers engaged in biodiversity prospecting. With millions and millions of species, sources of useful products are either so common as to be redundant or so rare as to make discovery unlikely. Either way, the sheer numbers involved weaken the argument that biodiversity prospecting generates any appreciable economic value. (p. 12)

There are many examples of unique biotechnologies that demonstrate the weakness of Simpson's argument. Although there are other palliatives, there is no replacement for morphine. Despite the many antibiotics developed, vancomycin is the only drug that kills drug-resistant bacteria. There are no substitutes for spices like saffron, nutmeg, and pepper. Only *Apis mellifera* produces honey in an economically useful way. There is only one aspirin (*acetylsalicylic acid*). There is only one "Empire" apple. Orange juice can only be made from oranges. Only *Mentha piperita* can produce natural peppermint. The Monarch butterfly is the only insect that displays precise transnational migrations of huge length. Only Merino sheep produce Merino wool. Nothing tastes like abalone. Despite years of effort, plant breeders have never created a true black tulip. Nothing grows taller than a redwood. The Komodo dragon is the largest lizard. Only *Yersinia* causes bubonic plague, and Mycobacterium, tuberculosis. In short, Simpson's redundancy argument is contrary to the definition of biodiversity. Politically, the philosophical basis of the law of the land is entirely contrary to such redundancy. The Endangered Species Act acknowledges that species are not redundant, that the loss of a species is irreversible and potentially so catastrophic that government must act to preserve such species' existence. Simpson is hoisted by his own petard with his example of tea and coffee as being redundant for caffeine. He fails to notice that tea and coffee are economically different and that it is the unique beverage that is valuable, not the caffeine. A logical extension of the redundancy argument weakens the justification for saving any species.

6.10.1 A Broader Conceptual Basis of Analyses

Freeman (1986) writes that it is difficult for neoclassical economics to accommodate the high uncertainty of creating a biological invention, simply because it is very difficult to value something that does not yet exist, and notes that species extinction is an irreversible loss of such potential. Nonetheless, some have attempted to estimate a value for biota based on undiscovered biotechnological inventions.

Brown and Goldstein (1984) have developed a valuation model that requires an *a priori* estimate of the probability of discovering valuable products in a species but acknowledge the difficulty of determining such probability *ex ante*. Ciracy-Wantrup (1968) and Bishop (1978) also acknowledge the importance of establishing an economic value of a species that includes potential for future discoveries, the difficulty in establishing that value *ex ante,* and describe a SMS economic policy approach. This skirts the issue of affixing a monetized value to a species and instead uses a decision rule that holds that a SMS of a species population be maintained unless the social cost of doing so is "unacceptably large." Bishop (1978) points out the difficulty of defining "unacceptably large," particularly given the irreversible loss of potential biotechnological inventions (and other values) of a species, high scientific uncertainty, and intergenerational equity.

Montgomery et al. (1999) approach species valuation by developing a model for the “management price” of increments in habitat that contribute to a population size. Their model incorporates a term for “index of diversity,” which represents the value of benefits consumers associate with biodiversity. Their model also utilizes “diversity weights” from phylogenetic data as an indicator of genetic scarcity. While they utilize a value based on consumers’ perceptions of biodiversity value, they acknowledge that contingent valuation is based on an elusive, credible quantitative measure of marginal willingness-to-pay on the part of consumers. Their model ultimately links the value of biodiversity to land value. Using their model, the value of biodiversity in Monroe County, Pennsylvania, is $60 million per resident, or a one-time payment of $600 million in 2020, or $16 million per resident now.

6.10.2 The Conceptual Limits and Future Needs of Valuation

The above analyses value each species as an independent economic unit. This is contrary to ecological structures in which species are integral parts of a biome. Leopoldism (the idea that any species must be valued in its ecological context) is difficult to reconcile with atomistic species-valuation approaches. A particularly serious limitation of existing valuation models is the reliance on a static domain of value and a bias in *ex post* analysis. Relying on this type of value and bias ignores technological and sociological change.

Daily and her colleagues (2000) point out the importance and difficulty of valuing natural resource systems and the limitations of prevalent economic models, especially their failure to encompass future costs and benefits. More comprehensive analyses are needed to produce estimates of value, especially those that include the value of existing and potential biotechnological inventions from wildlife. New theoretical frameworks that encompass the uncertainty of unpredictable invention, the uniqueness of species, and the irretrievable loss of their extinction are necessary.

However, some question whether the value of a species can be monetized (Norton, 1991). Norton believes that economists are very far from having, even for one well-known species, a complete accounting of all its present and future values. He criticizes reductionist economic analyses for ignoring the interdependence of species (e.g., destroying one species may destroy several; the biotechnological value of one species is dependent on another) and concludes that aggregation and the reductionistic language of economics is ill-suited to values so complex as those environmentalists pursue in protecting biodiversity.

6.11 The Political Economy of Biotechnological Inventions from Wildlife

The political economy of biotechnological inventions from wildlife is defined by the governing property regime and the economics of the biotechnological invention. The property regime of the biotechnological invention is linked to the property milieu of the particular wildlife taxon.

The federal government asserts control over the access, possession, use, and disposition of all specimens of species explicitly listed under federal laws. Those assertions extend to the corpus of these specimens and their parts. In some instances, governmental control is not asserted over all parts of the corpus (e.g., tissues taken from birds legally collected under the Migratory Bird Treaty Act). Existing federal laws and regulations do not explicitly assert the government’s rights in biotechnological inventions when they are in the form of intellectual property.

States assert rights in some wildlife within their borders that is not covered by federal law. These laws variously assert the state’s rights in the specimens of the species and their parts. State laws and regulations variously assert the state’s control over the possession and use of the specimen’s corpus and parts. Specimens that are controlled by the state belong to the state as long as they are free-roaming. Upon legal capture under state law, the corpus becomes the property of either the state, or the individual, or a mixture of both. Some states do not assert rights over many species of wildlife, such as arthropods,[8] protozoans, and microbes. States often assert rights over certain tangible biotechnological inventions but, as with federal law, this assertion does not extend to intellectual property. A review of state laws (Musgrave and Stein, 1993) reveals widespread use of hunting and fishing laws to regulate the taking, possession, and disposition of wildlife specimens. However, as with federal wildlife law, these laws do not explicitly regulate the conversion of the biotechnological inventions from wildlife into private property. A wild bear in New York exemplifies this situation.

Under New York State law, a free-roaming bear is state property. A bear hunter may obtain a hunting license from the state to legally kill (but not capture) the bear. The carcass becomes the property of the individual but the state retains some control over use of the carcass (i.e., the meat may not be sold). This includes tangible biotechnological utilities from the meat. Tangible biotechnological inventions from other parts of the bear and any intangible biotechnological inventions from any bear part are personal property, without obligation to the state of New York.

In the case of *res nullius* species such as most arthropods, the government has no rights in any specimens, or their parts, or any tangible or intangible biotechnological invention derived from them.

Private property in the biotechnological invention from wildlife can be perfected through first occupancy for any public specimen and through regulated taking of any *res publicae* specimen. In most cases, regulated taking is low-cost: a state fishing license, for example. In a few cases, regulated taking entails significant

[8] New York places some controls on stream insects.

cost or regulatory hurdles, as in a scientific-use permit for the possession of endangered species. However, the existence of patents on wildlife inventions demonstrates that existing governmental control of the tangible biota corpus allows private property in biotechnological inventions as intellectual property.

Biotechnological invention from wildlife has already generated significant value and will generate more in the future. The existence of such valuable inventions from wildlife prompts serious questions. Is the existing property regime for wildlife invention optimal? If so, optimal for which goals? Is the commercial exploitation and private gain obtained from these inventions optimal from a political and economic perspective? Is resource sustainability optimized in this situation? How should the rights in biotechnological utility of wildlife be allocated across the continuum of *res nullius*, private, public, and *res communes*? How is this allocation affected by efficiency, social equity, and ecological integrity factors?

These questions are made critical by the widespread decline of biodiversity (Reid, 1993b; Meffe and Carrol, 1997; Wilson, 1997), the rapid rise of biotechnologically generated value of wildlife, and the ambiguous or lacking governmental control of rights in wildlife inventions. Exacerbating this situation is the orthogonality of the bodies of intellectual property and wildlife conservation law. Right or wrong, there is no comprehensive and coherent national or state policy to allocate property rights in or to manage inventions from wildlife for the sustainable use of biodiversity. This policy void, lack of governmental control, and the market failure create a significant public-policy problem. This problem is exacerbated by the failure of government to carry out its *parens patriae* trustee responsibility to manage the public's wildlife resource. The following federal and state laws exemplify governmental failure to manage the wildlife biotechnological utility as a *res publicae* resource instead of a *res nullius* free-for-all.

The Endangered Species Act may be the most effective federal law controlling access to and possession and use of wildlife. However, its exceptions allow for possession, and once wildlife specimens are possessed, there is no explicit control over the creation of intellectual property from such legally possessed specimens, nor are there any apparent governmental rights in the commercialization of such intellectual property obtained from protected species, even if possession was illegal. The federal Migratory Bird Treaty Act controls the commercial exploitation of listed species. However, like the Endangered Species Act, the law does not explicitly control the use of protected specimens for discovery of biotechnological utility. Collection of tissue samples (e.g., blood) from temporarily possessed specimens is allowed with banding permits, allowing an individual to have unfettered access to the genome of otherwise federally protected birds in the United States. The other federal wildlife laws, including the Lacey Act, the Marine Mammals Protection Act, the Eagle Protection Act, the Wild Horse and Burro Act, and the Magnuson Fisheries Act, similarly fail to restrict private entities from creating *res privatae* intellectual property from *res publicae* wildlife.

The Lacey Act emphasizes this legal and policy void. Under Lacey, it is a federal crime to enter into interstate commerce any wildlife specimen, or part thereof, that has been obtained contrary to state law. While otherwise effective, this fails to control creation of *res privatae* intellectual property because it requires the entering of the specimen (or a part) *per se* into commerce. To obtain a patent, only information need be entered into commerce. With a patent application, one submits information (e.g., the DNA sequence of a gene), not the actual biological matter of the protected specimen.

One may violate one or more state laws to illegally possess a specimen of wildlife and then, upon discovering a patentable biotechnological utility from that specimen, submit a patent application to the U.S. Patent and Trademark Office. In so doing, the possessor of the illegally held material may own a valid U.S. patent on subject matter from that material.

Recent economic analyses of wildlife have relied on a property-right and transaction-cost framework (Demsetz, 1967; Williamson, 1985; Barzel, 1989). Lueck (1995, 1998) points out that perfecting property rights in wildlife is difficult and costly and that *res nullius* dissipates wealth and value. Also, the transience of wildlife and the patchwork pattern of land ownership present a difficult contracting problem among owners of real property. And, in general, wildlife is also typically valued less than other land-use purposes. Therefore, landowners normally lack incentives to maintain wildlife populations at a biological optimum. Incentive to assert rights in wildlife depends on the value of a viable stock less contracting costs among property owners that harbor the stock (Lueck, 1995). When contracting cost exceeds value, *res nullius* dominates, creating conditions for a commons tragedy. Under such conditions, if the resource is scarce, the typical political solution is to impose public rights, averting contracting problems but potentially conflicting with private-landowner decisions. This situation is particularly evident in the Endangered Species Act. Lueck (1995) points out that wildlife law has been largely formed by the belief that market forces should be curtailed and access regulated but that such laws generally reflect a market value and cost of the stock. For example, pelt values are reflected in trapping laws. Although trade restrictions are often considered a limit on wealth creation, Lueck (1995) sees such restrictions on wildlife as necessary to control *res nullius* and to increase its value.

The *res nullius* character of some wildlife species has created the conditions for a TOC (Hardin, 1977). Recommendations for correcting the tragedy range from the imposition of strong public-rights prohibition of market forces (Lund, 1980) to strengthened private, market incentives (Anderson, 1998). Lueck (1998) concludes that the existing wildlife-property mix is largely without economic logic and is too complex for application of simple property-rights economics. But, nonetheless, wildlife has large economic value, and institutions can be designed to capture such value.

These analyses do not explicitly address biotechnological invention in wildlife. Does a TOC exist for this resource?

6.12 A Tragedy of the Commons in Biotechnological Inventions from Wildlife?

6.12.1 A Commons Versus a *Res nullius* Resource

As originally defined by Lloyd in 1833 (Hardin, 1977) and by Gordon (1954) and Hardin (1968), a "tragedy of the commons" (Sage Action, Inc. TOC) can occur when an unowned and scarce natural resource is freely accessible to all and its use by one individual diminishes the resource for others. There are three criteria for a TOC in a natural resource: scarcity, rivalry, and a *res nullius* regime. A TOC resource is valuable only on capture, and there is no incentive for an individual to consider the needs of others or the long-term, sustainable use of the resource. The aggregate acts of individuals' capture causes resource degradation.

Many resource economists embrace the TOC concept and its property roots (Ciriacy-Wantrup and Bishop, 1975; Neher, 1990; Ostrom, 1990; Tisdell, 1991). However, there is terminology confusion in the literature. This confusion arises because the term "commons" is used in two very different ways: to describe both *res nullius* and *res communes* regimes. *Res nullius* lacks any property rights, while *res communes* regimes are characterized by private property held by a group.

This confusion of terms is evidenced by Tisdell (1991), who defines "common property" as a resource "to which all have free access." He terms this "common access," a resource in which individuals gain no property rights (and no value) from conserving the resource. Neher (1990) describes the fishery in his analysis of *res nullius* regimes, which he calls "common property." Neher espouses the TOC concept, stating that "open access, rule-of-capture" resources dissipate rents and lead to stock degradation, but he defines *res nullius* as "common property."

Despite the confusing terminology, there is general agreement by resource economists that property rights in a natural resource are directly linked to the use or misuse of that resource. Randall (1987) articulates a microeconomic basis for the TOC and states that ownership is a necessary precondition for trade. The TOC is a tragedy of inexorable events driven by human nature that lead naturally to destruction of the resource. It is practically inevitable that when no entity has rights to control access, possession, or use, all have unfettered access to possess and use; the resource is scarce, and valuable, and rivalrous.

Ostrom (1990) describes examples of a TOC in "common pool resources," with a *res nullius* cause. These include the 1970s Sahelian famine, the firewood crises in many developing countries, acid rain in the Adirondacks, and urban crime in the United States. Ostrom explains the TOC in terms of the "free-rider" problem: since an entity cannot be excluded from the benefits that others provide, each entity is motivated not to contribute to the joint effort but to free-ride on the efforts of others.

A true commons, *res communes*, is defined by the common control of possession and use. It is not *res nullius*. *Res communes* ownership and control is vastly different from the null-ownership of *res nullius*. A more precise use of terms and definition is needed. The tragedy of the "commons," "common property," "common resource," or "common pool resource" is more precisely termed the "tragedy of a scarce, rivalrous *res nullius* resource."

Bromley (1991) clearly articulates the important distinction between *res nullius* and *res communes* and the impact of those distinctions on the political, economic, and ecological fate of a natural resource. Several analysts have described the utility of *res communes* in sustainable, equitable use and protection of public goods (Ostrom, 1990; Ostrom and Schlager, 1996).

A *res communes* regime is characterized by the definition and use of property rights by a defined group. Entry into the group must be controlled, and communally accepted rules must control the access, capture, possession, and disposition (Ostrom, 1990; Bromley, 1991) of property. Ciriacy-Wantrup (1952) and Ciriacy-Wantrup and Bishop (1975) define *res communes* as “common property,” a distribution of rights in resources to which access is restricted to a group of defined “owners” that are co-equal in their rights of access and whose rights are not lost by non-use. They make it clear that *res communes* does not mean that co-owners are necessarily equal in the quantities of the resource they individually acquire. They draw an analogy between the tradition of “stinting” the commons (i.e., grazing quotas) and modern fishery quotas. Waldron (1990) defines *res communes* as “common property” in which a resource is, in principle, available to every member of a community that is limited by barriers to entry and governed by rules of membership. This requires an institution that defines community structure, governs with rules for equitable common-property access and disposition, and considers the needs of every community member when allocative decisions are made. Caldwell and Shrader-Frechette (1993) make a clear distinction between a “commons” and a *res nullius* resource and describe how *res communes* resources have often been well managed, particularly by pastoral and less industrialized cultures.

Lafargue (1894) describes the social evolution of property from types of *res communes* of tribal societies including non-family-centered primitive communism, consanguinal collectivism (family-centered communal property), feudal property (landed gentry, landless peasants with access to a common woods and pasture) and, finally, bourgeois property. Laveleye (1878) describes in detail the *res communes* of cultures ranging from the consanguinal collectives of Italian family alliances, early Celtic agrarian systems, Swiss allmends, and communities in Java, India, Russia, and Greece. Ciriacy-Wantrup and Bishop (1975) acknowledge the capability of less industrialized cultures to successfully manage common resources and observes that the true tragedy of the commons was the feudal transformation of peasants from co-equal owners of the commons to landless workers of the lord's estate. Laveleye (1878) posits that under feudalism, peasants were given a measure of group ownership of the commons in concert with the lord and that it was bourgeois mercantilism that destroyed the commons by carving it into private, alienable parcels. Berkes (1989) also provides several examples of *res communes* regimes for effectively sustainable and equitable management of common natural resources.

Ciriacy-Wantrup (1952) describes governmental intervention to remedy the tragedy of *res nullius*, such as control of the individual's right of capture in the Taylor Grazing Act, and makes a case for *res communes* rather than public-property solutions to resource allocation, giving examples of successful *res communes* systems including high alpine grazing areas in Switzerland (the "allmend"), Germany, and Austria, and riparian use in Anglo-Saxon and German land law. Ciriacy-Wantrup and Bishop (1975) view the political choice between private *res nullius*, private, or public property as simplistic and ignorant of *res communes*. They believe that common property and its implied institutional mechanisms is effective at managing natural resources in a market economy. According to Ciriacy-Wantrup and Bishop, *res communes* systems require institutional rules that include resource boundaries (geographic or biotic) and community governance that articulates membership entry, obligations, privileges, and regulations. Ostrom (1990) also criticizes those who provide only two choices to rectify the tragedy of a scarce *res nullius*: "Leviathan" (i.e., authoritative governmental coercion), or private ownership within a free market. She describes difficulties with Leviathan, including government's difficulty in determining resource capacity, unambiguously assigning rights, monitoring user actions, and certain punishment for non-compliance. She also points out that limitations of private property include the difficulty of developing cost-effective means of defining and asserting ownership. For Ostrom, *res communes* regimes can solve many *res nullius* resource tragedies if effective governance can be developed. She analyzes management of scarce, non-renewable resources in relatively small-scale *res communes* systems (i.e., 50–15,000 users) and presents general guidelines for structuring *res communes* institutions. Such institutions must implement rules to prohibit free-riders, define member commitment, and monitor compliance. Ostrom describes several *res communes* "design principles": clearly defined resource boundaries and rules defining who has access and use rights, congruence between appropriation and provision rules and local conditions, collective choice arrangements (i.e., participants freely participate in rule making or changing), monitoring for rule compliance, graduated sanctions (i.e., punishment fits the crime), conflict resolution mechanisms, and a recognition of the right to organize.

6.12.2 A Tragedy of the Commons in Biotechnological Inventions from Wildlife?

A TOC can occur in scarce and rivalrous, *res nullius* resources. So, a TOC in biotechnological inventions from wildlife depends on the physical nature and property milieu of the wildlife. The issue is the extent of *res nullius* in wildlife and inventions from wildlife. Any wildlife that is *res nullius* "contains" potential inventions that are also *res nullius*. And, because the private-property rights of a patent are given to the first to "capture" the invention, such wildlife and their inventions are susceptible to a TOC.

Public-property regimes are established to mitigate the problems of *res nullius* resources. Is it, therefore, safe to assume that inventions in public wildlife are safe from a TOC?

To answer that question, let us examine the public-property regime more closely. First, public-property rights are not homogenous. It has been pointed out that public property exists as a range of types and levels of governmental control (Clawson, 1983; Klyza, 1996). For example, the extent and type of control over Bureau of Land Management lands is very different from that over national parks. Control over national forest land is different from that over Department of Defense properties. Also, public accessibility to public property varies greatly. For example, nuclear weapons facilities and national forests are both public properties, but the public's right to access and use them is vastly different. How does this relate to public wildlife?

Some wildlife is public, but governmental control of it is limited, such that specimens or parts may be readily converted to private property. Under many state and federal governmental regulations, individuals can legally possess and, to varying degrees, control the use of a public specimen. Many states' laws permit the taking and possession of game animals, but the extent of governmental control of the possessed specimen or its parts ranges from none to very strict. For example, state laws typically prohibit sales of game carcasses or parts but allow personal use, including research. The Federal Endangered Species Act tightly controls the possession and use of a specimen and its parts but does not control the acquisition of intellectual property obtained from such specimens.

A review of state wildlife laws (Musgrave and Stein, 1993) reveals widespread lack of control of the use of specimens for obtaining tangible and intangible inventions. Thus, at the instant the public wildlife specimen is legally possessed, the physical specimen *per se* is private for the purpose of creating an invention. By extension, a tangible invention is also unfettered private property unless the law constrains the use of specimen parts. However, and most important, intangible inventions will almost certainly be unfettered private property.

Possessing a private specimen of public wildlife does not give the possessor inherent rights in free-roaming specimens of the taxon or in any inventions from that species except intangibles obtained by the specimen-holder through intellectual-property law or personal-property contract. Since the reach of government is limited, the store of potential inventions yet to be found in other specimens of the taxon remains *res nullius*. So, where wildlife is public for free-roaming specimens, but governmental control does not extend to tangible or intangible invention, there is a TOC of the inventions nested within a non-TOC wildlife form. Potential inventions in *res nullius* wildlife are *res nullius*. Since state and federal laws do not limit the ownership or use rights in intangible inventions and weakly limit such property and use in some wildlife, the potential pool of invention in wildlife is largely *res nullius*.

What about scarcity of wildlife inventions, another criteria for a TOC? Without scarcity, there is no TOC (Randall, 1987). Street pebbles are *res nullius*. But, because pebbles have no value and are abundant, there is no scarcity. Historically, scarcity of wildlife (particularly game, fish, and "useful" animals) motivated the gradual enactment of federal and state laws (Bean and Rowland, 1997). Species with value as sources of food, clothing, or sport developed scarcity, and wildlife control laws followed (Lund, 1980; Tober, 1981).

Many wildlife species have had no direct or apparent value to humans and have not, therefore, been economically scarce. Most arthropods, for example, are not considered scarce. But the development of biotechnological invention through technology can change this character. The PCR invention and potentially useful discoveries in ants (Attygalle et al., 1998), beetles (Borman, 1998), and flies (Steyn and van Heerden, 1998) suggest technology-mediated shifts in scarcity of certain wildlife.

Where free-roaming wildlife species are *res nullius* and become valuable through biotechnology, a TOC situation is possible. Where such a public species becomes valuable and the government controls possession, but not invention, a TOC is also possible. This latter situation may largely depend on the political will to eliminate the *res nullius* character of the biotechnological invention from the public wildlife though a modification of the law.

Finally, to what extent are biotechnological inventions from wildlife rivalrous? Wildlife specimens, or their parts, are all effectively rivalrous depending on their abundance. For example, blue whales are more rivalrous than are white-tailed deer, and gnats are effectively non-rivalrous. Rivalry can shift as a function of population dynamics, including the factor of human capability for harvest. Tangible biotechnological inventions will, at one level, be as rivalrous as their source organisms. However, some biotechnological inventions are reproducible. For example, a culturable cell line can be grown and reproduced *in vitro*. So, one can imagine such reproducibility mitigating rivalry. What about the patented information obtained from wildlife? Is it rivalrous? While tangible inventions are essentially rivalrous, information is not. However, a patent prohibits others from using that information for a limited period and is, therefore, institutionally rivalrous for that period. However, the patent information is public domain and is, for the purpose of educating others, not rivalrous. This public information may be used freely by others to develop their own intellectual property.

In summary, there are likely to be TOC situations in wildlife inventions that will hinge on the status of federal and state law as they control the rights to possess and use for the purpose of inventions and on technological advancements as they affect value and scarcity.

6.12.3 Efficient Property-Rights Regimes in Inventions from Wildlife

Since economic efficiency is non-unique (Randall, 1987), various property regimes can satisfy any particular efficiency perspective. The view that efficiency requires non-attenuated, private-property rights (Stroup and Baden, 1983) does not explain the situation fully. The simple view that there are only three natural-resource property choices—*res nullius*, public, or private—is incomplete (Randall, 1987). There are a variety of possible intermediate property-regime "mixtures." It is not difficult to envision a natural resource that exists in a blend of private, *res nullius*, public, and *res communes* in a complex web of interdigitated rights. Given the potential permutations of property-right mixtures, it seems that a reasonable number of them could approach efficiency. The question then becomes, Whose efficiency should take precedence: that of corporate shareholders, entrepreneurs, taxpayers, landowners, future generations, or conservationists?

There is general agreement by political economists that a TOC in a resource is a social bad and that it is caused, in large part, by a *res nullius* regime. However, there is significant disagreement over how to configure an optimal property regime for a scarce natural resource. Stroup and Baden (1983) and Hill and Meiners (1998) argue strongly for private and against public constructs as solutions to natural resource problems. These authors view the market as a preferred process for establishing the socially optimum condition of economic efficiency and articulate the central role *res privatae* plays in that process. They disparage public approaches as inefficient, often corrupt, or controlled by special interests. Others argue that public control is mischaracterized by free-market advocates. Lehman (1995) refutes the argument that *res publicae* is worse for the management of a natural resource that is a public good. Klyza (1996) describes the complexity and variety of *res publicae* in his analysis.

6.13 Public-Policy Considerations

6.13.1 The Problem

Inventions from wildlife present a potent mix of policy factors: the growing value of biotechnological invention, the ongoing decline of biodiversity, market externalities of wildlife value and conservation, an inadequate legal framework, and governmental inexperience with these issues. A serious public-policy issue is created as inventions from *res nullius* and public wildlife are converted to valuable private property while biodiversity declines. The lack of a comprehensive national policy for managing inventions from the nation's wildlife is made urgently problematic by the widespread and accelerating loss of biodiversity and the simultaneous rapid advancement of biotechnologies.

Evidence indicates an externality-based market failure or "missing market" (Neher, 1990) in wildlife inventions. When markets fail and the resulting lack of conservation has adverse income-distribution consequences, government is compelled to intervene (Tisdell, 1991). Existing markets undervalue the uncertain future inventions from wildlife (Barbier, 1992). The cost to future generations of biodiversity loss receives little weight in neoclassical economic evaluations (OECD, 1997).

The value of biodiversity must increase to effect sustainable conservation (Swanson and Barbier, 1992), and this requires new incentives and instruments that rely on more fully specified property rights (OECD, 1997). But who should hold such rights, and how they should they be used, presents a significant question. Some suggest governmentally regulated trade in wildlife goods. For example, Swanson (1994) argues that banning trade in ivory is counterproductive to sustainable conservation of elephants. Tierney (2000) describes examples of sustainable resource use through property mechanisms.

Using a policy-process definition of Jones (1984), the policy problem of wildlife inventions is in the earliest stage: problem definition. A policy vacuum exists at both the federal and state levels, and the literature suggests that governmental agencies are unaware of the problem. Congress and the executive branch have also been uninvolved, with the exception of some dialogue on the Biodiversity Convention (Congressional Reporter, 1993). The PCR from Yellowstone's thermophiles exemplifies federal inexperience (Milstein, 1994a,b). Although Yellowstone National Park has developed a case-specific handling of the biotechnological-utility issue (Varley and Scott, 1998), there is no evidence that this is widespread in the Park Service or the Department of the Interior. At the state level, managers in New York's Department of Environmental Conservation have no experience with the issue.[9]

6.13.2 Stakeholders and Actors

The following stakeholders and actors play a role in the disposition of property rights in inventions from wildlife.

The federal government: As the ultimate guardian of the public trust in wildlife, particularly biota that range across state borders, the federal government has a responsibility to deal with this policy question at least where it concerns wildlife covered by federal law. Through a legal void, the federal government is allowing private interests to take unregulated advantage of the public resource of inventions from wildlife while the resource suffers for lack of protection. It is conceivable that under certain policy alternatives, public coffers could gain revenue from certain types of controlled commercial use of wildlife invention, similar, for example, to the

[9] Managers in New York's Dept of Environmental Conservation, responsible for implementing ECL90, the law governing state biota, personal communication with author, 1999.

licensing of broadcast frequencies or to royalties on mineral extraction. Any comprehensive, national policy must involve the federal government.

State governments: States have control over all public wildlife except those few species explicitly covered by federal law. States are in the best position to assert public control over *res nullius* wildlife. They could establish proactive policies to manage public interest in wildlife inventions for various purposes; for example, financing conservation. However, such policies could stifle innovation and discovery of valuable inventions if implemented improperly. The Lacey Act could give states significant control over this resource, if modified to explicitly encompass intellectual property obtained from state wildlife.

Conservation groups: Non-profit, non-governmental conservation groups such as The Nature Conservancy, Sierra Club, Audubon Society, and World Wildlife Fund are likely to be motivated by policies that could provide a new, positive impetus and funding for conservation activity. Such groups could be expected to support expanded governmental control over wildlife inventions if such policy is designed to enhance the protection of wildlife. If properly designed, such policy could be used by groups that own habitat to generate income for their organization and conservation activity.

For-profit companies: Companies, especially those that sell products or services based on biotechnological inventions, are likely to resist efforts to give government more control over a resource that is now easily and freely accessible, and fundamental to their business. They are likely to perceive that expansion of governmental control over access and use of wildlife will add cost and reduce profit. Some corporate owners and managers may understand that some form of governmental control could provide enough structure to the market to eliminate the free-for-all chaos of the jumbled and ambiguous property mixture that now reigns.

Some companies may appreciate the long-term value of sustaining an accessible and diverse wildlife resource through regulatory mechanisms. However, corporations will always resist efforts to attach strings to their business assets. Although there is evidence that for-profit entities can work within a wildlife-property regime that is linked to conservation (Coughlin, 1993; Reid, 1993a; Tinker, 1995; Hunter, 1997; Varley and Scott, 1998; Weiss and Eisner, 1998), there are skeptics (Burk et al., 1993; Macilwain, 1998) and outright opponents (RAFI, 1997) of such plans.

Traditional commercial harvesters of wildlife: These stakeholders, including commercial fishers and trappers, would likely resist any increase in governmental control over their livelihoods. Given the power, influence, and long tradition of the exploitation of wildlife, these groups might play a key role in changes in policy. However, governmental control of inventions in wildlife that are already valuable and regulated would be less problematic for traditional harvesters. Commercial harvesters are unlikely to be concerned by new controls over wildlife that is, from their perspective, economically trivial (e.g., arthropods). New utilities in previously trivial species could create new types of commercial harvesters and expansion of these markets.

Public and private non-profit research institutions: Research universities and other non-profit research institutions are likely to support expanded governmental control over wildlife as long as it does not unduly hinder research and education activities. The federal government has a long track record of partnering reasonably well with such institutions; it has long been supportive of scientific activities and currently allows universities to retain intellectual property rights in federally funded projects. All federal and most state wildlife-protection laws provide for scientific, research, and educational uses. Based on this tradition, expanded governmental control of wildlife inventions could act, for the most part, in the interests of these institutions.

However, there could be some resistance to the sharing of benefits from inventions developed by these institutions.

Federal agencies: The U.S. Fish and Wildlife Service (USFWS), which enforces most federal wildlife policies, is most likely to manage increased federal control over wildlife inventions. It is interesting to consider how the USFWS would assume this role in light of the critique by Clark and McCool (1985) that compares a "bureaucratic superstar," the Army Corps of Engineers, to the "bureaucratic bumbler," the USFWS. Among their reasons for this distinction, they point to the political "pork barrel" value of Army Corps projects and to the lack of such values for the USFWS. If the USFWS could expand its mission into inventions, it might be a more powerful factor whose ascendancy could be matched by the rise in value of discoveries in federal wildlife. Other federal agencies, particularly land managers, could assert control of wildlife inventions. The National Park Service has already established a policy of control of such inventions within its borders (Varley and Scott, 1998). The Forest Service and Bureau of Land Management (BLM) could implement a similar policy. These agencies raise the issue of significant differences in enabling legislation, regulations, and management policies that govern any wildlife on lands. National parks have a clear path to assert control over wildlife on their lands, while national forests and the BLM have blurred jurisdictions as a result of their mixed public-use missions. Other agencies with considerable land holdings but little wildlife-management experience include the departments of Energy and Defense. Federal regulations require these land managers to coordinate wildlife management with state agencies, creating potential sovereignty issues. Overlapping jurisdictions may arise. For example, the Interior Department is likely to lead governmental wildlife control, but Commerce has control over fisheries and marine mammals, which it is unlikely to give up.

Recreational hunters, fishers, and trappers: These groups could be affected significantly if regulations strengthen governmental control over uses of game carcasses or parts. These groups might split into ideological segments that oppose or support additional governmental control over wildlife. Some view government as a necessary but negative aspect of their hunting lifestyle and would likely resist increased governmental control. Others may view the governmental control of inventions from wildlife as a positive, long-term benefit if it is linked to the conservation of game species.

Private landowners: This large and powerful group presents one of the most difficult political problems for any expansion of governmental control over wildlife. Any diminution of private land rights will be strongly resisted by private-property advocates (Jacobs, 1998), as well as by those who consider private property to be the optimal social structure for natural-resource allocation in general (Alessi, 1998) and wildlife in particular (Anderson, 1998). The political tension over public wildlife and private land is already high, particularly with the Endangered Species Act (Meltz, 1994), especially since the *Sweet Home v. Babbit* case (Lueck, 2001).

The public: It is extremely difficult to describe the public's interest. However, I presume that preserving the option to discover future inventions is a public good and that to do so requires the preservation of biodiversity. Therefore, the public's interest is served by maintaining sufficient biodiversity for present and future direct and indirect uses. Key questions include the meaning of "sufficient" and the issue of future use. Montgomery et al. (1999) have shown that the general public is willing to significantly value future inventions based on past discoveries. And, there is general public support for maintaining species viability via the Endangered Species Act. The public also demonstrates support for recreation and aesthetics that include wildlife. Concomitantly, the public interest is served by maximizing the entrepreneurial generation of inventions. All these goals could be met if conservation efforts synchronize with inventive activity. This is likely to be feasible given that inventions are usually generated by the consumption of very few wild specimens.

The acquisition of inventions from Yellowstone National Park by a Swiss-based multinational corporation (Hoffman-LaRoche) raises questions of whether the "public" of public interest is domestic, foreign, or both.

Future generations: These stakeholders may have the most to lose in the irreplaceable loss of species. Preserving future wildlife inventions could be the most important aspect of a proactive governmental policy.

Inventors: These are the drivers of technical innovation. Biotechnological inventors need access to the raw materials of discovery. Inventors, and their employers, are likely to resist restrictions on access to wildlife, although this may depend on the nature of the inventor's employer (i.e., self, corporate, or non-profit).

6.14 Policy Considerations and Prescriptions

Wildlife is a valuable public good (Tietenberg, 1990; Aylward, 1992), and its loss is a significant social problem that may be increasing in severity (UNEP, 1992; WCMC, 1992; Wilson, 1992; Barbier et al., 1994; Ward, 1994; Culotta, 1995; Pimm et al., 1995; Meffe and Carroll, 1997), although this view has its opponents (Simpson and Wildavsky, 1996).

Table 6.2 shows how the goods character of inventions from wildlife are a function of whether they are discovered or undiscovered, tangible or intangible. Undiscovered wildlife inventions are a public good that become mixed private–public goods when captured (i.e., discovered) and if tangible, and purely private goods if intangible. Undiscovered, tangible inventions are not purely public goods because they are rival. Ostrom and Schlager (1996) call such public goods "common pool resources," which can be depleted with no concomitant incentive for stock maintenance. Confusingly, although intangible wildlife inventions are private goods, they also fit the definition of pure public goods since they are non-rival and non-exclusive (Randall, 1987). In any case, when discovered, both utility types instigate market value that could link conservation and technology development depending on the policy framework embodied in property mechanisms.

Table 6.2. Inventions from Wildlife.

Invention	Undiscovered	Discovered
Tangible	*res publicae*	*res privatae*
Intangible	*res publicae*	*res privatae*

Some basic property-regime principles have emerged from the debate about the political economy of natural resources: private property is best for private goods but inadequate for sustainably providing public goods, and markets are ineffective in sustainably providing public goods because of free-rider problems and lack of present market value (Ostrom and Schlager, 1996). The complex property character of wildlife inventions presents a conceptual challenge to the creation of optimal policy through property mechanisms.

This policy challenge is exacerbated by technologists' increase of wildlife value by creating private inventions from public resources. It is as though undiscovered inventions in wildlife were a fishery commons in which technologists "fish" for inventions from the wildlife pool, owning them on capture and exploiting them for private benefit. This exploitation generates market value that is disconnected from the cost of maintaining the resource. Therefore, beneficiaries do not pay for resource maintenance—a classic externality. What is the cause of that externality, and what policy and property regime might correct it?

Correcting market failure in public goods typically results in public-property approaches that are more or less coercive and not incentive-based. But, although the market produces these externalities, it is also produces economic value in wildlife that could enhance conservation. What property mechanisms might harness present and future value of wildlife inventions to motivate conservation? Given the complexity of the problem, the answer is likely not simple. Exploring the tension between different resource-property regimes and the value of wildlife may provide insight.

The idea that markets could enhance biodiversity runs counter to the fact that uncontrolled markets have historically been ineffective in sustaining biodiversity (McDaniel and Gowdy, 1998) and typically accelerate its loss (Clark, 1976; Tietenberg, 1988), especially if the species (e.g., dugong or sea turtles) are "uneconomic" (Tisdell, 1986). These market failures lie, in part, in a fundamental incompatibility between the "instant-in-a-given-time-period" valuation by markets and the uncertain future value of most wildlife (Gowdy and O'Hara, 1986). Markets require valuation, and natural resources are particularly difficult to value (Daily et al., 2000). Existing methods of valuation of wildlife inventions are either incomplete, inaccurate, or lacking.

In addition to valuation problems, political economists across the ideological spectrum have identified the lack of property rights as a critical factor in the generation of natural resource externalities (Hardin, 1968; Randall, 1987, 1988; Berkes, 1989; Feeny et al., 1990; Swanson and Barbier, 1992). A lack of property-right definition or assertion in wildlife specimens as sources of invention produces an externality by failing to establish a firm and direct link between the value of present and future invention and the cost of maintaining sufficient wildlife populations. But correcting the property-right problem is complicated. Beyond simple definition and assertion, how should such rights be structured and distributed, who should hold them, and how should they be used?

Market failures in *res nullius* wildlife have traditionally been addressed politically, by imposing public-property regimes (Lund, 1980; Tober, 1981; Bean and Rowland, 1997) that range from comprehensive prohibition of private rights and market exchanges (e.g., Endangered Species Act) and tight regulation (e.g., Migratory Bird Treaty Act) to weak regulation of private rights in wildlife specimens (e.g., most state fish and game laws). The public-property regime includes a variety of policy approaches. Tisdell (1991) defines several typical policy mechanisms for a public correction of market failure: taxes; subsidies; fiats, prohibitions, and regulations; the auctioning and licensing of rights to engage in externality-producing behavior; state ownership and control of property; the strengthening of private-property rights and facilitation of private negotiation; and the internalization of externalities by extension of ownership. Market failures in wildlife use have historically been corrected primarily through the assertion of governmental control with some limited licensing of access to capture (Tober, 1981; Bean and Rowland, 1997).

Experience with years of public natural resource management has led to conclusions that such regimes are not socially optimal. Alessi (1998) argues that governmental control of natural resources is inherently flawed and should be avoided; that private or communal ownership of a resource is preferred for reasons of market efficiency, personal liberty, and individual welfare. Alessi (1998) and Gordon (1994) consider governmental "command and control" of wildlife to be an inherent failure in sustainable conservation as well as a diminution of private land rights, and to be unnecessarily costly and coercive. Using the Endangered Species Act as an example, they conclude that governmental coercion and prohibition of market mechanisms nullifies economic incentives to conserve and creates perverse incentives to destroy resources. They argue that private landowners are punished for providing a public good rather than rewarded because there is no economic return from the cost of maintaining an endangered wildlife population.

There are others reasons why the public-property regime does not produce socially optimal, sustainable conservation. Tisdell (1991) argues that governmental control often fails to conserve wildlife populations because agencies attempt to mimic the marketplace with an imperfect cost–benefit framework. Stroup and Baden (1983), Anderson and Leal (1991), and Yandle (1997) point out several governmental limitations, including innate bureaucracy inefficiency, lack of individual and firm incentives, imperfect information, centralization of decision-making, policy and operational inflexibility, excessive public costs, politics, and even corruption.

Given the disadvantages of public management, some political economists have concluded that non-coercive, private incentive–based policy approaches to public natural resources are generally preferable when feasible and equitable (Goldstein, 1991; Weck-Hannemann and Frey, 1995) and are always more cost-effective than command-and-control policy approaches (Markandya, 1997). Experiments with incentive-based, private-property mechanisms for resource management, including pollution control and fisheries (Pearse, 1994), illustrate the advantages of such regimes: decentralized decision making (Barbier, 1993), improved cost-effectiveness (Tietenberg, 1990), and opportunity for innovative contractual and institutional arrangements (Anderson, 1998). Even conservationists who are not typical advocates of private property–based solutions to common resource-use problems point to private economic incentive as critical to politically sustainable resource conservation. Hanemann (1988), McNeely (1988), and Tisdell (1999) all lend credence to the idea that enhancing the market value of wildlife under controlled conditions is essential for long-term conservation and that sustainable management of wildlife requires local ownership of that wildlife to establish motivation for conservation through linkage of conservation action to benefits from these actions (Mangel et al., 1996; Ostrom et al., 1999).

Advocates of marketable private rights in wildlife as a basis for conservation policy believe Coase (1960) was right: natural resource allocation problems can be solved if property rights are fully defined and private, and if transaction costs are zero. However, the difficulty in defining and enforcing such rights in transient wildlife populations and high transaction costs among many scattered landowners practically precludes simple private approaches for most (Lueck, 1995), but maybe not all, wildlife (Anderson, 1998). Coaseian *res privatae* solutions are infeasible with large numbers of property-right holders, but such large numbers might be tractable by aggregating private-property rights through associations, clubs, or other organizations (Yandle, 1997). Anderson (1998) and Lueck (1995) describe aggregated private-property mechanisms in wild game for market-based conservation, although their model is difficult to extend to wildlife that range widely (e.g., migratory birds) or that are obscure and lack obvious, present value (generally insects, for example).

Although private solutions have appeal, there are cautionary views. Incentive-based policy instruments that exploit the relative-price effect may be most efficient and desirable; however, they may also create perverse effects as economic incentive “crowds out” ethically based decisions (Weck-Hannemann and Frey, 1995). McDaniel and Gowdy (1998) view market-based conservation skeptically, pointing to the intrinsic conflict between ecosystem principles and rules that govern markets. They reject price as an infallible signal for sustainable wildlife use, providing examples where scarcity, high price, and functioning markets have not prevented the over-exploitation of a resource. They conclude that private economic exploitation is incompatible with the sustainable use of biodiversity because price will never fully reflect the true value of wildlife in its ecological and evolutionary matrix. Gowdy and O'Hara (1986) question the prudence of using unfettered markets as a conservation mechanism by exposing the economist's reliance on the substitutability of species. This economic view of sustainability trivializes the loss of a species, positing that the market will produce functional substitutes (Solow, 1993), a position that is fundamentally flawed, biologically (Ehrlich and Ehrlich, 1992). Tisdell (1991) summarizes by concluding that neoclassical market forces cannot be relied on to ensure biological preservation and are likely to "drive many species to extinction."

Lueck (1995) acknowledges the complex property milieu of wildlife but concludes that optimal property regimes will naturally evolve as the economic value of wildlife increases. However, difficulty in valuation stymies incentive mechanisms for wildlife conservation. A market approach to conservation using unfettered private rights might be accomplished by allowing private landowners to own inventions from wildlife on their land. Unfortunately, the incentive to conserve wildlife collapses because of indefinable present value. Since undefined value must compete with other, known values, more attractive market choices usually supersede conservation investments.

Presuming the valuation problem could be resolved, private rights in tangible and non-tangible wildlife inventions align with incentive-based conservation policy. But, such rights *per se* do not inherently solve the problem of linking market value to conservation. What is the nature of that linkage?

Beneficiaries of the market value of inventions from snake venom currently have no incentive to pay for snake conservation if the snake or its venom is available in the marketplace at a price disconnected from the cost of snake conservation. The key to linking the market value of inventions to conservation is determining the cost of sustainably maintaining wildlife in its habitat, who bears that cost, and whether the market value of wildlife inventions reflects that cost.

Possessing a snake with valuable venom provides the ability to farm the snake and to produce and sell venom at a price that reflects the cost of farming. The crucial question is whether possession of the snake is coupled to legal obligations to tie financial return from the snake to maintenance of other members of the species in its natural habitat. This raises the corollary questions of snake ownership and the owner's obligation to participate in snake conservation. What about snakes with venoms of unknown value or snakes with no venom? How can a mechanism that links the market value of inventions to conservation cost work without a known present value of these inventions?

The lack of quantifiable present or future economic value, the unfeasibility and too-high transaction-cost barrier of owning transient species, the patchwork of property rights in wildlife, and the disconnect between present market value and the unknown value of wildlife all argue against a pure private-rights approach. Conversely, there are compelling arguments that blanket prohibitions on private rights and market mechanisms in wildlife are not optimal for the sustainable conservation of wildlife in a politically and economically complex world. Do blends of public, private, and communal regimes provide solutions?

Evaluating property regimes for resource management requires stated policy goals. Considering wildlife inventions, two primary goals provide guidance: the sustainability of wildlife, and optimal technology development. Different policy choices could favor one goal over the other. Should policy emphasize technology, or wildlife protection? Simultaneously pursuing both goals requires an equilibrium of emphasis. What is the proper balance?

The numerous inventions from wildlife reveal the ability of technologists and entrepreneurs to exploit wildlife—unhindered by property rules—creating an externality-based market failure of resource use. A logical reaction is to shift away from technology exploitation toward conservation. However, policy mechanisms that tinker with a system that creates valuable inventions is likely to affect the public good of technology development. For example, future externalities like PCR and Yellowstone could be corrected by prohibiting all future research on park wildlife. But correcting such market failure with such a policy would inhibit technology. The Endangered Species Act is intended to preserve the value of this scarce public good but also thwarts the development of inventions that could provide some fulfillment of that value. This creates a conundrum: the act preserves a species' public value while precluding the full realization of that value.

A balance may lie in allowing the pursuit of technology development that is non-consumptive of wildlife. Inventions can be created with negligible consumption of wildlife, allowing technology to create wildlife value without reducing wild populations. However, a simple increase in market value *per se* is likely to be insufficient to sustain wildlife. As McDaniel and Gowdy (1998) point out, increased market value does not mean wild populations will necessarily be conserved, and a high price may actually accelerate extirpation (Clark, 1976; Silvert, 1977; Tietenberg, 1988). And, if Simpson (1997) and Barret and Lybbert (2000) are correct, increased market value will not be sufficient incentive for private-sector conservation efforts.

A pure private-property solution to the problem seems unsatisfactory. The high uncertainty of inventions from wildlife, the high transaction cost of contracting among too-numerous private-rights holders, the transient nature of wildlife, and the public-good character of this resource argue for a public approach regime of some kind.

Rose (1986) describes the long tradition of publicly owned resources going back to the Roman *res publicum*. Public resources, such as town defenses, roads, waterways, and intertidal zones, cannot be effectively managed by individual property holders. Such resources are not valuable enough to any one individual investor, are too boundless to privatize, and their users too numerous to collectivize. She argues that *res publicae* regimes are socially optimal when "economies of scale" render individual property holdings inefficient or unfeasible. For example, government must acquire rights to contiguous properties to build a highway or power line. Similarly, practical biological conservation requires an ecosystem approach (Grumbine, 1990; Baydack, Campa, and Haufler, 1999), which argues that a public-property regime is necessary to maintain the wildlife resource.

Any property regime for wildlife inventions will entail a fundamental tension between rights in wildlife and rights in land. Alessi (1998), Gordon (1994), and Epstein (1998) argue that public rights in transient wildlife should be superseded by private rights in land. By the extension of private rights in land, the wildlife thereon should also be private. Their arguments are based on the virtue of private-property rights as the social optimum of economic efficiency, liberty, and rule of law. Taking their view, free-roaming wildlife ought to be *res nullius* since private landowners can then capture rights and value to such wildlife via trespass law. Further, they would argue that if landowners could expect a return on the value of inventions from wildlife on their land, they would have incentives to provide habitat. This concept suffers from the free-rider problem created by the wide-ranging, geographical transience of many wildlife species. The habitat investor has no rights in the wildlife that moves to another's land; therefore, habitat-investment incentive is diminished. Despite allegiance to private-property resource regimes, even Alessi (1998) acknowledges that private-property mechanisms are insufficient when the present value of the resource is low and the transaction costs of enforcing such rights are high.

Despite their limitations, market solutions offer significant advantages. Private rights allow for the voluntary partitioning of rights to a resource, providing the flexibility to combine rights bundles (e.g., usufruct versus title) necessary for efficiency. The market provides a low-cost institution for organizing the production and consumption of a resource through the voluntary exchange of private-property rights. The key to eliminating externalities is the improved definition and enforcement of property rights in a resource (Alessi, 1998).

However, optimal property regimes for natural resources are not simply choices between Leviathan and private property (Ostrom, 1990). Evidence indicates that no single type of property regime works efficiently, fairly, and sustainably for all natural-resource, public-good situations (Ostrom, 1990; Berkes, 1996). Even within public regimes, wildlife-property mechanisms vary. Governmental control of a resource ranges from unorganized (no formal control) to organized (statutory; Rose, 1986). Types of public wildlife control reflect this range; from absolute prohibition of market transactions to less regulated. Aylward (1992) defines the mixed public-good character of wildlife and argues for a mixed public–private property regime. Barbier (1993) argues that a mix of property mechanisms is to be expected and defines criteria for designing resource policy: the balance of financial objective versus resource stability, uncertainty of market value versus private incentive, governmental difficulty in implementing market-based mechanisms versus certainty of regulation, charges on market activity that have unintended impacts on macroeconomic processes, and sufficient funding for policy implementation.

The equilibrium of private versus governmental control is the basic policy issue. At a fundamental level, all property is public because government, as sovereign, ultimately enforces all property rights. The puzzle lies in the tension of these two regimes. Private-rights advocates concede that private rights *per se* will be ineffective in sustaining the wildlife resource, whereas it is widely held that creating economic value in wildlife creates incentives to maintain it. The search is for property-regime blends that combine the advantages of both private and public control. Furthermore, property regimes are not the same as management regimes, and it is the management of resources that is ultimately most critical. Therefore, ownership may be less critical than who manages the resource and how (Weck-Hannemann and Frey, 1995). The combinations of public/private/communal rights described below may provide routes to solutions.

Anderson (1998) and Lueck (1995) describe game-ranching scenarios in which limited private property in wildlife, with an oversight role of government, produces economically and biologically satisfactory outcomes. Anderson (1998) describes how, in the case of transient wildlife, free-rider and hold-out problems created by multiple owners of habitat or species effectively preclude private-contracting solutions to conservation. But a solution to this is to combine ownership of species and habitat in the same "firm," and this is essentially what governmental agencies do. However, such agencies are hampered by an inability to integrate interagency jurisdictions, by lack of economic incentive by governmental personnel, and by politics. Anderson gives examples of innovative, non-governmental institutional arrangements for wildlife conservation that exemplify this "firm" approach. However, he does conclude that some governmental ownership of wildlife is unavoidable.

Covenants are another private–public property hybrid. Hafkamp (1997) describes these instruments as contracts between the government and a private right-holder to attain a public-resource goal. Such covenants are mostly private rights with relatively minor public rights that are voluntarily granted by the private entity.

Experiments with private rights in a wildlife resource under a public-control umbrella have been attempted in fisheries (Hanna, 1997; Fujita, Foran, and Zevos, 1998). In these property hybrids, the government establishes a limit on total harvest and creates a market in which individuals exchange “individual fishing quotas” (IFQ), which are tradable shares of fishery catch. Analysts have recommended this property hybrid in these rival and non-exclusive wildlife resources to mitigate over-harvest (NRC, 1999). These schemes grant private access rights to public wildlife but do not grant private ownership of the wild populations, nor do they provide private incentive to maintain the wild population. Radomski (1999) proposed to solve these limitations by a novel scheme in which the government grants private property in the free-roaming fish to non-harvesters who will have incentive to maintain the wild fishery. In this scheme, the government grants private property rights to the free-roaming fish, establishes ground rules and limits on over-harvest, and monitors compliance. Such systems are essentially communal-property regimes.

Numerous economic analyses indicate that communal regimes may be preferable for sustainable ecological and economic management of natural resources (Berkes, 1989; Leal, 1998; Ostrom et al., 1999). These authors all point out that destruction may befall scarce *res nullius* resources but that communal property in resources has worked to sustainably manage many different types of natural resources (including wildlife) in many different cultures. Such property mechanisms are a good alternative to pure private or public property for depletable, common-pool resources (rival but non-exclusive public goods), when exclusion is costly, when the resource is not physically divisible, or when it is mobile (Ostrom, 1990; McKean, 1996). Effective communal regimes require restricted access to the resource (no *res nullius*), creation of a governance structure, and incentive mechanisms to invest in maintenance of the resource. They are also limited in the number of participants and the size of the resource that can accommodated.

When confronted with the structural difficulties of private ownership of wildlife, free-market advocates suggest communal approaches because they permit the internalization of externalities over a large resource system and allow the privatization of rights without physical divisibility (Yandle, 1997; Alessi, 1998; Anderson, 1998). McCay (1995) points out that limiting access to a communal resource will fail unless incentives or regulations prevent over-exploitation. Some governmental control may be necessary to assist the community in organizing, monitoring, and enforcing rules of resource use, particularly when the users of the resource don't all perceive its value, don't all understand its biological nature, or have divergent interests. Uncertain resource value disincentivizes the organization of communal organizations, and very large numbers of users makes such organization difficult (Ostrom, 1990).

While locally devised property rights may be most effective for some resource management, other natural resource problems have boundaries that are too large for a manageable *res communes* institution. These may be managed by "nesting" local control within a larger institutional milieu that coordinates the nested organizations (Ostrom and Schlager, 1996). McKean (1996) describes a "resource federalism" in which smaller collectives own a resource and are nested in a larger resource federation. The smaller collectivities manage the resource unless externalities among the nested collectivities arise that the federation must resolve through coordinated and coercive action.

It is unlikely that any single policy can effectively cover all property issues in wildlife inventions. Nonetheless, it is useful to establish policy principles and defining resource parameters to inform the search for promising institutional arrangements. Those principles and parameters are described in Table 6.3.

Table 6.3. Policy Principles and Resource Parameters

1) Maximum biodiversity must be maintained, including the ecological and evolutionary process context.
2) Optimum technological advancement should be fostered.
3) Private incentives rather than coercion should be used whenever possible.
4) Blends of property regime are likely to be necessary.
5) Inter- and intragenerational equity and efficiency should be considered.
6) Making inventions is generally not a consumptive use.
7) The value of inventions must be linked to the cost of maintaining wildlife regulations and their habitat.

What property-regime types and policy choices are suitable? The policy principles require incentives for the sustainable protection of wildlife and the linkage of commercial benefits to conservation. Researchers should have freedom to explore wildlife for inventions and to develop them. But this freedom must be associated with investment in the maintenance of wildlife in its habitat. There must be a direct link between the financial returns from wildlife invention and conservation. There are several potential policy mechanisms to accomplish these goals. The following four meta-policies provide a framework for evaluation.

- **Laissez-faire/*res nullius*:** unfettered market in rights in biotechnological utilities privatized by capture.
- **Command and control/*res publicae*:** absolute governmental rights, market prohibitions, tight control of government wildlife property. Free-roaming, wildlife specimens (and their utilities) are privately ownable.
- **Governmental regulation of private rights/*res publicae–res privatae:*** regulated market forces.
- **Communal ownership/*res communes*.**

Laissez-faire/*res nullius*: This policy–property regime currently exists for all inventions from any *res nullius* wildlife, for all patented inventions, and for some tangible inventions from wildlife whose free-roaming corpus is *res publicae*. The advantages are unfettered commercial exploitation of inventions, the allowing of investment incentive to develop an enhanced economic value of wildlife, and a low cost of implementation. The disadvantage is no link between the economic value of such utilities and the cost of the resource. Despite cautions against upsetting the technology development engine with wildlife-property mechanisms (Burk et al., 1993), history shows that voluntary linkages to conservation are insignificant. The susceptibility of a scarce *res nullius* resource to a TOC under this regime is a good basis for eliminating this policy choice. Also, while private landowners might have incentive to sustain *res nullius* wildlife on their property, this is unlikely when the value of inventions is insufficient or uncertain. The free-rider problem also inhibits incentives to invest in habitat when the wildlife can be captured off the investor's property. These flaws cause insufficient habitat investment, a problem that indicates the need for some public control.

Command and control/*res publicae*: As exemplified by the Endangered Species Act, a key advantage of absolute governmental control of wildlife inventions is the preservation-of-species option value when such control is linked to the preservation of wild populations. Disadvantages include clashes between private-property rights and coercive government, lack of private economic incentive to sustain populations, failure to realize inventions and their attendant social and economic benefits, and failure to enhance the economic value of wildlife. Eliminating market exchanges in a resource destroys economic value and incentive to preserve the resource. Analysts point out that the sustainable protection of endangered species is likely to require controlled market forces (Swanson, 1994; Hutton and Dickson, 2000).

And, if it is true that increasing economic value is essential to conserving wildlife (Alyward, 1992; Swanson, 1992; Barbier, 1993), endangered species would be the most valuable because of their high scarcity. An alternative under this regime would allow governmental researchers to develop inventions, but this would eliminate the innovative power of the for-profit sector. Similarly, government could permit for-profits to discover and develop inventions but would own them. However, unless the sharing of benefits is allowed, profit-seeking firms will have insufficient incentive for the work.

Privatization/*res privatae*: This policy–property regime is distinguished from *res nullius* in wildlife by extending private rights to free-roaming wildlife populations, making the physical capture of inventions unnecessary. However, except for endemic populations entirely on a single private land, perfecting *res privatae* rights via trespass law and contracting with other habitat owners is technically infeasible—one of the primary reasons for existing public regimes (Lueck, 1995). However, it may be feasible for government to grant rights in a population (defined by geography or taxon) of wildlife to private entities, similar to the government's granting of certain private rights to a public fishery (Radomski, 1999).

Governmental regulation of private rights/*res publicae–res privatae*: Even the strongest private-property rights are ultimately granted and enforced by the sovereign government (Rose, 1986). But, in practice, there are a wide range of public–private blends that exhibit a gradient of governmental versus private control. The balance can be skewed to governmental control, as in federal and state law that allows possession, but not sale, of captured game, with an extension of such a ban to the discovery of invention. This would preclude technological discovery, value creation, and incentive. Shifting toward private rights might include allowing the private ownership of inventions in public wildlife captured under license and requiring payment of a royalty or fee to the government, as with certain mineral rights. If the state uses such monies for conservation, the externality could be, at least indirectly, corrected. Such policy could be designed by relatively simple adjustments to existing federal and state laws and regulations. Implementation would be costly because monitoring of possession, record-keeping of specimen disposition, and results of inventions discovered and commercialized, including patents applied for, would be necessary. To maximize the effectiveness of this policy, it might be necessary to modify patent law to require applicants to disclose the wildlife source that produced the patentable invention and to swear that such wildlife was held and used legally. This is politically more difficult than an assertion of rights through existing wildlife control laws. Also, this policy–property scenario does not effectively address externality created by wildlife specimens that are *res nullius* or that have already been made private by legal capture (e.g., zoos and other legally caged specimens). This externality might be corrected by expanded governmental rights in inventions from any wildlife. Such expansion, most likely by state government, would be politically difficult, particularly for obscure wildlife on private land or wildlife long-held and reared for many generations in captivity. Such difficulty might be mitigated if government does not assert ownership of captured specimens, limiting its rights to a share of commercial return or requirements to use in the public interest. Significant monitoring and enforcement issues would arise, some of which might require modification of patent law as described above. These policy–property mechanisms, whether more or less politically feasible, would indirectly correct the market failure if governmental uses returns for conservation. However, although the externality may be indirectly addressed by this governmental connection to private benefits, it yields no link between enhanced economic value of wildlife to private incentive to invest in sustaining free-roaming wildlife.

Communal ownership/*res communes*: Ostrom (1990) points out the general unfamiliarity with, and even resistance to, communal-property regimes in this country. Despite the long history of successful communal property in the form of the corporation, such resource management schemes are not well known. Communal-property systems provide an alternative, where applicable, to an otherwise stark choice between socialism or private property and free enterprise (Hardin, 1968). Property regimes of "shared private rights" (McKean, 1996) have many of the advantages of private property and can be applied where simple private rights in a resource are not feasible. Numerous examples of communal resource management in fisheries (Hanna, 1997; Leal, 1998; NRC, 1999), wildlife (Lueck, 1995; Anderson, 1998), water, (Ostrom, 1990; Somma, 1997), pasture (Netting, 1972), and others (Berkes, 1989; Ostrom and Schlager, 1996) suggest the potential of this approach for sustainable management of inventions in wildlife. However, other than large fisheries, successful *res communes* systems are typically relatively small-scale or single resource/user systems (Acheson, 2003; Ostrom, 1990; Warner, 1997; Iida, 1998). The challenge will be to apply these mechanisms to much larger and more complex systems and to solve complex system design and governance issues (Ostrom, 1990). In addition, unless effectively linked to land rights, the communal ownership of transient wildlife is likely fraught with significant conflict with private landowners (Geisler and Bedford, 1995; Alessi, 1998; Epstein, 1998). As a further cautionary note, the converse of the commons tragedy, the "tragedy of the anticommons," is a resource-use problem that results from too many owners of a resource blocking each other (Heller, 1998), and the anticommons may be a particular problem with intellectual property (Heller and Eisenberg, 1998).

6.15 Policy Prescriptions

Effective property policy for managing the resource of wildlife inventions must resolve the simultaneous challenges of correcting the market externality, creating incentive for conservation, facilitating technology discovery and development, and reconciling the species-focus of wildlife-property rights with the ecosystem approach of practical conservation biology.

Habitat owners could be incentivized to invest in habitat creation and maintenance if they were able to capture at least some of the value of any invention from wildlife on their property. This is easily done with *res nullius* wildlife and is possible for public wildlife in cooperation with government. However, two problems still loom large: the uncertain value of unknown inventions and the wide geographical range and transience of wildlife. The uncertain-value problem might be mitigated by technology investment that leads to the finding and owning of inventions from wildlife they harbor. Private and governmental investment in such research could play a role. But the free-rider problem of transient wildlife remains. One solution is to organize landowners in biologically contiguous or related habitat into associations that would share values found on any property in the association. A very different policy strategy might address the value and free-rider/transience problems: a species-focused property-rights approach.

In the species-focused policy strategy, exclusive rights to inventions are granted to a non-governmental entity such as a for-profit firm, conservation group, or other organization. As with the fisheries property example of Radomski (1999), the government would grant property rights in any invention to the entity obtained in their particular species. The entity would contract with habitat owners to support the wild population, and the exchange could include shares of commercialization return. This strategy also lends itself to the governmental auction of rights, as in the allocation of broadcast frequencies. For example, exclusive rights to the inventions of endangered species could be auctioned with fees and royalties used for conservation. Appropriate controls on wildlife exploitation would be required to assure population maintenance.

These strategies would require the organization of “firms” to hold private rights in wildlife inventions. Such firms might include novel conservation associations established solely for this purpose or existing organizations. Anderson (1998) describes several types of wildlife conservation organizations that could provide models. The variety of communal institutions for wildlife conservation described by Ostrom et al. (1999) are also templates. Such “firms” might be corporate or cooperative in governance. Reid (1996) postulates cooperative associations and other partnerships to own and exchange wildlife inventions. Such “biodiversity cooperatives” would be granted certain wildlife-property rights by government.

Ellis (2001) describes “common pool equity,” a particularly novel mechanism that aligns with these policy strategies. A “common pool equity” is a share of profits of any firm that extracts from the common resource. So, any firm that is a member of a common-pool equity association for exploitation of inventions from a wild species would receive a share of any profits obtained by any other member of the association. Such a structure might fit with the “nested resource federalism” model of McKean (1996) and Ostrom and Schlager (1996). For example, a migratory bird flyway could be organized as nested organizations with either a species or geographical focus, with a larger governing collective aggregating the rights of the nested groups.

Government often has rights in both habitat and species, sometimes separately and sometimes together. How should it manage its potential inventions? Regarding species, if it assures against population over-exploitation, granting certain private rights to such inventions is likely to have advantages for both technology and conservation. Where no private partner exists, government ought to invest public resources to fund inventions on its species and to license rights in such discoveries to private firms, as it does with currently patentable governmental inventions. A similar approach is possible with governmental habitat ownership. Government should maintain the integrity of habitat and populations and facilitate non-consumptive, non-destructive searching for biotechnological utilities by firms that will have the obligation to share commercial return with the government to use for conservation.

How does genomics affect these scenarios? A fundamental premise underlying the analyses in this work is the dependence of property in inventions on property in free-roaming or captured wildlife specimens. In order to invent an invention, someone must have had physical possession of a biological specimen. However, once information is extracted from the specimen, that information may be used to create property in intangible patents. Thus, once the information is untethered from the original dependence on the physical specimen, the linkage has been severed. If possessors of wildlife specimens have no obligation to previous owners or possessors, information gleaned from the specimen is purely private. The fact that genetic information from endangered species is being systematically obtained raises questions about the appropriate property rights in and disposition of such intangible material. For example, the San Diego Zoo reports genotyping and gene sequencing of the Arroyo toad, bighorn sheep, Chacoan peccary, California condor, owl monkey, Przewalski's horse, bonobo, black rhino, Somalian wild ass, and mountain gorilla (Mounce, 2001). The existence of the “Frozen Zoo” project in the Center for Reproduction of Endangered Species, in which a “bank vault” of cryopreserved cell cultures of many endangered species is maintained, emphasizes the importance of this question. These issues require further analysis and should be urgently considered given the growing use of genomics in wildlife study and the untethering of the valuable intangible inventions obtained from the specimens.

Finally, this analysis has provided only a preliminary base from which to probe deeper into the implications of potential design of optimal policy/property institutions for sustainable use of wildlife for technological discovery. Clearly, it is important to move the research in that direction.

CHAPTER 7:
CASE STUDY EVALUATION

7.1 Case Studies

The two cases examined below exhibit common themes of patent rights and inventions from wildlife. These cases also represent contrasts: of private- versus public-property rights and failure versus success in asserting a chain of property rights from wildlife in its habitat, through personal property of specimen collection and laboratory use, and eventually to intellectual property. The first case involves inventions from hot-spring bacteria in Yellowstone National Park and demonstrates a failure to link public rights in wildlife specimens to patents. The other case, bioprospecting and the Finger Lakes Land Trust, demonstrates a successful linkage of the chain of property rights by a landowner through contractual relations with research and commercialization partners.

In both cases, specimen possession and use looms as the critical nexus. In the Yellowstone case, this is a nexus of failure to establish the policy link between economic value of invention and conservation. In the Finger Lakes case, possession, and the contractual strings attached to it, established this policy balance.

7.1.1 Yellowstone's Valuable Microbes: Specimen Possession and the Failed Property Chain

Specimen possession and the failure to link that possession to invention and patents looms large in the Yellowstone National Park and patents on a polymerase chain reaction (PCR), one of the most valuable inventions of the biotechnology industry.

In the summer of 1966, Dr. Thomas Brock of the University of Wisconsin, and his graduate student H. Freeye, collected microbial mat samples at Mushroom Hot Springs in Yellowstone Park as part of their academic research, under a national park permit for scientific collection. The permit placed few restrictions on the researchers' use of specimens collected in the park. From these samples, they isolated a thermophilic microbe ("YT-1") and subsequently published a paper on this new species, *Thermus aquaticus*. As a routine part of the scientific publication process, Brock and Freeye deposited living, pure-culture specimens of *T. aquaticus* in the public repository American Type Culture Collection (ATCC) as "ATCC 25104." Nothing in the park's rules for biological-sample collection precluded such a deposit. In fact, some of the park's regulations actually encouraged it. The only restriction placed on public access to ATCC 25104 by the ATCC was a requirement to pay a small fee and a standard "hold harmless" clause for liability. Anyone could obtain an ATCC culture on payment of this modest fee, and obtaining a sample gave recipients unfettered personal property rights in that sample.

Several years after the deposit of *T. aquaticus* in the ATCC, Cetus Corporation paid ATCC's $35 access fee, which allowed its employee Kary Mullis to acquire ATCC 25104. Mullis used this culture to discover the novel enzyme "taq"[1] and to invent the patentable PCR method of DNA amplification. The PCR makes exact copies of specific sequences of DNA and has proven to be an essential biotechnology. It is used globally in research and has many commercial applications. Its discovery was so profound that Mullis was awarded a Nobel Prize in the late 1980s for its discovery, and *Science* magazine declared Taq polymerase the "molecule of the decade."

Cetus filed its first U.S. patent application on October 25, 1985, covering PCR materials and methods, with Mullis as sole inventor. Cetus filed a subsequent U.S. patent application, with Mullis and five other inventors, on February 7, 1986. These applications were issued on July 28, 1987, as U.S. Patent Nos. 4,683,202 (Patent

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[1] Taq refers to ***t**hermos **aq**uaticus.*

’202[2]) and 4,683,195. Patent ’202, titled “Process for Amplifying Nucleic Acid,” was issued with twenty-one claims covering a process for amplifying any “specific nucleic acid sequence contained in a nucleic acid mixture thereof . . . . ” With the issue of these two patents, Cetus controlled the making, using, and selling of PCR technology. Later, Cetus and its partner, Perkin Elmer Corporation, commercialized PCR through licenses and sales of PCR reagents and equipment. Eventually, Hoffman-Laroche purchased the Cetus PCR patent estate for approximately $300 million. Since this transaction, PCR has produced an ever-larger flow of commercially profitable activity.

As original custodians of the samples taken by Brock and Freeye, neither Yellowstone National Park, the National Park Service, the Department of the Interior, nor any agency of the U.S government has received a share of the commercial revenue streams resulting from the PCR intellectual properties. Other than the usual business taxes, there has been no financial link between the beneficiaries of PCR (particularly Cetus or Hoffman-LaRoche) and the U.S. government, despite the latter’s *parens patriae* rights and obligations in national park wildlife (Clifford, 1994; Milstein, 1994a,b). The source of this failed linkage can be identified in the failure to maintain the chain of property rights.

Because the original specimen was taken from Yellowstone National Park, a logical first issue to consider is the extent of a public-property interest in wild microbial biota both on federal parkland and after it has been removed from the park. Then, to what extent do any government rights extend to intellectual property from that biota? The analysis below answers these questions. It also sheds light on larger questions: Does the federal government have the sovereign right to control access to and use of wildlife on all federal lands, and does this right extend to all types of biota, including microbes? Do such rights depend on the type of federal lands (e.g., Bureau

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[2] K. Mullis inventor; Cetus Corporation Assignee (i.e., patent owner).

of Land Management, national forest, national parks, Department of Defense)? Can the federal government actively control the access to and disposition of all biota on federal lands? Should it, and if so, to what end? Does the balance of state versus federal jurisdiction affect property in wildlife on federal land, particularly national parks?

7.1.1.1 Federal Property in *T. aquaticus*

Chapter 3 describes the long judicial evolution of federal sovereignty in wildlife on federal land and species selected for federal protection by Congress. In particular, the 1920 *Missouri v. Holland* Supreme Court decision establishes federal sovereignty over wildlife Congressionally selected for federal control. The combined effect of *Hunt v. U.S.* (1928), *New Mexico State Game Commission v. Udall* (1969), and *Kleppe v. New Mexico* (1976) further cements federal sovereignty over such wildlife. But did Congress intend a federal property interest in national park wildlife?

Like any landowner, Yellowstone National Park has certain rights in wildlife fixed to its land. This includes growing plants and, by the doctrine of *ratione soli*, ownership of the soil and soil organisms. In addition, the federal government has a *parens patriae* trust responsibility in national parks. This trust responsibility is based on the Yellowstone National Park Act of 1874, the 1894 Act to protect the Birds and Animals in the National Park, and the National Park Service Organic Act of 1916. Taken together, these acts grant power to the Secretary of the Interior to make and implement regulations necessary for the "proper care" of designated national parks, including the prohibition of all hunting and "the preservation from injury or despoilation of all timber, mineral deposits, natural curiosities or wonders within said park."[3]

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[3] 16 U.S.C. §§ 881, 2-3 (2002).

There are other bases for a property right in the original specimen collected in Yellowstone by Brock and Freeye. Relevant federal regulations are found in the Code of Federal Regulations, Title 36 (CFR 36). Under CFR 36, which underlies the policies of Yellowstone and the National Park Service, select wildlife (i.e., large animals, fish, and birds) are explicitly controlled and their collection limited to certain uses (i.e., scientific research, museums). Other biota (e.g., arthropods, microbes) are not explicitly mentioned in these regulations. However, CFR 36 provides that all biological specimens taken from a national park shall remain the property of the National Park Service and that the superintendent of a national park has broad authority over all hunting or collecting in that park. Section 2.1 of CFR 36 prohibits the possession of any living or dead national park wildlife, fish, plants, or their parts and products without a permit. Section 2.5 ("Research Specimens") defines conditions for taking specimens from a national park and prohibits "taking plants, fish, wildlife, rocks or minerals except by permission from the Park management (a prerequisite of permission to include a collection permit)." Section 2.5 also requires that a permit for collection be issued only to "an official representative of a reputable scientific or educational institution or a State or Federal agency for the purpose of research, baseline inventories, monitoring, impact analysis, group study or museum study." Other requirements in CFR 36 for collecting in a national park include the following: 1) the park superintendent's approval of the stated scientific or resource management goals of the collecting institution or agency, 2) acquisition of all applicable federal and state permits, 3) that the intended use and final disposition is in accordance with applicable law and federal administrative policies, 4) justification that the specimen cannot be obtained elsewhere, and 5) that no damages will result. CFR 36 also states that killing park wildlife requires a research proposal approved by the park superintendent and prohibits "derogation of the values or purposes for which the Park area was established." In addition, such killing must have the potential for conserving and perpetuating the subject species. CFR 36 requires that collected park specimens be made available to the public and labeled "National Park Service" and "NPS Catalog." Related rules[4] include explicit requirements for the control of collected specimens (including a whole or part of an organism). Section 2.5 requires that intended uses and final disposition of any collected park specimen be consistent with all applicable laws, regulations, and policies. Most important, nowhere in CFR 36 is a transfer of ownership in collected park specimens authorized. Furthermore, perpetual "ownership" of the park's collected specimens is supported by the *Special Park Uses Guideline,*[5] which states, "if the collection is to be stored by an outside institution, it is placed on loan."

Beyond the national park's regulatory control of park wildlife via the permit process, the U.S. Constitution requires that Congress approve transfers of ownership of federal property. Also, the federal government cannot abandon federal property without expressly stating its intentions to do so.

Transient wildlife that are *res publicae* only when they are on federal land[6] are no longer federal property when they leave the park boundary on their own volition. However, the park's *res publicae* control does extend to wildlife that are wrongfully taken from the park. Court cases involving the illegal taking of public timber suggest the extent of these rights. For example, a purchaser of timber wrongfully taken from the public domain is liable to the government for the value of the timber at the time it was purchased, but not for the additional value added to the timber through manufacture.[7] This ruling might suggest that the federal government's rights in *T.*

[4] NPS 77, Chap. 5.
[5] NPS 53, Appendix 12.
[6] That is, they are not explicitly protected species.
[7] *U.S. vs. Kelly,* 17 p. 878 (Wash.).

aquaticus cultures do not extend to the intellectual property derived from those cultures.

Federal rights and obligations in national park wildlife are also defined in the *1988 Management Policies, U.S. Dept of Interior/Natl. Park Service,* which requires park policies to be based on the following principles: “National Parks must be maintained in absolutely unimpaired form; National Parks are for the use, observation, health and pleasure of the people; The national interest must dictate all decisions affecting public or private enterprise in the Park.”

Based on an explicit reading of the law that underlies Yellowstone National Park, it is clear that the federal government has the sovereign right to control all wildlife on national parkland. Federal statutes and regulations have granted the national park superintendent power to implement that right in furtherance of park purposes and the national interest. Park management has a public-trust duty to preserve, protect, and maintain park wildlife and its habitat. At a minimum, park managers are obligated to control the physical collection of park wildlife. It is also clear that ownership of any specimen taken from a park must remain with the federal government unless specifically authorized by Congress and explicitly intended by federal agencies. But what about progeny of the original culture-specimen? The law relating to property in livestock may provide guidance (St. Julian, 1995). By common law and custom, in lieu of a contract otherwise, the owner of the mother organism is the owner of all her progeny.[8] And although applying this doctrine to microbes is novel, it would extend federal rights to all subsequent cultures of the original *T. aquaticus* sample. Applying this doctrine, all *T. aquaticus* cultures are federal property. But the failure of the federal government to assert control over use of the cultures, allowing them to be made publicly available, and the lack of *res publicae*

[8] *Arkansas Valley Land and Cattle Co., v. Mann,* 130 U.S.S. (1888).

reach into manufactured value, militates against any federal rights in the PCR intellectual property. What is the source of this failed linkage?

Park managers did not violate federal law or policy in allowing Brock and Freeye to collect *T. aquaticus*. The placement of the organism in a publicly accessible repository was also in keeping with federal law and regulation. However, the NPS-property labels on the samples were not maintained by the physical possessors, a violation of federal regulation. More important, even if such labels were maintained and monitored, control was necessary to link the park specimens to the resulting patents. Park management did not fulfill its *parens patriae* obligation to keep track of and control use of the park's *T. aquaticus* property. This is the key point: The federal government failed to control the use of collected park organisms, in particular, their commercial use. If the government had maintained such control and extended it to patent activity, it could have allowed patent rights in exchange for a sharing of financial returns. The source of this failure lies in the terms and conditions of specimen possession, which were defined in the collection agreement. This agreement is dissected in the next section.

7.1.1.2 Yellowstone's Collection Permit and the Property-Right Failure

The original specimen collection was done under a required permit. However, the permit did not require subsequent labeling of the specimen as NPS property and placed no restrictions on its use or distribution. Since public availability and use were not controlled, the government lost its control of the possession and use of the specimens.

The *Special Park Uses Guideline* requires public access to all collected park specimens. This exemplifies the dual, contradictory policies of federal property in national park wildlife: perpetual governmental ownership of collected biological materials without restrictions on use. The result: loss of governmental interest in intellectual property rights obtained from governmental wildlife property. In the PCR case, there was no linkage between rights of possession in *T. aquaticus* specimens and the PCR patents. Implementation of federal regulations that prescribe public access to collected park specimens, without control over use, breaks the link between *res publicae* property rights in federal wildlife and biotechnological property derived from collected specimens. Reestablishing this linkage requires modification of federal regulations so that patentable subject matter from federal wildlife is subject to some level of federal control.

Until 1995 and the publicizing of the PCR issue, the Yellowstone National Park Collection Permit did not control most uses of collected specimens, including invention and patenting. Since then, Yellowstone has implemented a policy by which commercial use of its specimens requires prior approval of the national park superintendent, and gives the superintendent the authority to negotiate benefit-sharing arrangements. The park is also following federal rules that require that a park collection permit be granted only to a “reputable scientific or educational institution” and only with justification that the collection could not be accomplished outside the park. Also, any commercial use requires a written contract for the terms of such use (Varley and Scott, 1998).

7.1.1.3 Federal Policy on Intellectual Property from National Park Wildlife

Federal law and National Park Service policy guidelines implicitly allow, at the park superintendent’s discretion, the searching for and patenting of inventions, as long as the purpose is for the “use” and “health” of the public. Federal statutes also require that such activities serve the national interest. It can be argued that patents generally serve the public interest. However, allowing individuals to patent and profit by using an invention from park wildlife, without control by park management, may not be in the public interest and could be a violation of the government's public-trust responsibility. The question is whether it is in the public interest to allow a use of park wildlife that produces private profits but returns nothing directly to Yellowstone National Park, the National Park Service, or the U.S. Department of the Interior. Profit-making activity produces jobs, products, and taxes, and these are widely considered to be in the public interest. But is this indirect benefit sufficient or equitable? Does the public interest require a sharing of financial return to protect the source of the wildlife? Should such profits help park managers to steward park wildlife resources or to buy more park lands? After all, it is only because of the original purchase and ongoing protection of Yellowstone's ecosystems that the profitable PCR patents exist.

Before concluding that the park should share in the financial benefits of patents from its wildlife, consider picture-taking. The capture of visual images of the park is similar to the acquisition of patentable information from a small, ecologically insignificant sample of wildlife. National parks do not attempt to assert a property interest in park photos, and to do so seems over-reaching. Of course, a fundamental difference is the physical possession of wild biota required for patenting. However, federal law requires that the federal government maintain national parks "unimpaired." Therefore, a basic policy premise of park specimen collection for intellectual-property purposes is that collecting will be non-destructive, non-consumptive, and will have a negligible biological or ecological impact. So, if that possession has essentially no impact on the park, should patents be treated like photos?

The national park superintendent appears to have broad authority to design and implement a park-specific policy for specimen collection that could include invention and patenting. Is there a basis for a park superintendent's allowance of patents from park wildlife? Federal regulations appear to encourage activities that enhance the protection or management of park species and to discourage activities that do not. Therefore, establishing a mechanism to return resources for management through the controlled commercial use of collected specimens would appear to be a suitable activity. Discovering and patenting inventions from park wildlife would be within federal law and policy as long as: “1) the purpose is to provide for the health and use of the public; 2) is in the public interest 3) does not damage Park resources, 4) is undertaken by reputable research institutions; 5) is done under a proper collection permit and commercial use contract.”[9]

Since federal law and regulations currently are not explicit on the collection and use of national park wildlife for inventing and patenting, park managers would need to exercise judgment and interpretation on a case-by-case basis. The National Park Service *Museum Handbook for Complying with Regulations for Cataloging Natural History Specimens*[10] requires specimen labeling, recording of data on collection (site, collector, date), a specimen loan form, and a written contract with any who wish to *collect for profit*. Although the guide addresses the collection of museum specimens specifically, it provides a basis for the commercial use of park wildlife through patents.

Assuming national park managers allow such wildlife-specimen collecting, a related policy question is whether for-profit institutions should be considered “reputable research institutions” and, therefore, qualified for such activity. Unlike non-profit research institutions, companies conduct research solely for profit-making purposes. Furthermore, companies have a primary goal of protecting shareholder interests. However, law-abiding companies are arguably “reputable” institutions that conduct research and could qualify. If not, such activities must be done by universities and similar institutions or the federal regulations must be clarified, perhaps to include

[9] *1988 Management Policies, U.S. Dept of Interior/Natl. Park Service.*
[10] Ch. 4, Sec. E.

the term “development” in the requirement (i.e., “reputable research and development institutions”).

Based on changes in practice over the last few years, park wildlife patenting activities can be arranged to fall within federal law and regulation, and park superintendents have the authority to make key decisions that will affect the policy balance between technology and conservation. Undoubtedly, practical questions of implementation cost will arise. But a more fundamental question lingers: Should such activities be allowed (let alone encouraged) in national parks, at all?

An argument for a policy that facilitates and encourages inventions and patenting from national park resources is strengthened by the hypothetical “wonder drug” discovery scenario. If there is a possibility that the national park’s biological resources contain a wonder drug that would be a boon to human health and welfare, and if this drug could be discovered only if such activities are allowed, federal law and regulation would appear to encourage such activities. But there are alternative views. Such uses of park wildlife could be considered a commodification of the park and a wholly inappropriate use of this treasured public good. An extreme, anti-anthropocentric environmental view would hold that the development of new drugs exacerbates the problem of human population growth, a primary cause of biodiversity loss, and should not be encouraged. Clearly, however, this argument is politically infeasible.

Although it is likely that there would be widespread support for drug discovery in national parks, it is also likely that such support would be contingent on certain conditions: the protection of the park’s inherent qualities, no widespread commercialization of park feasibilities, and no “selling off” of the park’s resources.

The park directives, defined in the National Park Service’s *1988 Management Policies*, foster the protection of park genetic resources and support the concept of "appropriately-structured arrangements" for technical discovery and patenting. "Appropriately-structured" in this context could mean a mechanism that returns a share of financial gain to activities that protect "genetic resources." Returns to the United States Treasury through business-related taxes probably do not satisfy this requirement.

7.1.1.4 Yellowstone and PCR, Conservation and Sustainable Development

Yellowstone's hydrothermal features support a thermophilic microbial biota that is a globally unique natural resource. The financial value of the PCR patents and related products demonstrates the significant economic value of that resource. This value is emphasized by other commercial products that have been discovered from this resource.[11] This valuable resource exists only because of the federal government's intervention in the late 1800s to remove Yellowstone lands from the market, requiring a taxpayer investment in the land purchase and a public investment in the long-term protection of the resource.

Yellowstone Park's handling of *T. aquaticus* was a failure to assert *res publicae* rights. But was the park's handling of *T. aquaticus,* and its downstream inventions and products, a failure in terms of conservation and sustainable development? From a narrow, ecological standpoint of the sustainability of the microbial resource *per se*, the answer is no. Sampling, when practiced with a "light hand," and using appropriate collection procedures, is a non-extractive resource use. Quantity harvesting is another matter. Presuming that collecting *per se* does no long-term[12] damage to the resource, sustainability has been satisfied. The economic and social sustainability of the resource is another matter.

[11] John Varley, personal communication with author, 1988. Dr. Varley is responsible for all biota collection at Yellowstone National Park.
[12] The definition of "long-term" is an open question.

Was the PCR case a failure of sustainable economics policy? Long-term maintenance of the national park requires the expenditure of taxpayer resources for land acquisition, protection, and management. Adequate personnel, facilities, and equipment all cost money. Unfortunately, the National Park Service is usually strapped for cash—and Congress rarely authorizes purchase of additional park lands. Yellowstone has historically employed one technician-level person to monitor and enforce the terms of all scientific-collection activities in the entire park. Logic dictates that such oversight is insufficient given the number of collectors, their varied activities, the size of the park, and the significant economic pressure on the resource. A situation in which significant economic values are obtained from a national park resource that does nothing to enhance the national park's ability to sustain that resource runs counter to the concept of sustainable economic development.

Even if the National Park Service were fully funded to effectively manage current resources, it could be argued that the service has a public-trust obligation to obtain resources for the purchase of additional lands that could potentially provide other such resources for future generations.

From the standpoint of social sustainability (i.e., intragenerational equity), those who have profited from the commercial exploitation of national park wildlife have taken profitable advantage of the taxpayer's burden of supporting the national parks, their lands, and facilities. Taxpayers have paid the full cost of maintaining the resource, while patent beneficiaries pay only a *pro rata* taxpayer's share.

An alternative view holds that the sustainable use of this resource may best be accomplished by fostering indirect benefits that result from the commercialization of such resources—innovation, new products and markets, increased jobs, and expanded tax revenues. This view holds that such innovation and its benefits are most efficiently obtained by society when governmental control is minimized. A primary limitation of this argument is that the resource manager directly responsible for the resource (e.g., Yellowstone Park personnel) does not directly obtain benefit.

7.1.1.5 Epilogue

In August of 1997, the National Park Service announced that it would allow a small U.S. biotechnology company, Diversa, to take samples of soil, water, and plants over the next four years in return for a one-time fee of $175,000 and royalties of up to 10% of sales on any future products derived from park samples. This arrangement spawned the filing of a suit against the National Park Service by several non-profit organizations (Pennisi, 1998). Although the suit was dismissed, the court decided that the park is required to conduct an Environmental Impact Assessment before entering into such arrangements.[13]

7.2.1 Fungal Bioprospecting and the Finger Lakes Land Trust: Effective Specimen Possession Proves the Linkage

Unlike the Yellowstone–PCR case, in which the failure to maintain the chain of property rights destroyed the linkage between *res publicae* biota and personal patent rights, the institutional arrangements for fungal bioprospecting on the lands of the Finger Lakes Land Trust (FLLT) represent a successful connection of wildlife property and patents. In this arrangement, the FLLT established property rights in wildlife on its land and extended those rights to the control of possession and use by other parties. Most important, the FLLT's biota-property rights extended beyond the removal of specimens from FLLT land and into the realm of intellectual property.

Understanding how the biota-property rights assertion by the FLLT produced benefit-sharing from potential intellectual property sheds light on the mechanisms necessary to optimize the connection between the technologically derived value of wildlife and the cost of conservation.

[13] As of the spring of 2002, no new such arrangements had been entered into by Yellowstone Park (J. Varley, personal communication with author, 2002).

The FLLT was established in 1989 as a public-membership, non-profit corporation for the purpose of protecting unique natural lands in the Finger Lakes region of New York State. The FLLT's activities include land acquisition and management. In 1997, the FLLT purchased the "Biodiversity Preserve," a biologically diverse parcel of land near Cornell University and Ithaca, New York. One of the reasons to acquire the preserve was to develop its potential to produce valuable inventions from its wildlife.

Developing the bioprospecting potential for bioprospecting required the proactive development of a property-based framework that would allow non-destructive capture of the economic value of inventions from the preserve's biota. That framework was based on the FLLT's establishment and enforcement of its property rights in all biota on its land. The first step was to establish control over access to biota on FLLT land, which was accomplished by the following steps:

1) Control access to FLLT land: Using New York State trespass law, the FLLT established a coherent policy and the administrative capacity to control access to FLLT lands.

2) Prohibit the unauthorized taking of biota on FLLT land: In conjunction with the establishment of controlled land access, the FLLT established a policy of strict prohibition against the taking of any biota on its land except through an explicit collection- or hunting-permit process.

3) A collection-permit process to regulate the taking of biota: The FLLT established a biological sample collection- and possession-permit process that allowed only permittees to take and possess FLLT biota under explicitly prescribed conditions and protocols. These included justification for collection, definition of species to be collected, number/quantity of specimens, location, and nature of archived samples.

4) Property assertion in collected samples: The FLLT's collection permit, a bailment contract defining the conditions of possession and use by the collector, placed the following restrictions on the permittee's possession and use of collected biological material:

a) required labeling of all samples collected, regardless of form, such as whole caged organism, culture tube, petri plate, deep freeze, etc.

b) prohibited transfers to third parties without prior approval by FLLT.

c) prohibited commercial use (by the FLLT's definition) without license from FLLT.

d) required acknowledgment of permittee to hold collected materials as a bailment.

5) Ownership vigilance: The FLLT instituted mechanisms for follow-up monitoring of the permittee's adherence to permit conditions, for example, biological-property accounting.

By implementing these steps, the FLLT established its control over biota on its land and could then enter into a bioprospecting partnership from a position of property-right-based strength. In the first step, the FLLT asserted control over access to possession of any biota on its property (fixed or transient), through its rights under trespass law. In steps two and three, the FLLT established property rights in its biota (distinct from the *res publicae* biota on its land). In steps four and five, the FLLT asserted property rights in biota removed from its land.

The feasibility of this biota property construct was dependent, in part, on the biological taxa selected for bioprospecting.

FLLT lands comprise a variety of habitats in the Finger Lakes region. Although a variety of wildlife taxa could have served as bioprospecting targets, fungi were selected as a particularly promising source of technical discoveries. There were important biological reasons for this selection, but the lack of governmental law and regulation on fungi was fortuitous. There are no laws that give the federal or state governments control over wild fungal species on private land. Furthermore, as described in Chapter 3, law and custom in the United States consider soil to be part of real estate, and since soil organisms are part of the soil, these organisms are the property of the landowner by *ratione soli*. Fungi presented a clear original ownership situation: the FLLT is the unfettered owner of the fungi attached to its lands. Maintaining that property right after these specimens are removed from FLLT land requires a bailment contract.

7.2.1.1 The FLLT Collection Permit: A Bailment Contract Retains Property Rights in Biological Samples

Having established the basis for a property-right control over wildlife on its land, the FLLT created a protocol for the authorized taking of biota under the following guidelines: only select purposes[14] are allowed, collection applications must include full disclosure of the collecting purpose and details of the sampling scope and methods used, and the signature of collection permit by the permittee is required.[15]

The FLLT extended its biota-property rights after removal by transferring rights of possession, but not title, to their fungal materials through the bailment contract terms of the Collection Permit.[16] This created the basis for entering into agreements with parties that would strive to discover and patent biotechnological utilities from FLLT fungi.

[14] These are conservation, nature study, research, education, and approved bioprospecting.
[15] The Finger Lakes Land Trust Research and Collection Permit.
[16] The Collection Permit stipulates that a) all collected biological material must be clearly labeled as FLLT property and such labeling perpetually maintained throughout all laboratory manipulation culture, transport or storage; b) the permittee cannot distribute the materials to any third party without FLLT permission; c) the permittee may not use the material for any commercial purpose without FLLT permission; d) all collected biological material and any derivatives (clones, propagules, etc.) materials must be destroyed or returned on request by FLLT.

7.2.1.2 Establishing the Property Chain: The Bioprospecting Collaboration

The FLLT has neither the staff nor the expertise to exploit the inventive potential of the diverse fungal species on its lands. However, Cornell University, the FLLT's neighbor and bioprospecting partner, possesses both. Cornell and the FLLT agreed to allow Cornell mycologists to collect FLLT fungi under the terms of the FLLT Collection Permit. This allowed Cornell University staff to collect, study, and store FLLT fungi, but prohibited commercial use. It also obligated Cornell to maintain FLLT fungal specimens as a bailment. In order to realize financial benefits from inventions made with FLLT fungi, a commercialization channel was necessary. This necessity spawned a commercialization partnership between FLLT and Cornell's technology transfer arm, Cornell Research Foundation, Inc. (CRF), a non-profit corporation.

In the early 1930s, Cornell University created CRF as its mechanism for owning and managing the transfer of commercial rights to Cornell's intellectual property. CRF was the logical agent to legally transform the FLLT's research-use-only fungal biota into a bioprospecting target and the subject of a commercial transaction. CRF and the FLLT consummated an agreement in which CRF managed the FLLT's fungal property for the sole purpose of CRF's negotiating a bioprospecting contract with a commercial partner on behalf of CRF and the FLLT. Any such contract was to be in accordance with the FLLT's rights as the bailor of its fungal property. CRF and the FLLT agreed to an equal sharing of returns from commercial activity with the FLLT's fungal property. CRF and the FLLT agreed to transfer a certain number of the fungal specimens to the commercial partner under specified conditions in a bailment contract between CRF and the commercial partner. The FLLT agreed to not enter into other agreements that would be contrary to any bioprospecting agreement between CRF and the commercial partner.

Because the FLLT, Cornell University, and CRF have neither the capability to screen large number of samples for potential pharmaceutical applications nor the capability to develop, register, and market pharmaceuticals, Schering-Plough (SP), a drug company, was recruited to engage in drug screening of the FLLT fungi.

CRF, acting as agent for the FLLT, and as manager of the commercial applications of the FLLT fungi, entered into a biological material bailment and screening agreement with SP in which Cornell–CRF provided a select number of fungal samples to SP. In exchange, SP agreed to provide funding to support Cornell's mycologists to carry out the collecting, cataloguing, and storing of the samples. In the most critical provision of the agreement with SP, any discoveries or inventions, patentable or not, made using FLLT fungal specimens that generate commercial return are subject to a royalty paid to CRF that is shared equally between Cornell and the FLLT. In addition, SP paid a modest "bioprospecting access fee" to the FLLT. This provision established the final link in the property chain from specimen in its natural habitat to financial return on patent.

This inter-institutional, biota-property-based arrangement focused solely on the patents in the field of human health. This leaves the FLLT free to enter into similar arrangements for other uses of their fungi as well as other arrangements for other wildlife such as insects or plants. However, other taxa may be controlled by either federal or state law, which would bring either of these governmental entities into the property-chain equation.

The web of contracts between the FLLT and Cornell, Cornell and CRF, CRF and the FLLT, and CRF and SP all explicitly maintain the chain of FLLT property rights in fungal specimens, which began with the FLLT "enclosing" its lands to unauthorized taking.

An important aspect of these agreements is that patent ownership, throughout the chain of FLLT fungi possessors, is not necessarily for sharing in commercial returns. This demonstrates the power of property rights in biota *per se*. The holder of a property right in wildlife need not be an inventor in order to link their property rights in specimens to the financial returns from intellectual-property exploitation.

Because the FLLT's property-right assertion in its fungi possessed by any party exists as long as the fungi exists, and because the collection of its fungi is conducted in a manner that maintains the original population intact, sustainability is achievable. The sustainable use of wildlife is achieved by using biota property rights to link the resource conservation system (i.e., the FLLT) with a process of commercial exploitation and the generation of a benefit stream.

CHAPTER 8:
ETHICAL CONSIDERATIONS OF PROPERTY IN INVENTIONS FROM WILDLIFE

8.1 Introduction

Various ethical questions surround the concept of property in inventions obtained from wildlife. An understanding of the appropriateness of owning a wild creature, a cell line collected from that creature, or a patent on that cell line rests on a set of property ideas. At the center is property *per se*, particularly private property. The idea of property has been debated for hundreds of years, and the ethical tensions of the property institution remain as strong today as ever (Rose, 1986). The purpose here is to first determine whether biota property can easily be considered personal property or whether it presents some unique ethical conundrums. Although there is an ethical foundation for a property right *per se*, the question here is whether that foundation is wholly adequate if the property is alive. Is the ethics of biota property perturbed if the biota is wild or if it is a single organism, a group of organisms, or even an entire taxon? What if the biota is a natural propagule (an egg or seed, for example) or part of a whole organism, such as a test tube of cells? Are these ethical considerations of biota property constant through the reduction of organism to cell and cell to molecule? And finally, does intellectual property present unique ethical issues, particularly in the milieu of wildlife?

All biota can be divided into two fundamental property domains: wild commons and personal property. While the wild biota commons is, like most natural resources, enmeshed in a historical dialectic of private right versus public good, biota as personal property is a more mundane domain of longstanding legal rules. But ethical questions lurk even within the personal-property domain; for example, the issues of property in sentient beings, inherent rights of biota, and anthropocentric utilitarianism.

Examining the wild-biota commons first, I describe the evolution of wildlife from unowned commons to public good. This evolution can be seen as a balance of the public's right in a common natural resource with the individual's right of liberty manifest in private property. The ethics of biota as personal property is first approached by an examination of whether biota *per se* has unique moral significance, followed by a discussion of the applicability of general property theory to biota.

Understanding the ethics of patents from wildlife also requires a description of the linkage between tangible biota and intangible intellectual property. Intellectual property *per se* is beset with questions of the "privatization of the knowledge commons." Do patents derived from biota present an ethically special case? Elucidating the utilitarian basis of intellectual property leads to fundamental questions of anthropocentrism, cultural relativism, and commodification inherent in the property concept and also of the relation of religious and spiritual belief in the sacredness of life to biota property.

After utilitarian and spiritual perspectives, biota property is considered within the environmental ethic. A review of environmental philosophies invariably leads to a critique of anthropocentrism, economic liberalism, consumerism, over-reliance on technology, and economic growth. Aside from economic efficiency, inter- and intra-generational justice, and religious belief, there remains an ecology-based ethic. How does any form of property in wildlife align with interpretations of environmental ethics? The hardly disputable assumption that property—especially intellectual property—drives technological development leads to a critique of faith in technical progress *per se*.

Finally, in the spirit of Norton's (1995) criticism of certain theories of environmental ethics, I consider how ethical considerations of biota property inform the relationship between nature and humanity.

8.1.1 Biota as Two Property Archetypes: Wild Commons and Personal Property

Biota can be divided into two archetypes: that which is wild and free-roaming, and that which has become possessed as personal property through taming, capture, or killing. In the first domain, wildlife is a natural resource—a public good such as air, rain, or a natural body of water. This domain is subject to public-access rules of the commons. The issue here revolves on the socio-political tension of natural resources as a common good and/or a private right. This tension is attendant with questions of generational equity and economic efficiency created by social allocations of rights and benefits. In the natural resource domain, the biological character of biota is hardly relevant. The type of organism (e.g., degree of cellular organization, sentience) is no more relevant to the ethics of property in biota than specific wavelength is to society's allocation of rights in the electromagnetic spectrum. The question here is private rights in a public good, and the public-good character is little affected by the type of organism. Conversely, in the personal-property[1] domain, biological character is ethically relevant, and there is little practical relevance to the question of social allocation of rights. Here, there is a difference between owning a dog and owning a hive of honey bees, but there is no public-good character to either. In biota property, the fundamental question is whether owning biota is ethically different from owning non-biota chattel.

While all free-roaming wildlife can be lumped together as a single natural resource, such lumping ignores that some creatures are more valuable in terms of human utility than others (for example, oysters versus zebra mussels). But lumping allows us to focus on the question of distributive rights in this common good rather than on distracting questions of biological character. In this context, wildlife is like

[1] Personal property, also "chattel" or "personalty," is defined as any movable property; it is distinguished from real property (land) and its fixtures.

other common goods where ethical issues center on equity and efficiency and also the degree of anthropocentrism that should guide the relation of humans to nature. But the moment a wildlife specimen is possessed, it becomes tangible personal property. Personal property includes all tangible objects such as clothing, furniture, cars, art, and biological matter, and intangibles such as bank accounts, corporate shares, and patents. Property in these things is defined by the rules of personalty (Burke, 1983). Once legal possession has occurred, any biota, its progeny, parts, or by-products are personal property. Defining the divide between wildlife as a common good and as a possessed personal property begins by characterizing the wildlife commons.

8.2 Wildlife as Common Good

Why should wildlife be a common good? Is it unethical for free-roaming wildlife to be private property? Is it wrong for individuals to capture, for their own use (whatever that may be), a single wildlife specimen? What if they capture and possess all the specimens of a species? Even if there is no legal prohibition against an individual capturing and owning all ladybugs, would this be wrong? Does our moral intuition suggest that such possession is a violation of some common social principle?

Many western philosophic arguments for property are built on the premise that untamed nature belongs to no one and should be accessible to everyone. Harper (1974) describes an early Christian view that the earth was originally owned by God, who grants right in common to all humanity. Henry (1974) describes the biblical view that “every person is to share abundantly in God’s created universe,” quoting Psalm 24:1 (KJV): “the earth is the Lord’s and the fullness thereof; the world and they that dwell therein.” Henry states that private property is a biblically sanctioned moral good, but it must be combined with certain requirements of moral goodness in the use and holding of such property. In the Leviticus 25:23 statement “The land shall not be sold forever for the land is mine [God’s],” the Bible supports the notion that land (and in a larger sense, all natural resources) is a sacred, common good. In 1646, Grotius summed up an early Christian view of property ownership that God is the genuine original owner (Grotius and Kelsey, 1962).

Locke and Rousseau begin their theoretical property constructs with an original "state of nature" in which there is no property, a philosophic "ground zero" that gives everyone free access to all. In his *Second Treatise of Government,* Locke (1966) defines "a state of perfect Freedom and Equality . . . by Nature" as follows:

> God who hast given the world to men in common . . . all the fruits it naturally possesses and beasts it feeds, belong to mankind in common . . . and nobody has originally a private dominion, exclusive of the rest of Mankind, in any of them as they are thus in their natural state. (p. 15)

Rousseau (1974) begins his discourse on private property with the exhortation to an early member of the human race: "You are lost if you forget that the fruits of the earth belong to everyone, and the earth to no one!" (p. 164). He then proceeds to describe a degeneration from this pure egalitarian state as people carve out private property from the state of unowned things. Locke views private property as a necessary and basic human good. However, he believes acts of privatization must be delineated by a threshold: sufficiency for the possessor but not so much as to deprive fellow humans of the necessities of life. For Locke, the creation of private property by an individual's labor is a moral bad if it takes from others that which they need to survive.

The original state of *res nullius* nature is reflected in early human societies. In their descriptions of the evolution of the concept of property in various cultures, Laveleye (1878) and Lafargue (1894) support the hypothesis that many human societies began under a communal-property structure in which nature was unowned. Many early tribal cultures did not conceive of the idea of private property for the basic articles of sustenance, including game and the earth's resources. Many of these early cultures were also characterized by a belief in a spiritual source that provides natural resources to all people. Lafargue (1894) claims that when such tribal common societies were required to allocate resources, it was by lot, a random selection in which all had an equal chance of acquisition. In primitive societies, wildlife was the joint property of the tribe, and it was inconceivable to these peoples that an individual would have an exclusive right to such basic necessities (Laveleye, 1878). The rise of private-property consciousness in technologically evolving societies runs counter to the hunter-gatherer cultural mindset. Hughes (1983) describes how the idea of ownership of land, wildlife, or any natural resource was alien to Native American cultures. Beatley (1994) and Hargrove (1980) argue that the notion of private property in natural resources is a uniquely European construct.

Lafargue (1894) and Laveleye (1878) depict the typical social evolution from communalism to private property as a gradual loss of the commons. Societies begin with pure common ownership and move successively to consanguine collectivism,[2] feudal property,[3] and ultimately to bourgeois property.[4] The rise of private property and the decline of the commons was accelerated by the development of complex civil societies and technologies such as agriculture and manufacturing (Schlatter, 1951). As Rousseau (1974) states, “The first person who, having fenced off a plot of ground . . . was the true founder of civil society” (p. 173).

Agriculture and manufacturing economies contributed to the motivation to create private property from the unowned commons. But how can such privatization be morally justified and more than mere assertion of power? Locke’s *Treatise* (1966) provides moral grounds for taking a private-property right from a public good.

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[2] Consanguine collectivism is family-based ownership of some property in alliance with other families; with a commons.
[3] Feudal property is a hereditary and class-based concentration of property; with a commons.
[4] Bourgeois property strengthened private-property institutions; no commons.

Locke's theory of a property right is based on the moral foundation of individuals' inherent right to the fruits of their labor. And individuals' inherent, exclusive right to possess and use their labor-fruits is essential to their survival and to the effective working of society. However, weaknesses in Locke's labor theory have been described (Nozick, 1974; Becker, 1977). For example, parents do not own their children, and pouring a can of juice into a lake gives no rights in the lake to the pourer. Despite some flaws, Lockean theory underpins modern market economies.

The importance of Lockean theory to modern liberal economic thought argues for an examination of Locke's boundaries to individual acquisition from the common pool. How should we determine the ethical limits to an individual's right to possess as much as he or she can labor to produce? What is the moral divide between the rights of all in an unowned common resource and the right to make something "mine" from that which is "everyone else's"? Such private appropriation creates a drastic change in the relation of the appropriator to all non-appropriators. This appropriation transforms individuals from the tenants-in-common of Locke's "God's largesse" to a certain type of dependence on the appropriator. Locke establishes this boundary with the premise that a private-property interest, created by and for an individual via his or her labor from the public domain, is good only to the extent that the appropriation leaves enough and as good of the commons for others. For Locke, the "enough and as good" premise defines the ethical border between the rights of all members of society in a common resource, and individuals' right to their labor-fruits implemented in a property-right structure. Locke's justification of this boundary is based on several premises.

First, Lockean labor theory links ownership of one's body to one's labor and thence to things labored on. Locke's notion is that only human labor creates value, and the labor of the value-creator gives the laborer a property right in the valued thing.

Locke’s “spoliation proviso” limits the right to accumulate property to no more than the individual can use. Any taking beyond this amount will result in spoilage and waste, which is a moral bad. This proviso precludes the wasteful accumulation of perishable goods and even of land. However, for Locke, wild nature is also waste until labored on by humans—a view similar to that of some Judaic, Islamic, and Christian theologies.

Each of Locke’s points has logical weaknesses, particularly since his Eurocentric, resource-rich, and sparsely populated world of the late 1600s was very different from that of today. Waldron (1988) points out a limitation of Locke’s premise by spelling out the difference between labor values made by creating and those of mere gathering. Also, the “spoliation proviso” has been left mostly irrelevant in modern society because, with money, there is no “spoliation” limit to an individual’s property accumulation (Waldron, 1988). However, money does create questions of moral limits to the amount of private property that may be accumulated, if it does not leave “enough and as good” for others.

The asymmetrical accumulation of property within society is supported by the liberal economic thesis that individual welfare may be diminished by an act of private-property acquisition if the net social product is positive (Paul, Miller, and Paul, 1994). The moral standard of net positive social gain allows individuals to be made worse off *vis à vis* other individuals in any act of private-property creation or acquisition. This is the essence of liberal utilitarianism: public good defined by the sum total of incremental increases in individual good, less decreases from individual bad. Everyone’s boat floats higher on the increasing sea of net social gain. Allowing individuals to carve private property from the public domain encourages them to invest labor and assets in the development of resources. Private-property rights allow free exchanges between rights-holders until the properties arrive in the hands of those that value them most highly—benefiting all (Holderness, 1985). Liberalism encourages the private acquisition of resources in the belief that the world is best managed when divided among private-property owners (Bentham, 1931; Posner, 1977; Yandle, 1983). However, this creates fundamental tensions and the conundrum of the liberal state as a mix of egalitarianism in the public-citizen sphere and a market system of inherent inequality (Boyle, 1992). Also, the required use of private-property rights to facilitate trade, economic growth, wealth accumulation, and resource exploitation confronts the finite public natural resource domain of "space ship earth" (Boulding, 1973).

Despite various flaws, the justifications for private property as an essential social organizing principle are persuasive. Property rights are essential for a functional civil society (Hobbes, 1651; Bentham, 1982). Hobbes (1651) describes an anarchistic state of no boundary between "mine and thine" as so dangerous and unpleasant that individuals voluntarily give up some modicum of their liberty to a sovereign that will organize and protect individuals and their property.

Large congregations of humans require a civil society based on institutional structure, laws, and custom. A stable society requires private security in property possession, use, and modes of acquisition. Property and its underlying institutional framework are necessary for the efficient and equitable allocation of resources among naturally competing individual interests. The "tragedy of the commons," in which an unowned common good is destroyed by selfish individuals who seek to maximize only their well-being, compels the private-property right. But is it an unbridled right?

The Romans understood that unbridled individual rights in a public good produce a diminution of that resource, which requires social control. Under Roman law, certain public resources such as roads and defensive walls required the assertion of the public's right through statute, while in others, such as running water, the public's rights were asserted through custom and practice (Rose, 1986). Property rights are society's means of supporting an individual's freedom to participate in commerce, at his or her own discretion; to control socially centrifugal forces such as coercion that would otherwise destabilize the socio-economic order. Property rights are simultaneously necessary for the twin moral goods of social order and individual economic freedom (Buchanan, 1993). Is private property critical to other types of personal freedom?

Liberty is a basic human right. The Declaration of Independence and the U.S. Constitution embody this political philosophy. A private-property right is a manifestation of an individual's fundamental personal liberty in the socio-economic world: "property is not a natural, innate right, but it springs from an innate right, which is liberty" (Dalloz, a French jurist of the 1800s, cited in Laveleye, 1878, p. xli).

The argument that private-property rights are necessary for economic and political freedom is based on the idea that in order for unlimited personal liberty to exist, individuals must be free to act to affect their own survival and pursuit of happiness, unfettered by anyone or anything. The importance of individual liberty and the freedom from coercion by the state and one's fellow citizens is emphasized by the horrors of state-implemented genocide and other atrocities against individuals perpetrated in recent history (Caldwell and Schrader-Frechette, 1993). Unambiguous and unmitigated private-property rights provide the individual with this ability and, thus, his or her liberty. Anything that acts contrary to this ability is a diminution of liberty. The linkage of private property and liberty is a cornerstone of the liberal democratic social construct (Becker, 1977; Waldron, 1988; Buchanan 1993; Beatley, 1994; Alexander, 1997).

A society constructed on a framework of liberty through property must balance that with the pool of rights that is the common good. This creates a collision of two “tectonic plates” of human right: the right to property that springs from the right to liberty versus the right of equal access to common goods. How can an individual’s liberty-based right to wildlife be reconciled with another individual’s right to not have that wildlife taken from the commons?

Since Roman times, assertions of such public rights (Rose’s “comedy of the commons”) have been guided by a desire to facilitate commerce (Rose, 1986). So, aside from personal liberty and “tragedy of the commons” justifications, private property has dominated mercantile societies because it enables stable commerce. The ethical milieu that allows individuals to carve out their sphere of freedom from the nexus of social interdependence via a property right is tailor-made for commercial society. As Rose (1985) describes it, “private property is an articulation of a specific vocabulary within a structure of symbols approved and understood by a commercial people” (p. 88).

Despite the potential ethical constraints on private property in natural resources, their value to a commercially driven society in a framework of a free-market political economy ensures that this social institution flourishes. The legitimization of private property is manifest in legal support. The law has generally supported the idea that private property may be acquired, through labor (even if that labor is simple physical possession), from the commons, and, once property is acquired, the state enforces the legitimate owner’s rights. For example, the law recognizes a property right perfected through first possession (Rose, 1985).

There seems little room for another social paradigm. However, within this political economy, ethical dilemmas are created when the utilitarian social goods of property produce intra- and inter-generational asymmetries. Does the utility of property rights fairly benefit future generations? Does it equitably benefit all of the present generation? More basically, is this utility inherently flawed because it is inappropriately anthropocentric? Is human utility the only utility?

Given the importance of private property to individual freedom, mercantile efficiency, and the liberal paradigm of integrating individual welfare and net social good, why should any resource be off-limits to private acquisition? Rose (1986) claims there are three fundamental reasons: 1) there are some goods that are so plentiful or so valueless as to not be worth allocating, 2) some goods are not ownable, and 3) some goods must be controlled by government so that individuals take others' interests into account. Where does wildlife fall in this scheme?

Locke's property theory assumes an unlimited reservoir of natural resources and the premise that such resources have value only if and when humans make them valuable through human labor and productivity. The equitable allocation of a common natural resource becomes an issue only when the resource is useful and scarce. Who cares about property in gnats? They're not useful (to humans) and are more than plentiful. If wildlife is useful but not scarce, as with game in early U.S. colonial days (Tober, 1981), everyone can have as much as they want or need. If wildlife is scarce but not useful, or *vice versa*, the ethics of allocation is academic. However, technology creates utilities in "economically trivial" wildlife, stimulating changes in utility and scarcity and the ethics of property-right allocation.

At this point, it is useful to discuss biota as personal property and to determine whether biota represent a special type of such property.

8.3 Biota as Personal Property

First, let us define biota: all non-human, living organisms, their parts, and by-products. Biota include domesticated and non-domesticated animals, plants, and microbes. Some biota are, without question, ownable, such as companion animals, livestock, and crops. What is the relation between property theory and biota? Are biota simply chattel under property principles? Does personal-property theory apply equally to biota and non-biota? If biota property is no different from non-biota property, one need only look to property theory generally for ethical guidance. If biota property is qualitatively different, however, further analysis is required. Once the relation of biota and property is clarified, an understanding of the ethics of property rights in biota can be approached. Below, I first describe how biota differs from non-biota under property theory. Then, I construct a “dog and sofa” parable to further elucidate the unique character of biota property.

Although biota property has unique characteristics that distinguish it from non-biota (Hannah, 2001; Root, 2003), in practice it falls squarely in the personal-property realm. As such, basic justifications of property are applicable to biota. A deeper understanding of biota property requires an exploration of how biota property may differ from generally applicable property-right theory.

8.3.1 Labor Theory

The labor theory grants an individual a property right by virtue of his or her “labor” that wrests a new thing from a “state of nature.” This labor must be distinguished from mere intention, declaration, occupation, play, or accidental improvement (Becker, 1977; Waldron, 1988; and O’Brien, 1996). The Lockean labor theory is based on the premise that humans add value to raw (valueless) nature and that the individual’s labor creates a distinction between the thing worked on and the thing in its natural state (Becker, 1977). Locke’s arguments are directed primarily at land and manufacture. Does the labor-value basis of a property right apply also to biota?

Do humans add value to biota through their labor? Certainly, animal husbandry, plant breeding, and crop cultivation adds utility for humans. Similarly, human labor creates utility in cell cultures and genetic constructs that did not exist prior to the labor. This argument applies more weakly to the caging of a wild animal and also depends on the caging purpose. For example, there is a moral difference between a capture that restores public safety or that aids education or research and one that provides mere amusement. Caging animals for entertainment involves a level of frivolity, which suggests that labor-based values range in importance and vary according to moral perspective. For example, a circus elephant is valuable to the seller and buyer of tickets, but has a different value to the conservationist or animal-rightist. Thus, the labor-value of biota is likely to be a complex basis for applying the labor theory.

Locke's (1966) property theory begins with a philosophical "ground zero" of a "state of nature" in which everything is *res nullius*. Locke states, "God gave to mankind in common . . . all the Fruits it naturally produces and Beasts it feeds, belong to Mankind in common, as they are produced by the spontaneous hand of Nature; and no body has originally a private dominion, exclusive of the rest of Mankind, in any of them as they are thus in their natural state" (p. 15). In his law of "reason and common equity," Locke uses the "fish in the sea" as his example of property created from a property-less state. Locke grants property in caught fish to the fisherman who removed it from "nature" by labor. Locke states that "this law of reason makes the deer, that Indian's who hath killed it . . . 'tis allowed to be his goods who hath bestowed his labor upon it, though before, it was the common right of every one" (p. 16).

Locke's arguments underlie the premise behind most state law in which a caged wild animal is considered the property of the cager as long as the animal remains caged (St. Julian, 1995).

One of the flaws in the labor theory of property rights is their mitigation by superior rights (Nozick, 1974; Becker, 1977). Why is it that parents do not own their children? Because human rights supersede a property right. Singer (1994) argues that the intrinsic rights of higher animals similarly mitigate a property right in a specimen of that species. Taylor (1986) and Hettinger (1995) consider such rights applicable to all species, regardless of their complexity.

8.3.2 Utilitarianism

Utility arguments for property are based on the premise that such rights are necessary for human well-being and that property rights are essential for ordering stable social systems that clearly and consistently allocate scarce resources to their members. This utilitarianism is complicated by questions of inter- and intra-generational equity (Bullard, 1994). Biota property provides utility for humans and their societies and appears to fall under the utilitarian theory. However, this raises questions over property rights in non-utilitarian species.

Utilitarianism is anthropocentric, and from this view, biota property satisfies utility for human welfare, social order, and rational natural resource management. Utilitarian property begs the question of non-anthropocentric utility. Would arguments against anthropocentric utility weaken the basis for property rights in biota?

8.3.3 First Possession, A Root of Utilitarian Property Right

Under the doctrine of first possession, original ownership lies with the one who first physically possesses a thing (Dukeminier and Krier, 1993). The capture of wildlife, which converts it from free-roaming public good to private property, is the paradigm of first possession. Rose (1985) calls it the “root of title.” Becker (1977) points out certain weaknesses of the first-possession theory. For one thing, it assumes that all things are, *a priori*, ownable; regarding wildlife and other common-pool natural resources, this notion is contested. Wildlife as *res nullius* was the basis of U.S. Supreme Court Chief Justice Holmes’s 1920 majority opinion on sovereignty over wild birds in *Missouri v. Holland*. Justice Holmes made it clear that under the supreme law of the United States, wildlife is not ownable. Duckler (1997) describes the “legal netherworld" of captured wild animals as falling somewhere between the personal property of a companion animal or livestock and an indentured servant. She argues for a reassessment of zoo animals as a unique type of property more akin to unique entities worthy of preservation (like great art or other cultural treasures) than to trade goods and recommends that abuse of such property, even by the owner, should be considered an offense against the public welfare.

8.3.4 Personal Property in Biota Wholes and Parts

To what extent do the concepts of biota property apply to parts of organisms? Biota parts include body parts, horns, teeth, skin, hair, feathers, eggs, and tissue samples. With biotechnology, cells *in vivo*, enzymes, DNA, as well as other biomolecules and structures are included. Do all these parts fall similarly under the property concepts described above? For purposes of property, is a feather the same as an egg? Unlike an egg, the feather is not alive and cannot auto-reproduce. A first simple distinction is the capacity of the part to become a whole organism. A fertilized egg can, without human intervention, become a whole animal. Similarly, but not identically, through biotechnological means, cells *in vivo* can (in some cases) be made to produce a whole organism. In both cases, one enters a realm in which the biota part is not a complete creature but has the potential to become one. This is related to the controversy over abortion. A feather or any other dead and non-auto-reproducible part would seem to have, for ethical, property purposes, lost its biota character. This would seem to apply to genes and other molecular pieces of biota. If the parts cannot auto-reproduce the whole organism, they have lost their full biota character and, if legally acquired, may be owned with no more or less ethical consideration than owning a pair of leather shoes.

Technological methods that allow the creation of whole organisms from single, non-sex cells present complexity to the whole-versus-part question. The ontogenous character of an egg conveys some difference to the egg compared with a test tube of cells. Both are capable of ontogeny, but the cells only by human labor. Human labor can thus alter the property-rights structure in biota parts.

Functional pieces of DNA (i.e., those that encode a biological function) represent a unique type of biota part. They are parts, but they are also part of the molecular “blueprint” of the organism and all members of the species. Removed from the genome, a gene cannot reproduce the organism and has, therefore, lost its organismal character. However, the catholic nature of a gene in a species gives it a public-good quality. Private property in a gene may be ethically problematic to the extent that such rights impinge on the public’s access to this good, not because it is a part of a wildlife species but because it is a public good. However, if owning a piece of DNA from wildlife does not preclude the public from access to identical DNA (since it is catholic and copyable), the public-versus-private issue is moot.

8.3.5 The Ethics of Property in Biota Specimens and Species

A biota-property right presents an ethical dilemma related to specimens versus species. Private property in one fish is a very different matter from owning the fish species. Owning one deer deprives the public of practically nothing if deer are plentiful. Owning all deer drastically alters the relation between the owner and the public and the ethical equation of property. The ethics of owning domesticated creatures is different from that of owning wildlife because they are not public goods. However, control of unique genetic resources of domesticated creatures presents a similar private-versus-public question. Should the maintenance of wildlife as a public domain be applied to genetically unique domesticated creatures? Does the public have some right in a rare breed of domesticated livestock, all the specimens of which are owned by an individual? From an animal-rights perspective, the collective species has no more or less moral value than an individual of that species (Singer, 1975; Regan, 1983). But, there is a difference here. Why is it justifiable to own one ladybug but not all ladybugs? The answer may lie in the utilitarian Lockean limit to “leave enough and as good for others” dictum for distinguishing the limit of private rights in a public good. The species is a communal resource, and as long as there are plenty of specimens, an individual is, practically speaking, not a communal resource. The Endangered Species Act is predicated on the idea that the value of society’s loss of a species is incalculable (Norton, 1991).

8.3.6 A Dog and a Sofa: The Moral Uniqueness of Biota Property

Consider property in a dog and a sofa. The owner may buy, sell, trade, give, or rent either one. As with any personal property, the owner may restrict others from possessing or using them. Both dog and sofa apparently fall within the same domain of personal property. A review of Honoré’s several rights of property ownership (Becker, 1977; Waldron, 1988) reveals that the owner’s right in the sofa and the dog are similar. However, one right stands out—the right to destroy, waste, or abuse. One of the owner’s property rights in the dog is constrained. The owner cannot be cruel to the dog, whereas there is no such prohibition with the sofa. The owner of the sofa may destroy it with impunity but may destroy the dog only by sanctioned, cruelty-free methods. Animal-cruelty laws limit ownership in the dog. So property in at least some biota is different from non-biota property. Biota have different moral considerations. Bentham (1948), Goodpaster (1994), and Singer (1994) have all argued for sentience and capacity for suffering as the fundamental criterion for moral consideration of a being. A dog presents an easy case because of human affection for and communion with this species. But organisms range widely in their cellular organization, sensation, motor control, and cognition; the moral relevance of these characteristics is explored in the next section.

8.3.7 Moral Distinctions of Biota Types

In any discussion of biota property, there is an implicit distinction between self-motile (e.g., free-roaming animals) and immobile (i.e., plants) biota. Historically, plants have been considered land fixtures and part of property in land. Is there a moral basis to this tradition? While Stone (1974) develops the thesis that trees and other "natural objects" have certain inherent rights, Regan (1983) and Singer (1990, 1994) consider only higher animals as beings with inherent rights that can mitigate against property rights. Taylor (1986, 1994) extends inherent rights to all living entities. Should the moral distinction be one of mobility? Level of tissue organization? Sentience? In terms of mobility and the capacity to sense and react to stimuli, a mollusk and an orchid are biologically similar, yet they are treated very differently under property law. To what extent do the rights of other species that have been described by animal-rights proponents apply to other creatures? What about "lower" creatures such as mollusks, insects, and protozoa?

Do the tenets of the dog and the sofa apply equally to other biota species—to a chicken, for example? Animal-cruelty laws for chickens are considerably weaker than those for dogs. This difference is due, in part, to the fact that, unlike dogs, chickens have long been considered food.[5] A property right in a chicken is stronger (or less mitigated) than those for dogs. What about insects? No one speaks of insect rights; nor are there any insect-cruelty laws. However, Lockwood (1987) describes evidence that insects sense pain, communicate, organize in social systems, and learn, and believes their level of sentience places them within the realm of our moral consideration. While Lockwood acknowledges that individual insects may be of infinitesimal moral significance, he states that humans "ought to refrain from actions which may be

[5] The fact that dogs are eaten in other cultures points out the cultural relativism of ethical perspectives or empirical judgments.

reasonably expected to kill or cause nontrivial pain in insects when avoiding these actions has no, or only trivial, costs to our own welfare" (p. 70).

What about even simpler creatures such as planaria, nematodes, protozoans, and fungi? Is it ludicrous to consider that microbes have inherent moral significance that would mitigate a property right? Hettinger (1995) does not think so. Clearly, the type of organism has a great effect on the ethics of a property right therein. A detailed analysis of the biological characteristics that affect property rights is required but will not be pursued here.

8.4 Intellectual Property and Biota

Tangible biota property is implicit in the discussion above. As Waldron (1988) points out, it is necessary to develop a legal framework in tangible property before moving to the intangible. Intangible property is widely and commonly accepted and plays an increasingly important role in modern economies. Corporate stock, commodity futures, insurance policies, bonds, promissory notes, and complex financial instruments exemplify the importance of such properties. Intellectual property, particularly patents, is a form of intangible property. Since the enactment of the United States Patent Law of 1790 and the first patent drawn specifically on biota in 1887 (issued to L. Pasteur), thousands of patents have been issued by the government on inventions from biota.

Does a link exist between tangible biota property and intangible intellectual property obtained therefrom, and, if so, is there an ethical implication to that link? Are there ethical considerations unique to intellectual property in biota subject matter *per se*, and do these considerations apply equally to intellectual property obtained from wild and domesticated biota? To answer these questions, it is important to examine the ethics of intellectual property *per se* and to then ask whether intellectual property from biota presents a special case. In other words, if patents are bad, surely patents from biota are bad. But, if patents are good, is it the case that patents on mechanical devices are good but patents on “life” are bad? And, finally, is there an ethical difference between a patent on an invention from a companion-animal dog and a patent from a wild animal?

8.4.1 The Link Between Biota Chattel and Intellectual Property

Obtaining a patent requires an invention or discovery. Making an invention or discovery from biota requires the possession and use of tangible biota. Through the necessity of physical possession, the existence of a personal-property right in the tangible biota precedes and, to some extent, dominates any ensuing intellectual property. That is, the holder of private property in tangible biota has, at least initially, a superior right in the tangible matter to the extent of their assertion of that right to control its possession and use by others.

Once intangible intellectual property is created from biota, it exists independent of the tangible property. There is a significant nuance in the relation between these distinct property types. A dog owner owns all the parts of the dog as long as they’re attached. Someone may obtain a patent on a gene sequence from that dog, and unless the owner has asserted his or her control over possession and use of the dog and its parts, the dog owner has no right in that patent. Conversely, the owner of the patent on the dog gene has no right in the actual DNA sequence as it exists *in vivo* in the dog. This scenario may be complicated if the dog part was obtained without the owner’s knowledge or permission.

So, with few exceptions,[6] intellectual property in biota is absolutely independent of tangible biota property unless the tangible-property holder has created encumbrances. What, then, is the ethical environment of intellectual property from

[6] Pure microbial cultures, cell lines, and certain plant varieties exhibit connections between tangible property and intellectual property.

biota? Answering this requires an understanding of the intellectual-property institution.

8.4.2 The Intellectual-Property Institution

Patents confer property rights in discoveries and inventions to the first inventor. This follows the first possession rule for creation of a property right (Rose, 1985; Lueck 1995). As with other arguments for private property, a justification for intellectual property is its utility in the stable functioning of a civil society based on rule of law and a free-market system.

Intellectual property is intended to accomplish the social goal of advancing the creative and technological arts by providing incentive to creators, inventors, and those who invest in such activities (Machlup, 1958; Lesser, 1991). With early roots in the first intellectual-property law of the Republic of Venice in the 1500s, the codified English patent law of 1642, and patent laws enacted in the United States, France, and Germany in the late 1700s, intellectual property has evolved into a global phenomenon (Crespi, 1997). Every nation now has some intellectual-property laws, although their scope, extent, and enforceability have historically ranged widely from country to country. At present, the General Agreement on Tariff and Trade (GATT) requires the global harmonization and implementation of intellectual-property laws. Although some question whether intellectual property is equitable and appropriate (Hettinger, 1989; Shulman, 1999), by many utilitarian measures, it is a widely accepted social good. Is such measure complete or satisfactory?

As a subset of property, intellectual property falls prey to the same ethical questions that beset property in general. However, intellectual property has characteristics that present unique ethical issues: for example, questions of privatizing the pool of human knowledge and intellectual property's demonstrated effectiveness in technological advancement.

The utilitarian justification for property rights in general similarly justifies intellectual property. But other than utility, is there an ethical justification for an inventor's right to own his or her intellectual fruit? Is intellectual property a justifiable right, supported by political economic theories of liberalism, or is it an inappropriate taking from the public good of human knowledge?

Shulman (1999) believes all knowledge is a public good and should be freely shared by all. He objects to patents as an unethical taking from the public pool of knowledge. This belief ignores the fact that patents are public documents. U.S. patent law requires complete and accurate public disclosure of an invention. And, unless Shulman also advocates a police state in which individuals must publicize everything they know, the alternative to patents is secrecy. Shulman's view also lacks an understanding of how technical knowledge is created, implying that the only investment is one's mind and hands. Technical-knowledge generation requires significant investment in facilities, salaries, and equipment. How should this knowledge creation be paid for? Shulman's prescriptions leave one wondering, and it is in this pragmatism that intellectual property finds much of its justification.

Ethical justification for intellectual property has at least two components (Ostergard, 1999). First, Lockean labor theory grants the creator inherent rights in something created *sui generis* by his or her labor, and second, intellectual property contributes to the overall social good. While Ostergard generally supports the property rights of a creator, he argues that the rights of the individual in his or her intellectual property must be counterbalanced by the public's right to general physical welfare. His arguments are based on the idea that there is a hierarchy of intellectual "objects" relative to physical welfare and that the rights of the "consumers" of intellectual property must be considered along with those of the creators of that property. For example, Ostergard points to patents on life-saving drugs in which the practical necessity of a patent right to encourage the investment needed to develop the drug collides with the ideal of curing human suffering. Recent controversies over patents on AIDS drugs exemplify this point.

Both Ostergard (1999) and Shulman (1999) view the labor basis of intellectual-property rights as flawed because the "cumulative process of invention" renders inventors—at most—co-inventors who rely on the labor of numerous prior inventors. However, this view ignores the patentability requirement for absolute novelty and nonobviousness. Only by clearly satisfying these criteria can an inventor demonstrate his or her unique intellectual creation of something unexpected and never thought of by anyone else. Ostergard claims that granting intellectual property to inventors makes all others "worse off" than they were prior to the granting of the intellectual-property rights because they cannot have free access to the invention. However, this notion is also contradicted by the patent-law requirements of novelty and nonobviousness. By these criteria, a patent takes nothing away from the public that it did not already freely enjoy before the patent was issued.

Ostergard (1999) believes human progress is hampered by intellectual property because of restrictions on the free use of an invention. But this belief ignores the fact that the patent-law requirement of candor and full disclosure provides the public with all the information necessary to understand and examine the invention. Because a patent is a public document, anyone is free to "invent around" the intellectual-property rights of the patent, thereby improving the invention and resulting in overall technical progress for society. Ostergard claims that patents shield the creator from the competitive forces that normally force product improvements and that the patent monopoly allows "artificially" high prices. But this interpretation ignores the role of competition in developing alternative and improved inventions.

Ostergard (1999) bemoans the failure of patents to benefit the public because they stifle the dissemination of ideas. However, the basic nature of the patent is "teacher of the nation" (Machlup, 1958). Ostergard also completely ignores the role of patents in providing incentives for the large investment needed to develop an invention from conception to completion. Doesn't this investment represent greater progress than the widespread dissemination of ideas that will never develop for lack of investment?

Ostergard (1999) boils his ethical argument down to a basic contention between private-property rights in ideas versus subsistence rights that require the use of those ideas. Ostergard believes that subsistence rights are superior to property rights because the right to survive is morally superior to the right to wealth. Using the example of an AIDS-drug patent, Ostergard would see an ethical wrong in using patent rights to allow someone to suffer and die. But isn't this an argument against any and all property rights? Is it not similarly unethical if a homeowner keeps a homeless person out? Does this argue against the private-property right *per se* or for a public-property-type solution?

Locke's labor theory of property is strongest when applied to novel creations (Waldron, 1988). By law, an intellectual-property right belongs only to the first creator of a novel creation. But Hettinger (1989) attacks the Lockean basis of intellectual property on several fronts. However, his critique of intellectual property suffers from several key blunders, including his mistaken idea that a patent provides its owner an exclusive right to make, use, and sell the patented invention. In fact, the only right granted by a patent is a negative one—the right to stop others from making, using, or selling the invention. Hettinger (1989) and Ostergard (1999) attack the labor and first-possession basis for patents by arguing that an inventor is not the sole laborer because the invention requires the prior work of others and because the labor of others was used to create the institutional framework of the patent system itself. The first part of this argument ignores the distinction in patent law between the "prior art" and the novel invention. To obtain a patent, an inventor must establish absolute novelty *vis à vis* any prior work of others. The second part of their arguments, that the labor of others is required to create and maintain the intellectual-property institution, argues against any property right. Hettinger argues that a patent deprives subsequent inventors (who independently toil on the same invention) of their rightful property, thus violating the Lockean proviso to leave "enough and as good for others." This is a rejection of the first-possession basis of most property rights and the "net positive social product" of asymmetrical appropriation in liberalism. Patent rights are time-limited, but Hettinger ignores this in suggesting a ludicrous solution limiting a patent to the time it would take others to invent the same thing. Hettinger (1995) attempts to weaken the desert basis for a patent by arguing that reward in the marketplace does not necessarily belong to the creator of value but, in any event, should be proportional to effort. That is, it is unethical when an easily made invention returns a greater reward than a more difficult invention does. This is obviously a criticism of the free-market system, in general. Why, for example, is it ethical for the inventor of the cure for a childhood disease to be rewarded less than the inventor of napalm? For that matter, why are the discovers of cures for disease paid less than movie stars or professional athletes?

Shulman (1999), Hettinger (1989), and Ostergard (1999) all argue against intellectual property as an unethical privatization of the common good of human knowledge. Shulman's thesis is that knowledge and its free exchange has always been a public good and that patents inappropriately remove ideas from this public domain. Both he and Hettinger (1995) characterize "intellectual objects" as non-exclusive economic goods, which, they believe, argues against the economic logic of private rights in such objects. These arguments suffer from a serious misconception about patents and a failure to appreciate the utilitarian argument for private property created from the knowledge commons.

Do patents restrict idea creation and intellectual intercourse? By law, ideas *per se* are not patentable; only ideas that are inventions conceived and reduced to practice are patentable. Further, a patent must “teach the nation” the best way to reproduce the invention. The requirements of “candor” and the “duty to disclose” the best mode and preferred embodiment of the invention provide all the knowledge of the invention as a public good. The right to exclude others from making, using, or selling the narrowly claimed patent is another matter. That restriction is justified based on the utilitarian return on investment. The knowledge contained in many patents costs a great deal to create, and without such investment, the knowledge will not be created. Hettinger belatedly acknowledges this fact and prescribes complete public funding and ownership of all intellectual work! Shulman (1999) attempts to weaken the utilitarian argument for intellectual property by pointing out the transaction costs of its management and litigation, but he ignores the fact that such costs also apply to any property type.

Hettinger (1989) invokes Locke’s spoliation proviso, claiming that it is wasteful when a patent holder withholds the invention from others. This could equally apply to any property, but it raises the point Ostergard (1999) elaborates on. Ostergard describes the ethical tension of the public’s right of access to an invention that is essential for human welfare. He points out that this dilemma is irrelevant for some inventions (a new compact disc) and acute for others (life-saving drugs). Can an inventor ethically withhold a cure for disease from those it would benefit? Such withholding appears to violate Nozick’s (1974) proviso that property acquisition must not make anyone “worse off” than before the acquisition. But a patent takes nothing away from the public that it freely enjoyed before the patent was issued. Ostergard's critical point is that any property needed to maintain individual well-being must be accessible. But, he also acknowledges the importance of property rights. The fundamental tension here is between property rights and subsistence rights. Ostergard claims that a patent holder's right may be outweighed by a duty to assist others. He describes a moral fulcrum where profits may come at the expense of human well-being. He argues that in certain situations, duties may outweigh rights, and that the duty to protect well-being outweighs wealth-based property-right considerations. Of course, such dilemmas are posed by any property rights in which social asymmetries arise.

The arguments that all knowledge should remain a public good are further analyzed by Boyle (1992). Boyle defines a basic social tension of intellectual property in a liberal economy. The ideal market requires perfect information, but the commodification of information renders the market imperfect. He points out the dichotomy of information as a commons in the public sphere and a private good in the private sphere. For example, while free debate, dialogue, and scientific publications are the lifeblood of the public domain, forcing individuals to provide private information for public databases is a different matter. Further, the Fourth and Fifth Amendments and the attorney–client privilege protect the individual from mandatory sharing of knowledge.

Unlike Hettinger (1995), Boyle (1992) understands that knowledge is not an infinite and costless resource; it requires incentive to create. Boyle concludes that there is no black-and-white answer to the ethical conundrum of knowledge as a public good versus a private right but that these opposing ideas can and must co-exist.

Patent property presents exactly the same problems as the liberal conception of property in general (Boyle, 1992). However, a basic question arises from the inherent purpose of patents. The overarching public-policy purpose of patents is to motivate technological development. Abraham Lincoln (a patentee) called patents, “the fuel that added to the fire of genius.” Compelling evidence indicates that patents do drive technological advancement (Machlup, 1958; Lesser, 1991). From a utilitarian perspective in which entrepreneurial capitalism feeds on and furthers technological development for the production of goods and services, patents are a social good. If patents are good because they catalyze technological development, a more fundamental question is whether technological advancement *per se* is good.

Crespi (1997) points out that patents are applied for, prosecuted, and issued in an ethical vacuum. There is nothing in the patent law that applies any ethical criteria: it is concerned only with ethical issues of truthfulness by the inventor solely on matters of patentability. The purpose of the patent law is guided entirely by the ethic of technological and scientific progressivism and the liberal economic faith in private property. Although some consider patents on biological materials to be “morally dangerous” because they “institutionalize disrespect for life” (Hettinger, 1995), I believe the ethical question here is not patents *per se,* but rather the technological development they facilitate.

8.4.3 A Critique of Technical Advancement

Winner (1986) presents a convincing argument that technology *per se* should be critically analyzed (but is typically not) for its intrinsic impact on socio-economic and political systems. Winner suggests that technology ought to be considered an integral part of the socio-political process and not passively accepted by the body politic because of long-held principles of economic efficiency, liberalism, and blind acceptance of inexorable technical change. Winner believes that framing public issues as mere questions of economic efficiency is inappropriate in the dynamic process of democracy. Winner critiques the blind acceptance of technology as it spreads throughout social spheres and argues for more moral and political discourse over the proper use and extent of technology.

Technology and social progress are inextricably woven in our cultural mindset. Beginning with the Greek dichotomy of humans and nature, and the Judeo-Christian view of linear history, with its providential progress, belief in the pursuit of technological solutions has been a given of western society. This faith in science and technology also has roots in the Baconian conquest of wild nature, Descartes' mind-and-matter dualism, and the Newtonian basis of the "divine watchmaker." The economic liberalism of Machiavelli, Montesquieu, and Adam Smith provided the basis for entrepreneurial capitalism as a great social good. This belief holds the pursuit of individual economic welfare, fueled by technology, as a hugely civilizing influence and the basis for a just and stable society (Polanyi, 1968). These ideas, combined with the scientific positivism of Descartes, Bacon, and Dewey, produce a faith in technology as an overwhelmingly positive force for human welfare. Arendt (1978) describes a belief that technological change, and the economic development it brings, equates to the building of a good society, regardless of its consequences. The idea of ever-expanding technology as a social good took root in the fertile soil of the United States with its virgin resources, liberal philosophy, technologists, mercantile society, and belief in manifest destiny. It is not surprising that the right to patent is written into the U.S. Constitution.

Although the great political movements of communism, capitalism, and socialism differ in how social goods and services are allocated, all are technocentric and technophilic. One reason communism failed is that it produced too little and shared too much, and capitalism may fail because it produces too much and shares too little. However, both depend on technology as a primary driving social force.

An overwhelming belief in economic efficiency and technology as a good has dwarfed concerns about the social impact of technology. Although many social problems have been caused by technology, viewing technology as a core problem has been derided as Ludditism.

Modern concerns over technology have been spurred by ecological treatises such as Carson's *Silent Spring* (1962) and the realization that technology can have unintended effects, such as pollution. While the downsides of technologies such as DDT, PCB, thalidomide, and plastic land mines are part of the social dialogue, Winner (1986) argues that these negative effects of technology are the tip of the iceberg and that technology has huge and often less-than-desirable social impacts to which we are blind because we are immersed in the technology-as-social-good dogma. Tenner (1996) presents numerous cases in which technology has unintended repercussions. Some are huge social negatives, such as pollutants that cause childhood leukemia. Others, such as the degradation of plastics, are merely annoying. Tenner alerts us to the widespread use of technology and its consequences—good and bad. Winner (1986) and Barbour (1980) go deeper to point out the profound cultural significance of technology. All implore for a public dialogue and critique of the assumption of the inexorable "advancement of technology."

Barbour (1980) describes four characteristics of modern technology that run counter to human welfare: uniformity, efficiency, impersonality, and uncontrollability. Each of these factors tends to dehumanize, counter individualism, and erode genuine community. Winner (1986) points out how technology facilitates centralization and social control and that, even without explicit choice by the body politic, technology advancement has become our dominant social form. Technology can also foster organizational gigantism to the detriment of smaller organizations and local communities. Winner argues that technology crowds out other forms of human activity, replacing artisanship and craftsmanship with mass-produced articles. Technology has also led to ever-more sophisticated and powerful means of controlling social and political forces and individuals.

Is the computer good or bad, or is it so intertwined in every aspect of who we are that the question can no longer be asked? Evaluating the goodness or badness of a technology is confounded by layers of interconnected ethical questions. Even anti-anthropocentrists who look askance at much of technology might think twice about technology such as Global Positioning Systems when used to mitigate human abuse of the environment.

Intellectual property covers a vast range of types of inventions, from simple devices to esoteric electronics, business methods, and software. What about patents on subject matter from biota? Strictly speaking, a wooden device is made from biota, but for this discussion, the question revolves on biotechnological inventions. Do patents from biota present an ethical taxon distinct from non-biota subjects? Is there any ethical basis for differentiating intellectual property on biota matter versus non-biota matter?

8.4.4 Biota Intellectual Property

Do patents from biota differ from patents on non-biota subject matter? This question is complicated by the difficulty in defining biota subject matter. Since the 1790 Patent Act, many patents have been issued on objects made from wood, and these are, of course, patents from biota. But patents on novel types of furniture are not the ethical question here. For this discussion, patents from biota include methods and materials such as cellular components, biological molecules, cell lines, whole organisms, and populations. Such patents include a large variety of inventions, including secondary metabolites or antibodies and other complex molecules made by organisms. Patents may be issued on genes that encode for proteins that confer certain whole-organism traits. Patents may be issued on isolated or genetically modified whole organisms, select plant varieties, or pure microbial cultures. Each of these exists in a different ethical milieu. First, let us examine a patent on a molecule isolated from wild biota.

The inventor who first purifies and characterizes a molecule from an organism is entitled to a patent on a first-possession basis because the purified substance satisfies statutory patentability. Is this different from a chemist who discovers a new polymer? Is there a difference between assemblages of inorganic elements organized into inorganic and organic forms? Isn't a living creature just a complex combination of carbon, hydrogen, oxygen, and other elements? The discoverer of a unique molecule from an organism is entitled to potential patent rights because, although the molecule pre-existed in the organism, human manipulation isolated it. Could it not also be argued that the chemist who first makes a novel inorganic compound similarly manipulates nature to produce a natural (in the sense that natural forces are used) compound? If a biotechnologist only manipulates pre-existing nature to produce a biota invention, could it not be said that the inorganic chemist merely manipulates the pre-existing nature of chemical reactions dictated by the natural laws of elemental structure and kinetics? Thus, distinguishing an ethical difference between a patent on inorganic molecules and organic molecules based on a difference between the human-made and the nature-made is difficult. Human-made molecules require nature-made processes and elements. At the level of chemistry, what is the difference between synthesized DNA and a synthesized organic polymer or inorganic compound?

Perhaps human-synthesized strands of DNA are ethically no different from strands of polyvinyl chloride. But can the same be said about a naturally occurring sequence of DNA (i.e., a gene) from an organism? At the level of chemical structure, isn't a gene just like an inorganic compound? Both are taken from nature by their discoverers. Of course, the gene is taken from something alive, but that is no different from taking a piece of hair or bone. However, a naturally occurring gene represents something more: it is a part of the blueprint of a living being. Is this a critical ethical difference?

Owning a cat is acceptable to all but the most radical animal-rightists. What, then, is the ethical difference between owning a cat and owning the DNA of or a patent on a gene from a cat? At one level, owning a cat and owning the DNA of a cat gene are the same. But there is a difference: specimen versus taxon. Owning a cat gives no rights in other cats, but owning the gene patent can grant exclusive rights to the technological use of that gene. This difference is an ethical boundary between a private right and the public good. Locke's proviso that an individual's right to privatize something from the public domain is limited by "enough and as good left for others" may be violated when the gene, which exists throughout a population, is privatized by the first possessor. Despite this, the political philosophy of liberalism allows such violations.

A critical aspect of patent law distinguishes the domain of private rights from the public domain of nature. A patent on a piece of genetic "blueprint" of an organism does not grant the patent owner a property right in the whole organism. That is, a patent on a gene sequence does not give the patent owner any personal-property right in the gene as it exists in nature, only as it exists as a technological entity. A patent on a gene does not give an ownership interest whatsoever in the free-roaming creature!

Do patents on whole organisms present a different ethical milieu? Is there an ethical difference between a patent on a whole organism and a patent on a gene? Unlike a gene, an organism is alive, capable of metabolism, sentience, and auto-reproduction. So, there may be an ethical difference based on "aliveness." The legal discourse in *Diamond v. Chakrabarty* case sheds light on this issue. Opponents of the patentability of a living organism[7] claimed that life has a "vital" or "sacred" property and that life could not be reduced to mere physiochemistry (Cooper, 1998). The principle of "vitalism" crumbled in the eighteenth and nineteenth centuries as the advance of reductionist science led to the blurring of any distinction between a "vital force" and definable physicochemical principles (Needham, 1930; Coleman, 1971). According to the Supreme Court, aliveness *per se* does not affect patentability. The 1980 Supreme Court decision in *Diamond v. Chakrabarty* represents a triumph of amoral property rights in the service of utilitarianism and a rejection of the principle of life sacredness as a prohibitive.

The argument against vitalism as a valid criterion of patentability raises important questions. In *Diamond v. Chakrabarty*, the Supreme Court rejected life-sacredness as a criterion relevant to an intellectual-property right. This provokes at least two ethical questions: What effect will lack of "sacredness" have on the commodification of biota, and what role, if any, should religious or spiritual beliefs play in the biota-property issue? A detailed discussion of these spiritual issues is taken up in a later section. But now, the question is the owning of a specimen versus the owning of an entire group.

What is the ethical distinction between owning a patent on a pure culture of a microbial species and having personal-property rights in a single animal specimen? For example, is there an ethical quandary if an individual owns the only specimen of a rare breed of domestic livestock? This is a taxon-owning question. What is the ethical difference between owning the only animals of a breed (and thus, that unique genetic resource) and a owning a patent on an organism? From the perspective of private rights in a public resource (i.e., the gene pool), the answer is none—except one: the patent automatically terminates 20 years from the date of filing, whereas personal

[7] That is, a bacterium modified by human addition of DNA-containing plasmids.

property can last in perpetuity. Thus, it appears that patents on biota are not ethically unique and fall into the same realm as any private property–public good dichotomy.

All of this argues that questions about patents on biota subject matter are not ethically different from general questions of tangible biota property and intellectual property.

8.5 Biota Property and Anthropocentrism

Property is a human construct and is inherently anthropocentric. This raises questions of anthropocentric versus non-anthropocentric ethical systems. The anthropocentrism of property-right theory is implicit in most philosophical systems, including those of Locke, Rousseau, Marx, Hegel, Bentham, Rawls, Marcuse, and Nozick (Waldron, 1988; Paul et al., 1994; Cahn and O'Brien, 1996). Pyle, Bentzien, and Opler (1981) describe a view that humanity's interests are the basis for ethical concern in non-human life and that such life is a "resource" to be used for human purpose. This fits Locke's view of wild nature as "waste" and human productivity as the essential good. Locke's arguments for property rights are based on human utility and the underlying theistic grant of human dominion over biota and all nature. Hegel's (1996) "Philosophy of Right" also claims a position of human dominion.

It is useful for a human to own a pig, but is it useful for the pig? What about human ownership of a wild animal? Some argue that biota have certain inherent rights that counterbalance strict anthropocentrism. Stone (1974) has argued that all natural objects have certain inherent rights. The idea of animal rights counterbalances human-centered, utilitarian property rights in biota. Beginning with Singer's work (1975), some have argued that animals have inherent rights that mitigate absolute human dominion (Regan, 1983; Gruen, 1994; Jamieson, 1994; and Watson, 1997). Going beyond animals, Taylor (1994) has defined a biocentric ethical view in which

> all organisms are teleologic centers of life in the sense that each is a unique individual pursuing its own good in its own way . . . humans are not inherently superior to other living things. (pp. 44–45)

Rolston (1994) describes a “vital ethic” based on ethical consideration for all life. He defines an ethic in which human respect for and responsibilities to other organisms, species, and ecosystems is based on a utility-and-value system that integrates human interests into a larger biosphere whole. Devall’s (1988) “deep ecology” philosophy is inspired by Arne Naess (1973), an “ecocentrist,” who believes the “natural world” has value independent of its usefulness to humans.

Alternatives to a strict human-centered ethic should be borne in mind when examining the ethics of biota property. It should also be kept in mind that although property is an anthropocentric construct, it can be used to primarily benefit non-human nature (Stone, 1974), for example, assertion of a property right in an ecosystem to protect it from human-made destruction.

8.6 The Cultural Dependence of Biota Property

Ethical constructs of biota property are culturally dependent. For example, owning a dog for the purpose of eating it is acceptable in Asian cultures and unacceptable in the United States. Owning a cow to make steaks is acceptable in the United States and abhorrent in India. However, there is a global dogma that ownership and dominion over biota is ethically acceptable (Hargrove, 1980; Beatley, 1994).

European and U.S. jurists, in support of the mercantile community, have led a historical globalization of property and contract law from Roman roots to a modern network of global business organizations backed by the economic and legal power of the U.S. and European governments (Braithwaite and Drahos, 2000). The worldwide system of clear and defensible property rights as the basis for market exchanges has its origin in ancient rules of mercantilism. Braithwait and Drahos make the case that the current paradigm of property and contract rules is ultimately based on economic and military coercion of the dominant economic powers, particularly the United States, and is designed by and for global capitalism. This coercion is manifested in the outcomes of the General Agreement on Tariffs and Trade (GATT) and Trade-Related Intellectual Property System (TRIPS) and the creation of global business organizations, including the World Trade Organization (WTO).

While it is clear that modern property-rights systems foster mercantilism and economic liberalism, this should not overwhelm an appreciation for other cultural paradigms. We should not forget that the concept of private ownership of land was alien to Native American cultures (Laveleye, 1878; Lafargue, 1894; Hughes, 1983), or that some modern views express alternatives to the dominant property paradigm, especially with regard to wild biota and the natural environment.

8.7 Commodification and Biota Property

The commodification of things is an issue fraught with ethical issues. Whether it is proper to commodify biota or not, this question remains: What is the relation of property rights to commodification? Utilitarian arguments, personal liberty, and economic liberalism provide the justification for property rights in practically anything. Private property is strongly linked to commodification, as a primary purpose of the property right is to affect trade. For market efficiency, property rights must be clearly defined, enabled, and enforced (Randall, 1987). Private-property rights in biota make it possible to trade such rights in a marketplace (Stroup and Baden, 1983; Hill and Meiners, 1998), and most, if not all, societies have accepted biota ownership and trade in domesticated and legally captured animals.

From a market-efficiency perspective, property mechanisms can solve natural resource problems, even for wild biota (Anderson and Leal, 1991; Lueck, 1995, 1998). And, if you believe in American liberalism, which bases the public good on a net aggregate of incremental increases in individual welfare through private transactions in a “free” market, commodification is desirable.

Commodification translates things into monetized terms, a situation that presents dilemmas in the case of wild biota. Norton (1991) describes the impossibility of quantifying the economic value of wild biota according to neoclassical economics and refers to the Endangered Species Act as an embodiment of this idea. Some argue that the commodification of nature is a serious strategic error that disregards other attributes that could outweigh market value (Farrier and Tucker, 2001) and creates potential perverse outcomes such as the loss of biodiversity (McCauley, 2006) and even social justice (Isla, 2005). But, beyond the quantification problem, let us examine the ethical significance of commodification *per se*.

Andre (1992) describes various things that cannot or should not be commodified: for example, humans and their relationships, public necessities, and subsistence needs. Some things are technically commodifiable but ethically unownable, such as culturally significant objects of great art or historical artifacts. Some things, such as personal honors and awards, cannot be alienated, while others such as personal rights and freedom can, but should not be. Regarding subsistence, there is an important distinction between owning a loaf of bread and owning all loaves of bread. Certain things may be exchanged, but only if there is no attendant financial gain, such as in the adoption of babies. Some commodities are ethically bad for both buyer and seller such as body parts and things in a gift relationship.

Commodification can have negative effects on the commodity. For example, commodification prices things, which are then commensurable with other priced goods, even if such things should not be valued. Furthermore, pricing emphasizes the instrumentality of things, detracting from intrinsic value. In summary, commodification can negatively disrupt social relationships and create social bads.

Northcott (1996) argues that the quest for economic growth drives the commodification of “more and more areas of human social interaction” (p. 75), which diminishes social goods and norms of behavior. He believes that trust, neighborliness, mutual regard, care, and non-violence are likely diminished by commodification and that commodification of nature is a major factor in environmental destruction.

If we accept that the commodification of natural wildlife may be ethically bad, is it also true of the commodification of domesticated biota? While animal-rightists would say yes (for many types of biota), most would probably say no. Environmental ethicists argue for relaxed anthropocentrism, but since their focus is wild nature, they may be ambivalent about the sale of dogs or pigs.

Let’s return to the question of commodifying wildlife. The commodification of biota emphasizes instrumental value and human dominance and serves human purposes: cultivation, manufacture, business. State and federal wildlife laws are focused on prohibition of the commercial use of wild biota, and the rise of such laws was spurred by the destruction of wildlife for market purposes (Tober, 1981; Bean and Rowland, 1997). Currently, there is widespread acceptance that the commodification of domesticated biota is not ethically problematic. But this is not true of wild biota. A thriving but regulated market in zoo and aquaria specimens is perhaps another matter. The commodification of these creatures may be acceptable because of the educational, scientific, and conservation purposes of these institutions. McCauley (2006) has described a set of problems that could arise with wildlife commodification. First, it values biota that have human utility and the expense of those that have none or less than none. The volatility of markets may prove ineffective in the long-term protection of biota. He believes protecting biota should be a wholly moral issue, like civil rights. And as Farrier and Tucker (2001) point out, it is critical to preserve potential value, which is very difficult to commodify.

8.8 Biota Property and Religion

The Supreme Court's rejection of the sacredness of life as a criterion for precluding or mitigating intellectual property in *Diamond v. Chakrabarty* is a triumph of utilitarianism. But has the court's rejection violated other ethical principles? Religion is an obvious place to look. How do religious doctrines relate to biota property generally, and to intellectual property from biota in particular?

Webster (1952) defines that which is sacred as "holy, set apart and consecrated; hallowed by association with the divine and protected, in some fashion, by religious sanction; it is something worthy of reverence and respect."[8]

All of the world's major religions speak of the sacredness of life. For example, in 1986, representatives of Buddhism, Christianity, Hinduism, Islam, Judaism, Baha'i, Jainism, Sikhism, and Taoism met and expressed life's sacredness in the Assisi Declarations (Posey, 1999).

For Christians, Muslims, and Jews, life is created by a monotheistic God. Respect for life follows from devotion to and adulation of God, the Creator. These religions have a very strong anthropocentric core: Humans are made by God *imago dei*—in God's image. Humans are closer to God than to other creations and are first in the hierarchy of creation. Humanity's role is one of dominion and stewardship over all life: the Christian "steward," Islamic "khalifa" (vice-regent), and Judaic "leader and custodian" of God's creation. While there are various interpretations of the meaning of human dominion, these religions generally accept that wanton disrespect and abuse of life is disrespect for God. However, it is also clear that non-human life exists to serve the needs of humanity. The Assisi Declarations (Posey, 1999) reflect these values:

> Acts of irresponsibility towards God's creatures are an abomination (Christian);

[8] *Webster's New International Dictionary* (1952), s.v. "sacred."

> Humanity is a very special creation among all God's creations and must act as God's steward as responsible for the Earth's integrity (Islam);
>
> Humanity, as the leader and custodian of the natural world, must exhibit justice and compassion (Judaism);
>
> Humans are co-inhabitants of the earth and other species have the right to survive (Buddhism);
>
> The human race is not something apart from the Earth and its life-forms, the divine is not exterior to creation and thus, a reverence for life is required (Hinduism);
>
> The natural world is a reflection of God and that nature is to be respected and protected (Baha'i). (pp. 604–607)

Islamic teaching includes "Iawheed," a doctrine of absolute monotheism and divine ownership of nature by Allah. Man, next in the hierarchy, is appointed over nature as khalifa. Allah prefers the unprogrammed free will of man to the programmed goodness of angels and has conferred on man the power of reason and obligation to balance intellectual judgment with moral commitment to justice. Allah has given humans the right and power to use, but not abuse, the "nourishing goods" of the Earth. Extravagance and excess are forbidden, as man should conserve the balance of Allah's creations. Mammon is an evil, and its pursuit is forbidden. Nasr (1990) argues that for Muslims, the technological domination of nature is a sign of deep spiritual lack in the denatured experience of modern humanity.

Judaism places the earth under human dominion, as described in Genesis 1:26 (KJV): "And God said, 'let us make man in our image, after our likeness and let them have dominion over the fish in the sea, and over the fowl of the air, and over the cattle and over all the earth and over every creeping thing that creeps upon the earth.'"

Judaic teachings hold that the relationship between man and nature is one of ownership and that love of nature may not take precedence over love of man.

All major religions teach respect for life. Their precepts do not prohibit property rights in biota *per se*. How one uses those rights, however, is another matter.

Christianity plays a primary role in the analysis of biota-property ethics. An exploration of its varied interpretations of the human–nature relationship is illuminating. A great deal has been written on the Christian relation of God, humans, nature, and economics. White (1967) triggered some of this debate when he indicted Christianity as a primary cause of modern environmental destruction. White views the Bible as a clear call for human dominion over nature. White's provocative argument is that Christianity, capitalism, liberalism, and technology have produced environmental destruction. White's theme is fueled by Weber's (1998) thesis that Christian adulation of capitalism and individual wealth accumulation is firmly based on Protestantism.

The Christian view of non-human life balances on a fulcrum of deity–nature dualism versus wholism. In ancient religions, deity and nature were unified (Keller, 1990). However, because of the biblical doctrine of fallen nature, Protestantism removed the spiritual power from the natural world (MacIntyre, 1981). Christian theologians purged the natural landscape of its sacred qualities and replaced it with God's actuality solely within the human individual. Martin Luther reduced nature to a repository, at the service of man, for the work of God through man (Hendry, 1980). Thomas (1986) argues that the deification of nature ended with the advent of private property, the money economy, and Protestant desacralization of the natural world.

In his modern fundamentalist interpretation of the Bible's teaching on nature, humanity, and God, Beisner (1997) believes humans have an unequivocal mandate of dominion over nature; that wilderness is "waste," in which God is displeased; and that the human cultivation and subduing of "cursed" wilderness and nature to create the "garden" is desired by God. In Beisner's theology, humans have a duty to subdue nature and increase nature's productivity—for human ends. Although Beisner believes that wanton destruction and waste of nature is ungodly, he believes that “nature transformed by . . . man” is much preferable to pristine nature. Beisner asserts that the free market, constrained only by God’s law, is the manifestation of humanity’s biblical stewardship duty. Beisner rejects the premises of an environmental crisis, that biodiversity is truly threatened, even that biodiversity is necessarily a social good. Such narrow anthropocentric views have produced indictments of Christian teachings for their negative impact on the natural environment (White, 1967; McHarg, 1969; Moncreif, 1970). Nash (1989) believes that Christianity and Judaism are partly to blame for ecological destruction because of their overwhelming anthropocentrism and demonizing of nature and their central role in developed industrial societies. Stoll’s (1997) historical study of Protestant influence on the environmental movement and capitalism in America describes how the themes of “fallen nature,” “human dominion,” and “stewardship” have produced a philosophy of nature as an anthropocentric warehouse, a belief in manifest destiny, a conquest mentality, and a mind/nature dualism. However, there are alternative views of this indictment of Christianity.

Samuelson (1961) rejects Weber’s (1998) link between Protestant theology and capitalism, arguing that other social forces have played a more important role. Such forces include mercantilism, the Enlightenment, Darwinism, and economic liberalism and its faith in economic expansion as the preferred means for enhancing human welfare. Passmore (1974) points out that the Christian denigration of nature is really an attempt to distinguish Christianity from nature worship with its myriad fears, taboos, and inhumanities, abundantly described by Frazer (1963). This view places nature at the bottom of the Christian moral hierarchy. Passmore also argues against Christian responsibility for “ecocide” by stating that ecological destruction results from a complex of social forces and that many environmentally problematic concepts (such as mind/nature dualism) are actually rooted in Greek thought. As emphasis, he points out that modern non-Christian cultures do not manifest greater environmental virtue.

Some Christian theologians have responded by admitting that some expressions of Christian theology may be “environmentally toxic” or, at least, complicit in some “earth destruction” (Hessel and Ruether, 2000). They accept that Christianity has played a role in the conquest of nature, driven by technological and market-based economic expansion. But they also believe Christianity provides a basis for “eco-theology”—that Christianity can contribute to a sustainable earth–human relationship by connecting contemporary science (particularly, ecology) with biblical teachings of community and justice. Since Christians are primarily concerned with human welfare, they can be persuaded to support economic liberalism. But, in eco-theology, a wholistic God cares for the well-being of humans and the earth; Godliness includes a theological and biological kinship between humans and nature and a belief that the natural world reveals God. A number of Christian ethicists have constructed a cosmology that differs from the narrow anthropocentrism of Beisner (1997). Nash (1991) extends Christian love to God’s creations and includes non-human “neighbors” in the “love thy neighbor” commandment. Wallace (1996) believes God is the tangible universe, that ecocide is deicide, and that damaging the earth harms the “mystery we call God.” Northcott (1996) believes that the ecological crisis is a moral one and that the Christian tradition provides a basis for solutions. He replaces narrow anthropocentric Christianity with an “ecologically-informed focus” on humanity and the “moral significance” of the natural order. Northcott argues that Christianity does not legitimate “ecological plunder” and that under Christianity, the human relationship with nature is a covenant. However, Northcott does believe the root cause of ecological destruction is the Calvinist “gospel of prosperity” combined with Adam

Smith's mantra of individual wealth-striving, which has produced a faith in property accumulation, self-interest, and avarice as means of achieving the public good. However, the environmental catastrophe of Soviet-style communism counters this argument. Northcott states that the Christian restraint of self-interest and its belief in community provide solutions, and that unbridled consumerism, the myth of inexorable human progress by technology, and economic expansion—not Christianity—are the real culprits. He argues that it is the loss of Christian ethics and the modern denial of teleological and moral significance of "embodied, biophysical, existence" that lays the natural world open to wanton physical reordering by humans. Northcott believes money has displaced God as the ordering force of human relations, allows abstractions of human welfare, and dissipates the relationships between social classes and "between humans and nature."

For Northcott (1996), the money economy and technology produce an instrumental view of nature that has gone "hand in hand with the demise of the traditional Christian view of creation as the sphere of God's providential ordering" (p. 83). Northcott decries the continual quest for economic growth as motivating the expansion of commodification into more and more spheres of human endeavor.

The loss of Christian temperance, combined with un-Christian pursuits of individual pleasure and materialism, has also driven environmental destruction. Hessel and Ruether (2000) describe how the Christian tenets of economic sufficiency, generosity, self-restraint, frugality, and values independent of market value provide a basis for an ecologically sustainable society.

Wallace (2000) describes a biblical basis for God as Holy Spirit that indwells and sustains all life-forms and a Christian ecotheology that is shifted toward a "biocentric model of spirit in nature" in which God and earth are inseparable. Low (1996) refers to Celtic theology to similarly develop a modern, Christian nature theology. McDonagh (1994) rejects narrowly construed Christian earth stewardship because it fosters ecologically and socially unjust economic growth. He calls for an earth-centered Christian "ecological ministry" in which the dignity and value of humans is not abandoned but in which respect for other creatures is incorporated with traditional Christian ideals that prescribe personal lifestyles of moderation, simplicity, harmony, and discipline. Bratton (1993) counters the view of wilderness as a godless or demonic state. She rejects the idea that Christianity inherently considers wilderness as evil, as imparting evil, or that it is incompatible with wilderness preservation, describing the biblical tradition of wilderness as a setting for spiritual events.

Some modern Christian writers search for a connection between God and nature. Gilkey (1993) describes nature as the *imago dei* (image of God). He believes the power, life, and order of nature are "traces" of God's activity and presence, that order is a sacred principle, and that a mechanistic explanation of biological order is improbable. Other traces of God in nature include evolution, the human psyche, and the union of life and death. Gilkey points to verses in Matthew, Joshua, Timothy, Psalms, and Job that describe the order, beauty, and regularity of nature as signs of God. He arrives at this sacred nexus of God and life: "this is DNA . . . Here, if anywhere is the locus, principle or vehicle of the sacred in nature . . . It is DNA, not the neutrino that is the icon of the sacred" (pp. 96–97). Expressions of a more encompassing Christian nature theology from mainstream Protestant religions are demonstrated in these recent church declarations:

> The claim to have mastery over creation has resulted in the senseless exploitation of natural resources . . . every creature and whole creation in chorus bear witness to the glorious union and harmony with which creation is endowed . . . [9] we affirm that the world as God's handiwork has its own inherent integrity; that . . . all creatures . . . are good in God's sight. We will resist the claim that anything in creation is merely a resource for human

[9] The World Council of Churches, declaration in the Granvollen document of 1988 (Posey, 1999).

> exploitation. We will resist species extinction for human benefit . . . and the policies and plans which contribute to the disintegration of creation . . . it has been human selfishness, greed, foolishness or even perversity that has wrought destruction and death upon so much of the planet.[10]

> The divine presence of the Spirit in creation binds us human beings together with all created life . . . we are accountable before God in and to the community of life . . . as priests of creation. This requires attitudes of compassion and humility, respect and reverence.[11]

While these mainstream religious statements clearly call for respect for nature and acknowledge the divinity in nature, there does not appear to be any ethical prohibition of property in biota, and some views even prescribe it. Further, there does not seem to be any Christian prohibition against intellectual property from biota, although Gilkey's (1993) thesis of DNA as an "icon of the sacred" raises interesting questions. Christian teachings do provide guidance on the use of such property rights. Certainly, the use of biota property to harm persons violates religious principles. Similarly, while property in biota is compatible with traditional religious ethics, if such property is used to abuse God's creation, an ethical barrier probably exists. For example, using ownership to wantonly harm violates the stewardship commandment.

Despite significant differences in doctrine between mainstream religions, they all support biota property. This is based on the monotheism of Christianity, Islam, and Judaism, a God outside of nature, humans as God's special creation with dominance over all other creations, and the goodness of nature measured by human utility. The teachings of mainstream religions and the political philosophies of modern economic liberalism are tailored for human use of nature and anthropocentric progress through private-property rights. However, the unfettered, anthropocentric use of nature has origins in the teachings and philosophies of several hundred years ago—long before the ecological crisis evolved as a human concern. For example, when confronted with

[10] The World Council of Churches 1990 Affirmation.
[11] The 1991 World Council of Churches General Assembly.

the problem of private- versus public-property rights, Locke suggests that the New World will supply boundless lands and resources for all. Modern awareness of a finite Earth, an ever-increasing human population, and ecological degradation has stimulated a rethinking of these basic philosophies (O'Briant, 1974; McKibben, 1989; Northcott, 1996).

Some Christian ecotheologians have reinterpreted the relation of Christian theology and practice to humanity's relationship to the environment. Fowler (1995) describes a wide gulf between Christian ecotheology and apocalypticism. According to Fowler, Christian ecologists believe in the possibility of eco-collapse and are willing to take counter action. Apocalyptics believe that saving nature is futile because preparing for the return of the Savior is paramount. Fowler also describes "Green Protestantism," a Christian ecotheology characterized by a focus on human welfare through the political good of community and an unease with liberalism and its emphasis on individuality, rationalism, and capitalism. Green Protestants believe community is the nexus of humanity and ecology (Ellingson, 1993) and that Genesis can be interpreted such that human "domination" of nature is, rather, "dominion" and stewardship.

Do other spiritual belief systems, particularly those that place wild nature in a spiritual context, create ethical boundaries on biota property?

8.9 Biota Property and a Spiritual View of Nature

Anthropocentric monotheism, in which the Creator is external to nature, establishes a dualism between the sacredness of man and his Godly works, and a mechanistic world in which desacralized nature is mere backdrop and props for the sacred human drama. An alternative, sacredness in nature, can be found in many ancient nature mysticisms and religions (Frazer, 1963). This fundamental divide has produced thousands of years of struggle between nature-as-sacred and man-god-as-sacred. McIntosh (1999) describes the transition from nature-as-sacred paganism to Christianity as embodied in the early Celtic Christians, who integrated God and nature: the long conquest of pagan Celtic religion by Christianity, in which the Celts' "high regard for nature" and "gentle . . . love for all creations" was lost as Christianity focused less on nature and more on the salvation of the human soul (Hull, 1993). History is replete with the destruction of animistic religions of native peoples by Christian colonizers of the New World and Africa (McManners, 1990). Frazer (1963) describes how nature-worshipping peoples were freed from irrational cycles of subservience to nature's whims, blood sacrifice, and acts of inhumane propitiation by a nature-free theism. Although the violent and inhumane worship of a nature deity seems a long-distant memory, "nature-worship" is still viewed negatively by some traditional religious believers such as Pat Robertson (1991).

Modern expressions of nature-as-sacred draw upon reinterpretations of traditional religion (Hayden, 1996), new spiritual developments, and syntheses of spiritual teachings with ecological theory (Spangler, 1993). Page (1996) describes "pansyntheism," in which nothing is outside God's presence; God is not a finite creature but each creature has a relationship with God. Spangler uses the "Gaia Hypothesis" of Lovelock (1979), in which the Earth is a living organism, to develop a spirituality of Earth as sacred being and cornerstone of an eco-theology.

Hayden (1996) draws out the nature-loving tenets of Christianity, Judaism, and Buddhism to create an "Earth Gospel" that provides a spiritual basis to protect the planet and its "life systems" from the destructive forces of "industrial enterprise."

The modern American nature-as-sacred belief has roots in the writings of the ecstatics and romantics such as Muir, Thoreau, and Emerson, in which a monotheistic God is not rejected but is manifest in nature. Stoll (1997) describes how neo-Platonism, a yearning for union with God through worldly beauty, led to natureecstasy writings in which nature theology in America evolved to enlist reason, rather than mysticism, to articulate God through scientific nature study.

Some spiritual views are wholly nature-centered. Neo-pagans believe that nature *per se* is holy and that Divinity is immanent in all nature (Adler, 1986). Modern expressions of pre-industrial religions often define God and spirit synonymously with nature.[12]

Nature-as-sacred philosophies share beliefs that veer from a strict locus of sacredness in man and an external God toward non-human creation (living and non-living) as embodying a sacred principle. All share a belief in a shift from God as the sovereign power outside of and ruling over nature to a God who is within and around everything, supporting and sustaining all nature and humans in a holistic community. They share a de-emphasis of the mechanistic nature of Descartes and Bacon, to a view of all life as an organic whole. Nature-as-sacred rejects the ethic, exemplified by Dewey (1939), that nature has neither purpose nor intrinsic value and that maximization of wealth in which nature is merely a source of goods and repository of wastes is the ultimate good.

What, then, should be made of the relation of property in biota to the nature-as-sacred belief? Property is a purely human construct, intrinsically anthropocentric, and tailored for commodification. This would seem to run counter to nature-as-sacred. Commodification is a powerful corollary of property and can be intrinsically unethical and damaging in certain spheres—certainly in sacred spheres. Weiskel (1999) relates the story of Jesus and the money-changers in the temple (Matthew 21:12). Regardless of the ethics of the commercial transaction *vis à vis* buyer and seller, the transaction itself is blasphemous. Weiskel believes this should also apply to biodiversity as a source of goods. Andre (1992) points out that commodification is antithetical to

[12] Declaration of the International Meeting around the First World Gathering of Elders and wise persons of diverse Indigenous Traditions (in Posey, 1999).

sacredness. So, would a property right in biota profane sacred nature? In practice, property in biota is utilitarian and rarely, if ever, considered a violation of the sacred. Property and commercial transactions in livestock, pets, or zoo specimens are not profane. However, before biota property is unquestionably accepted, it should be recalled that it has not been so very many years since property in humans was considered an ethical practice.

Although a property right may, in many cases, equate to commodification (and thus a profaning of the sacred), it need not necessarily do so. The antiquated *res sacrae* or sacred property was a common type of property hundreds of years ago. But it is hardly apparent today. The assertion of a *res sacrae* property right by the Catholic Church in the Pope's mitre does not profane the object—it protects it. So, the property right *per se* does not inherently affect sacredness, but rather the intent and use of that right. Thus, holding a property right in an endangered species in order to simply profit with no regard to the species is profane. But using the property right to protect the species, even while profiting, may be sacred.

The mechanistic, Cartesian reductionism of biotechnology and intellectual property seems somewhat contrary to nature-as-sacred. But this view would indict all the life sciences of medicine, environment, agriculture, and veterinary medicine. Is it profane to conduct mechanistic work on life to produce a result that is used to preserve life? Is it a violation of the sacredness of life to obtain a cell culture that is used to preserve endangered species? Does a sacred end justify profane, mechanistic means? This raises two final aspects of the nature-as-sacred versus utilitarian property dichotomy: ethical complexity created by aggregations of ethical concerns (even within a single event or action) and the need for a practical ethics.

Ethical complexity is a result of the ethically different components of a single act. The interplay of these components presents conundrums that stymie the practical application of moral absolutes. When a soldier kills an enemy soldier in war, is that act right or wrong? What if the soldier kills in hate rather than remorse? What if the war is unjust or illegal? What if the soldier killed is a criminal, and the killer a philanthropist? What if the war is unjust but the killer is a philanthropist killing another philanthropist to save the life of an innocent child? Any number of ethical layers can be aggregated, producing different ethical quandaries.

Consider property in biota and the sacredness of nature. Does it violate the sacred to possess a wild animal in order to exhibit it for entertainment or profit? What if the entertainment is demeaning or cruel, or educational? What if the cage is uncomfortable? What if there is no profit motive and the cage is a good facsimile of the animal's natural habitat? What if the purpose of caging is research on a disease that threatens the wild population of that animal? It seems that the violation of sacredness hinges, at least in part, on the end purpose of a property right. Perhaps a *res sacrae* property right asserted in biota for the purpose of its protection, even when involved in a profitable transaction, is a moral good.

Norton (1991) describes the need for useful ethical guidelines that will inform real situations in his critique of non-anthropogenic "deep-ecology." Absolutely avoiding the use of nature as a human resource is impossible. Absolute nature-as-sacred is a difficult ethics template for the making of difficult decisions concerning humans and nature. A non-anthropocentric view of nature-as-sacred may be a valid moral theory and a necessary counterbalance to the obsessive and destructive anthropocentrism of the past but, alone, cannot clarify real-world ethical dilemmas if too strictly adhered to.

8.10 Biota Property and Environmental Ethics

Property rights are a cornerstone of mercantilism and economic liberalism and are essential for an efficient market function that rations natural resources among free, economic individuals (Stroup and Baden, 1983). As Rose (1985) makes clear, the state-supported right to acquire and defend property is tailor-made for a merchant people that adhere to economic liberalism as the road to human well-being. Conversely, Taylor (1989) believes that a focus on efficiency in the search for happiness can lead to the destruction of a society's way of life.

Biota property aligns with the ideals of free markets, liberalism, and mainstream religion, tempered only by limited constraints that preclude animal cruelty, waste, and the egregious taking of public goods. Constraints on the commodification of biota by property mechanisms are overwhelmed by the mercantile ethic and its global reach (Braithwaite and Drahos, 2000). Mainstream religions are attuned to an ethic that easily allows or encourages a mercantile and mechanistic use of biota. A spiritual view of nature provides some mitigation of this utilitarian view. Is the environmental ethic relevant to the question of biota property?

Environmental ethics include beliefs that the natural, non-human environment has intrinsic value apart from its human use in a market economy. Environmental ethics provide another perspective—mostly non-transcendent and largely based on ecologism and its subtending scientific disciplines. The varied expressions of environmental ethics are an important framework for interpreting the rightness of biota property.

The early beginnings of an American environmental ethic can be seen in the late-1800s tension between John Muir's God-in-nature and Gifford Pinchot's stewardship of natural resources. John Muir's "wilderness gospel" made a moral good of wilderness beauty as divine immanence. Muir believed that God's word could be read in the "Book of Nature" more readily than in the Bible (Miller, 1993; Stoll, 1997). Muir's "divinity in nature" conflicted with Pinchot's utilitarian natural-resource conservation philosophy (Norton, 1991). Muir viewed utilitarianism as Mammon worship that would destroy the holy places of wilderness. Pinchot also believed in God, but in the rational stewardship of God's resources by and for man. Muir came to view the private ownership of land as a primary roadblock to preserving God's temple of wilderness. Pinchot shared Muir's concern with private property but for different reasons: Pinchot believed unbridled private rights in resources were antiethical to the moral goal of resource conservation for the greatest public good. Stoll (1997) describes how these two men's views, both rooted in Calvinism, came to a head in the political battle over the damming of Hetch Hetchy Valley near Yosemite, California. This debate continues today as some call for a dismantling of the Hetch Hetchy dam. Muir considered the drowning of this beautiful valley as the destruction of a temple of God, whereas Pinchot viewed unused wilderness as a waste of God-given resources. Muir lost the Hetch Hetchy battle, but the debate spawned widespread belief, especially in New England, in the idea that nature had intrinsic worth—an idea that provided a basis for a modern environmental movement.

Seeds of early environmental ethics were also sown by Thoreau, who popularized an "Ethic of Adoration" for nature that emphasized the moral good of social asceticism (Santimire, 1985). Thoreau's ethic rejected consumerism, reckless economic development, and human appetites in the service of and love for nature. The writings of Muir's contemporary John Burroughs gave further voice to an environmental ethic based on love of nature for its own sake and its redemptive powers for humanity (Wiley, 1967; Bergon, 1987).

Environmental ethics also has roots in the evolution of the concept of ecology. Perkins (1965) espoused the first environmental ethic arising from an ecological basis rather than from the transcendentalism of the nature ecstatics. The ecology-based environmental ethic was given modern impetus by Leopold's "Land Ethic," formed in his professional wildlife ecology experiences (Leopold, 1949) and by Rachel Carson's

Silent Spring (1962), an alarming account of ecological destruction by pesticides. These works, followed by other indictments of society's destruction of the environment,[13] stimulated a rethinking of society's relation to the environment.

In reaction to the apparent cause of environmental destruction, a number of ethicists began to challenge the premise that moral good is defined solely in an anthropocentric framework (Zimmerman, 1998). Awareness of the centrality of ecology awakened the notion that absolute anthropocentricism may be flawed. Environmental ethics is a shift, weak or strong, from narrow anthropocentrism. Weak shifts from anthropocentrism are represented by "anthropocentric reformers" who believe the cause of dysfunction in the human–environment relationship is not human-centered values *per se* but rather flawed human behaviors such as ignorance, greed, illegal acts, and short-sightedness. Such reformers believe the situation can be remedied by existing institutions. Ecofeminists (Mies and Shiva, 1993) and social ecologists also believe the problem is not anthropocentrism *per se* but rather the inherently inequitable institutions of patriarchy, capitalism, corrupted wealth, racism, and other social injustices. Strong shifts from anthropocentrism include the radical ecologists and animal-rightists. Radical ecologists include deep ecologists, biocentrics, and ecocentrics, who call the displacement of humans the locus of morality.

Much of the intellectual dialectic of human and environmental ethics has centered on the proper locus of intrinsic value. If this locus is not human, what is it?

Leopold's (1949) locus of ethical value is the ecosystem (the "land," in his lexicon). It is holistic, not individualistic, and denies human superiority. Leopold defined his ecocentric, moral compass as follows: "A thing is right when it tends to preserve the integrity, stability and beauty of the biotic community; it is wrong when it tends otherwise" (pp. 224–225).

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[13] *The Closing Circle* (Commoner, 1971), *The Population Bomb* (Ehrlich, 1968), and *End of Nature* (McKibben, 1989).

The idea that the integrity of an ecological community is the defining principle of the environmental ethic differs from the animal-right ethic (Regan, 1983; Singer, 1990) in being inclusive of all living creatures, their natural behaviors, and the connections between creatures and their abiotic support factors. Ecocentrists place highest value on the soundness of the ecological whole, including the interconnections of creatures ranging from sentient higher animals to microbes.

The animal-rightist locus is higher animals, a view that produces an ecological blind spot. Singer (1990) applies the Benthamian utilitarianism of pain = bad, pleasure = good to sentient animals, but this does not prohibit the painless killing of animals. Regan (1983), on the other hand, extends inherent moral value to certain animals and thereby confers the right to be free from human domination to such animals. While animal rightists may be considered non-ecocentrists or "speciesists" because their moral locus is limited to higher animals (and in some cases, only mammals), Callicott (1994) points out that their view provides a "way station" between absolute anthropocentrism and an environmental ethic. Callicott relies on Leopold's ecocentric moral good to argue that the animal-rights ethic leaves many creatures out of moral consideration and ignores the necessary ecological wholism of a truly informed environmental ethic.

Taylor (1981, 1986) attempts to justify a "biocentric" ethic in which the good of the biotic community is the moral optimum. His ethical locus is the "teleological center" of each and every organism. He rejects human superiority as simply an irrational bias in our own favor. For Taylor, each wild organism is a teleological center, independent of human instrumental use. Property in organisms is antithetical to Taylor's teleological centers to the extent that property is a utilitarian value, unless such property could be used to serve the teleological interests of organisms. Goodpaster (1994) extends moral consideration to all beings that are "alive" (i.e., that harbor the “life principle”) and believes that unfettered human freedom of action regarding non-human beings is human chauvinism.

“Bioegalitarianism,” the idea that all creatures have inherent and equal value, has generated a great deal of controversy and may have use in theoretical justification for some shift from anthropocentrism, but it would be “diabolically difficult to practice” (Zimmerman, 1998). Taylor’s extreme non-anthropocentric biocentrism would undoubtedly infuriate adherents of mainstream religion and utilitarians. Sylvan and Bennett (1994) place less emphasis on the value of an individual, shifting the focus to “wholistic entities” such as biomes and ecosystems. Such wholism is troubling to those who fear loss of individual human rights. Bioegalitarians and ecocentrists have been labeled “environmental fascists,” a name that recalls the human tragedy of the Holocaust that resulted from an erosion of the supreme morality of human-centered value (Regan, 1983).

This tension between atomism and wholism is exacerbated by the imperative to maintain liberty-strong private-property rights as a shield for the individual against an oppressive state and other members of society. From an environmental perspective that values ecological wholeness and integrity, advocates of strong property rights seem too willing to allow ecologically destructive commodification. As Waldron (1988) points out, the “utmost property right” in a thing is the right to destroy it. Therefore, strong private-property rights are necessary to protect individual liberty, which may include the individual’s right to own parts of an ecosystem and to destroy those parts as well as the intact ecosystem. The ecocentric view would argue that ecological integrity has a higher rank than the individual’s right in property. Ecologically based ethics favor wholism at the expense of the atomism of private-property rights. But this ecological view is tempered by the specter of “eco-fascism,” in which individual rights may be trampled by an aggressive state (Bookchin, 1988).

Rolston's (1991) attempt to synthesize individualism and ecocentrism creates a gradient of moral value in which all living beings have a moral good of their own with a premium for sentience and self-consciousness. In Rolston's ethic, humans take precedence in critical decisions, and ecosystems have value derived from the aggregate of intrinsic value of individual organisms. For Rolston, a "vital ethic" respects all life, and the species (the "genetic set") is the telos; therefore, an individual member of the species has less moral weight than the species as a whole.

The ethical clash of animal-rightists and ecocentrists is evidenced by the U.S. Fish and Wildlife policy of killing introduced, feral goats on California's Santa Barbara channel island to protect native species (Zavaleta, Hobbs, and Mooney, 2001). Animal-rightists protested the killing of a single goat, whereas ecocentrists accepted goat-killing for the greater good of the native ecosystem. The biocentrism of Taylor would not support either approach, since each goat and each wild plant threatened by goats has a teleological good. The biocentrism of Sylvan and Bennett (1994) and Rolston (1991) would allow some destruction of either plants or goats as long as the species as a whole and the ecosystem are sustained. In a further ethical complication, the American Livestock Breed Conservancy[14] has denounced the killing of these goats because they are a rare domesticated breed whose gene pool is endangered. The question of removing an alien species from an ecosystem presents a puzzle for environmental ethicists, particularly for ecocentrics. How does one define a "natural" ecosystem? At what point does an alien species belong in an ecosystem? Furthermore, the cost of returning to a "native" state may offend utilitarian-minded ecocentrists. These present practical difficulties but are underlain by very much larger ethical questions of human involvement in ecosystems. When is human involvement in an ecosystem natural or not natural? Furthermore, when Taylor denounces humanity's

[14] The American Livestock Breed Conservancy is a non-profit organization dedicated to preserving rare domesticated animal breeds.

ecological chauvinism, doesn't he ignore the nature of the human species in seeking its own survival?

Callicott (1998) believes Leopold's "Land Ethic" transforms humans from conquerors to citizens of nature. Callicott defends ecocentrism against claims of "ecofascism" by arguing that the ecocentric ethic does not necessarily cancel human-centered morality but adds to it, just as a human's obligations to community add to those of family. For Callicott, anthropocentric values are in balance with a respect for other members of the ecological community and of the community itself. He looks to the cultures of Native Americans for insight in finding this balance, describing how they traditionally treated animals, plants, waters, and minerals as non-human persons that engage in reciprocal, mutually beneficial socio-economic intercourse with human beings (Callicott, 1982). However, Partridge (1982) points out that Native Americans may have considered non-human beings as having more moral value than humans of another tribe and questions whether this construct is a viable ethical guide. Further confounding the human-versus-ecological focus of an environmental ethic, Fritzell (1987) points out a paradox: If humans are equal members of the biotic community, their drive for self-survival is no more or less moral than wolves eating deer; if humans are natural, their behavior is natural. Callicott (1998) restates this paradox by asking whether ecocentrism is prudential or deontological. That is, is ecocentric ethics a matter of enlightened, collective human self-interest, or a genuine granting of true moral standing to non-human entities and ecosystems?

The "deep ecologists" combine a modern return of the nature ecstatics with a clear displacement of anthropocentrism (Devall, 1988; Naess, 1989; Sessions, 1995). Deep ecologists believe "shallow ecology" (in which anthropocentrism remains firmly in place, but is reformed by political, economic, or technological means) is insufficient and that the problem is that nature should not be an instrument of human utility.

Sessions (1995) denounces “sustainable development” as “shallow environmentalism” and as just another improper instrumental use of nature. He claims that the use of biota for genetic exploitation particularly exemplifies anthropocentric instrumentalism. Deep ecologists find the profit-seeking exploitation of nature to be particularly immoral. Mander (1991) describes a corporate view of the world that is “megatechnological,” focused on consumerism and akin to a Disney theme park.

Berry (1988) calls for a paradigm shift toward ecocentrism and away from the “economic-technological-consumerist-wonderworld” that is creating a “wasteworld.” He scorns the view of the industrial entrepreneur, as exemplified by Drucker,[15] that human possession and use is what activates the true value of any natural object.

Seabrook (1990) believes the market has ruined the traditional conception of nature and wonders if we are satisfied with the results of a solution provided by market forces.

Instrumental values of wild biota reflect anthropocentric thinking. Do such values represent moral thinking, or are they value-free and based on scientific principles of market economics?

“Deep ecologists” represent a most extreme non-anthropocentric environmental ethic. Naess (1989) initiated the movement in the late 1980s with several papers in which he rejected the “shallow ecology” of anthropocentric reformism for a profound veneration of nature. With roots in Thoreau’s ethic that “in wilderness is the preservation of the world” and that “all good things are wild and free,” Naess (1998) defined a deep-ecology ethic with the following tenets: A non-human world, independent of human purposes, is invaluable; diversity of life is a value *per se*; humans have no right to reduce biodiversity except to satisfy “vital” needs; smaller human populations are preferred over larger ones; present human

[15] “Before it is possessed and used, every plant is a weed and every mineral is just another rock” (Drucker, 1985, p. 30).

interference in the natural world is excessive, and policies that produce such interference should be changed; and life quality is preferable to a material-quantity standard of living. Deep ecologists believe humans are the primary cause of environmental destruction and lay the cause on humanity's failure to venerate non-human nature or to set limits on population, technology use, human appetites, and greed (Devall, 1988; Sessions, 1995; Worster, 1995). The facilitation of human-centered manipulation of nature is criticized by deep ecologists, and rejection of wild-biota property would obviously follow, although one can imagine wildlife property used to protect nature as a deep-ecology good.

Some critics of deep ecology consider the ideology dangerously misanthropic (Bookchin, 1988). The militant ecocentrics (Foreman, 1991) are of particular concern. Ecofeminists accept human destruction of the environment as a moral bad but view the problem as andropocentrism (Diamond and Orenstein, 1990) and consider deep ecology as disguised male dominance (Saleh, 1984).

Social ecologists reject ecocentrism and biocentrism and consider the inequitable intra-generational allocation of power and resources to be the critical issue (Zimmerman, 1998). Clark (1998) describes the wide range of ideologies that comprise social ecology.

Liberal environmentalists espouse an expansion of government regulation (WorldWatch Institute; Paehlke, 1989), while free-market environmentalists (Andersen and Leal, 1991) promote the decentralization of private property and unfettered market forces as solutions. Both of these groups would see wild-biota property rights as useful tools. However, liberals would put those rights in the hands of the state, and the free-marketeers would argue for privately held rights.

Socialist environmentalists reject both liberal and free-market regimes, believing that capitalism is inherently flawed with regard to the environment

(O'Connor, 1988). Neo-Marxist analysts point to the globalization of the capitalist economy as a cause of environmental destruction (Harvey, 1993; Pepper, 1993; Foster, 1995). These critics view socialism and its strong, centralized state control as essential, and wild-biota property rights completely held by the state suit this model.

Social ecologists view social inequity as caused by the dominant paradigm of state and corporate control, concentrated economic power, patriarchy, the technological–industrial complex, and a variety of authoritarian and repressive ideologies. Social ecologists would view private and public wild-biota property rights with suspicion. Although such rights could conceivably be used to counter repression, authoritarianism, and social injustice, the history of wealth concentration and the use of property rights in the service of oppressive or corrupt corporate and state interests would be cause for rejections.

Fox (1998) believes social ecologists (Merchant, 1992) are firm anthropocentrics who focus on socio-political agendas rather than on the core environmental problem, which is ecological.

Some liberal environmentalists center their ethic on the ideal of sustainable development (Attfield, 1991), which rests on the premise that the conservation of nature is dependent on the generation of economic capital (Golliher, 1999). Within the liberal paradigm, environmentalists have sought to correct the traditional economic equation, which is skewed by the inadequate valuation of nature, by establishing novel methods of assessing the true economic value of the environment and its components (Costanza, 1991). This approach has been criticized as inappropriately requiring the commodification of all value and as being particularly unsuited for the valuation of biodiversity (O'Neill and Holland, 1999). Sagoff (1999) critiques the utilitarian model of liberal economics and argues for a deontological (Kantian) framework. Sagoff describes conceptual weaknesses of the willingness-to-pay basis of individual welfare that underlies the liberal utilitarian model. He posits that the utilitarian model, expressed by free-exchange markets, can produce obnoxious social outcomes such as prostitution, child labor, pornography, and the narcotics trade. Therefore, although it would be efficient to have a market in human organs, our society prohibits such mercantilism as morally abhorrent. Sagoff also questions the fundamental premise of free-market liberalism, the satisfaction of personal preference, as highly manipulatable (through advertising, for example) and capable of producing personal and social bads. Sagoff believes that utilitarianism is insufficient to accommodate those social decisions that require a collective ethical decision. He prescribes a deontological approach to the conservation of natural resources, including biodiversity, in which citizens arrive at mutual goals and characteristics of the society they aspire to and in which such goals may have little connection with any particular individual's preference. Weiskel (1999) also rejects the idea that monetary value is the only rational valuation and argues that society cannot solve a collective problem by multiplying private solutions. He describes how individuals are urged to think only as consumers and that market mechanisms are the one viable solution to social/economic problems. But Weiskel points out that individuals have alternate identities—as parents, citizens, and members of religions—and that these are often ignored in the public-policy formulation of liberal economics, which protect "the rights of the consumer." Finally, Weiskel believes that the justification of the public good in terms of private gain is a fundamental mistake in moral reasoning.

Sagoff (1999) has argued for a deontological approach to decision making by the body politic on questions of environmental ethics. Complex questions of what is right and good in environmental decision making are not appropriately addressed by simple utilitarian and efficiency models. Rather, such decision making must include non-monetizable values that are woven into the social fabric. Sagoff suggests that narrowly construed utilitarian models provide part of the framework for determining the appropriateness of wild-biota property rights, but the complete picture requires public decision making through a political process that includes utilitarian, aesthetic, and other values.

An organizing principle of most environmental ethics is the displacement of humans from the absolute zenith of all ethical determinations. This dislodging has spawned a great deal of discussion about the intrinsic worth of non-human life and abiotic support compared with human-centered value. These arguments have produced debate about differences in value between species and have yielded ethical arguments that are logically crafted but practically irrelevant or ludicrous. For example, Hettinger (1995) develops an argument against intellectual property from biota by basing it on the ethical premise that no human should have the right to own any other organism, even a bacterium! Obviously, such a position is useless in guiding any practical decision making. Norton (1995) makes this point by rejecting non-anthropocentric ethics as politically impractical and counterproductive. Norton's thesis accepts the intellectual value of a shift away from a purely anthropocentric value framework but, if the goal is ethical guidance for a useful praxis, such constructs are not relevant. So, for Norton, the ethical question of the rightness of a wild-biota property right rests on something more than theoretical rights and values. The question is whether, in practice, wild-biota property rights produce an environmental good. This leads to the question of practical ethics of wild-biota property.

8.11 A Practical Ethics of Wildlife Property

Is a property right in wild biota right or wrong, a necessary evil or a great good, or something in between? Ethical theorists present a wide spectrum. Regan (1983) and Jamieson (1994) hold that animals have intrinsic right of liberty and freedom from human domination. Hettinger (1995) argues that a property right in any organism is immoral. Conversely, Buchanan (1993) believes private-property rights are essential for the human right of freedom. (McCauley, 2006) believes that any steps that aid in the commodification of wildlife are dangerously misguided. Anderson and Leal (1991) and Stroup and Baden (1983) make compelling arguments that private-property rights are required for the proper allocation of natural resources among all members of a society. But where in the polarized theoretical debate can we find guidance in practical matters?

In reality, property rights in biota are a custom of thousands of years, and arguing against them is largely an academic exercise. But property rights are also used to degrade biodiversity for profit, and a lack of property structure produces a tragedy of the commons. The practical rightness of property in wildlife is confusing and complex. Is there a way to cut this Gordian knot and solve this problem practically and ethically? Norton (1995) points out that ethics theory is monistic, based on absolutes, and divorced from real management issues; that theoretical, ethical arguments do not inform practical decision making. Norton suggests that the good of property in non-human life rests on the intent and purpose of such property. So, for example, Regan (1983) and Jamieson (1994) argue that zoos are immoral regardless of their purpose. For Norton, if the purpose is pure profit-making, with no regard for education or animal welfare, imprisoning animals is bad. But if the purpose is research, education, and captive breeding for species survival, imprisonment is justified. Similarly, a property right in biota solely for profit is ethically different from the use of such right for conservation. A fur company owning caged foxes presents biota property in a different light from the Nature Conservancy asserting rights to protect biota on its lands. But if the fur company dedicates some portion of pelt-sale profits for wild-fox conservation, the ethics of its property right is modified.

Does the use of property rights for a morally good purpose render such rights *per se* a moral good? Conversely, does the use of property in biota to accomplish a moral bad make the rights unethical? In both cases, morally good and bad outcomes result from property rights. Thus, such rights can be ethically good or bad, depending on their result. Is the absence of such rights a moral good or bad? The "tragedy of the commons" destruction of the environment is a widely perceived to be bad, but a private right that impairs a common good is also bad. Property in wild biota is a fulcrum on which the seesaw of ethical goodness or badness tips according to the application and outcomes of such rights.

Owning biota property to accomplish the goals of ecocentric land management would satisfy Leopold. Holding biota property in order to exclude anthropocentric use would satisfy the biocentrics and deep ecologists. Various types of biota-property rights uses can be configured that would satisfy the goals of any one of the several branches of environmental ethics, although perhaps not simultaneously.

Thus, in practice, wild-biota property rights are amoral. As in the case of money, the question is not whether it is bad or good but, rather, is a particular use bad or good? And while wild-biota property rights are neither bad nor good, their intent and use is likely to be one or the other, or a complex mix of both.

A practical ethics requires the appreciation of a "nuance of ethical obligations" in the context of a community and will provide guidance in practical decision making when it is pluralistic and pragmatic (Norton, 1995). In this vein, property rights in wild biota may be used to effect biodiversity protection and mercantilistic exploitation. The challenge for those who seek the former rather than the latter is to understand these property rights and how to use them like civil rights, in which proponents learned to use the political and legal system to achieve their noble goals.

CHAPTER 9:
SUMMARY AND CONCLUSION

9.1 Summary

As I have studied the law underlying patents and wildlife conservation, it has become clear that the concept of property is fundamental to understanding the relationship between people and institutions to things, and to the relation of patent and wildlife law. My analyses have shown that tangible biological property and the rights surrounding that property are the critical link between patents and wildlife conservation law. While others have noted the distinction between patents and tangible property in wildlife (Koopman, 2005), I characterized that distinction and have shown that the nexus of patent and wildlife law is the possession of tangible biological property. This nexus forms the orthogonal relationship between these bodies of law and is the basic link between wildlife in their habitat, patentable inventions, and the benefits that result from such patents (Farrier and Tucker, 2001).

In Chapter 1 I described issues raised by the existence of patents on inventions from wildlife and presented this basic premise: patent law and wildlife conservation law are orthogonal. That is, they are entirely independent "planes" of jurisprudence and social engineering, having no relation to one another other than along a line of intersection—the intersection of tangible property. And, after stating this premise, I wondered about the implications of orthogonality and the tangible property intersection of these laws.

As a first step in evaluating the premise of orthogonality, in Chapter 2 I explained the scope of patentability of biological subject matter in the United States—arriving at a point at which "everything under the sun made by man" is potentially patentable regardless of whether the source of the invention is covered by wildlife conservation law or not. In this chapter, I described an important point about species and patents, and a curious exception: wildlife species *per* se are not patentable under United States patent law but microbial species, if isolated in pure culture, are.

In an important step in the analyses, I described the historical evolution of federal, state, and private control over wildlife in the United States in Chapters 3 and 4. This evolution has led to a situation in which the federal government has ultimate authority over wildlife but the states remain in control of most wildlife species. And, despite this level of governmental control, government has no control over thousands of wildlife species, particularly arthropods.

The relation of intellectual property in biological subject matter and the laws that define the control of wildlife are analyzed in the pivotal Chapter 5. In this chapter, I have demonstrated that there is no explicit connection between the bodies of patent and wildlife conservation law in the United States. This chapter also describes the implicit nexus between these laws: the physical possession and use of tangible biological property—the domain of personal-property law. Although I have pointed out how connections could be made between patents and wildlife conservation law through the use of personal-property mechanisms, I have stated the conclusion clearly: patent and wildlife conservation laws are orthogonal, and their intersection is the physical possession of specimens.

Based on the earlier results described in Chapters 2, 3, 4, and 5, I have defined, in Chapter 6, a political economy of a "new" natural resource: patentable discoveries from wildlife in the context of the legal orthogonality I have shown. I have also described some implications of this political economy. These important implications include a market failure in patentable inventions from wildlife and a "tragedy of the commons" in the wildlife resources that are the sources of these patents. Historically, a market failure in a wildlife resource has often resulted in governmental intervention to stop or regulate that failure. I have defined such potential governmental interventions in Chapter 6 but have also described possible market failure solutions that include private-property approaches.

I have tested the findings of orthogonality and market failure in the natural resource of wildlife inventions by evaluating two case studies in Chapter 7. In both cases, orthogonality is the rule. However, in one case such orthogonality has been used to make an effective link between patents, their value, and the wildlife resource. In the other case, orthogonality has worked against such linkage. In both cases, the underlying orthogonality works either for or against the patent-wildlife resource link by use or failure to use the tool of personal-property mechanisms in tangible wildlife specimens.

9.2 Conclusions

The evidence presented here, including detailed analyses of patent law and wildlife conservation law in the United States, substantiates the premise of orthogonality. These bodies of law are entirely separate in their societal intent, jurisprudence, rules, and outcomes. For example, the intent of patent law is to encourage inventors to create technical advancement, whereas the intent of wildlife law is to conserve this natural resource. There is nothing in U.S. patent law that has any impact on any provision of any federal or state wildlife law. Symmetrically, there is nothing in wildlife law that affects any portion of patent law. Evidence for this includes the fact that a legally valid patent may be obtained on an invention made while breaking a wildlife-conservation law. Also symmetrically, holding a valid U.S. patent on an invention obtained from a specimen covered by wildlife law gives the patent holder no standing in the eyes of that wildlife law nor any power to affect any processions of that law. Further evidence of the mutual insularity of these laws is the fact that with one special exception for microbes discussed below, it is not possible to patent a wildlife species under the requirements of patent law. The implications of this mutual insularity are several; however, the most salient is the failure to link the economic value of patentable inventions from wildlife to the sustainable conservation of that natural resource.

But orthogonality also requires an intersection. Chapter 1 presented the most obvious evidence of this intersection: the existence of issued U.S. patents on inventions made through the possession of wildlife. It is the possession of specimens that provides the intersection of these bodies of law. Specimen possession is the domain of wildlife-conservation law. Where a species is covered by law, the controls on possession do not impact the act of inventing and obtaining a personal-property right in a patent. And, where a species is not covered by wildlife law, such as with most arthropods, wildlife law is wholly independent of the possession-invention-patent chain.

The orthogonality of these laws is also shown by the unique intersection of patents on microbial species. In every other wildlife domain, a patent is not possible on a species *per se*. Furthermore, a patent on any invention made using a wildlife specimen gives the patent holder no rights in that specimen or in the species. However, microbes provide a unique intersection in otherwise unrelated domains. As described in Chapter 2, by virtue of the Bergy cases, the Supreme Court opened the door to patents on microbial species. Such patents present a critically close intersection of patent law, possession, and wildlife law. Although the collision of patent-law rights, personal-property rights, and ethical questions of private species ownership is raised in such microbial patents, a true intersection with wildlife law does not exist because microbes are not explicitly controlled by wildlife law. However, the intersection is critically close because some federal and state laws govern the collection of microbe-containing samples.

The implications of these intersections are important to linking the economic value of invention from wildlife to sustainable conservation (Farrier and Tucker, 2001). The failure to make this linkage can mean the loss of significant benefit that could be used for conservation (Svarstad et al., 2000). The intersection of specimen possession provides a focal point for designing policy solutions. And, most important, this focal point can be used to design policy solutions that provide a balance between the two different intentions of these bodies of law: technical advancement and wildlife conservation.

The policy balance could be shifted to favor either one or, optimally, both of these goals. For example, policy could be designed to maximize the pursuit of patentable inventions from wildlife with no regard to conservation issues. Regulations could be modified to encourage the possession and use of wildlife for this purpose, and conservation protocols could be streamlined or even avoided. Conversely, policy could prohibit all inventive possession and stop this form of technical advancement, while maximizing wildlife protection. While these opposed policy goals might appeal to some, it seems intuitively obvious that a balance is the preferred policy design.

A certain type of balance has accidentally developed between these bodies of law. Currently, patents are obtainable on inventions from wildlife and, simultaneously, conservation law acts to protect certain wildlife in various ways. However, a more proactive balancing act could enhance the goals of each body of law. Done right, this policy balance would encourage technology and invention while also improving wildlife-conservation mechanisms and resources. Most important, this proactive balance would provide that critical linkage between the potential economic value of inventions from wildlife and the cost of wildlife conservation.

The balance point is the orthogonal intersection of possession. Using possession as a focal point, existing federal and state law should be analyzed to determine how best to foster non-destructive possession for inventive purposes and to make firm links between their commercial use and the flow of financial benefit for conservation purposes. Beyond a review of existing law, the balance point of possession should be used to analyze the situation of non-protected wildlife and to develop strategies to make the patent–conservation linkage.

The two cases described in Chapter 7 demonstrate several key points. The Yellowstone–PCR case confirms the fundamental premise of this work: Patent law and wildlife conservation law are orthogonal. This orthogonality acted to sever the financial benefits of patented discoveries from the wildlife steward. In the FLLT case, this orthogonality was made irrelevant through assertions of personal-property law and contracts. Of course, the second case is an example of how private-property rights can be used to create the kinds of linkages that are naturally missing in the orthogonality of patent and conservation law. Indeed, the outcome of the second case could have been quite different if public property in wildlife specimens were involved.

9.3 Implications of Wildlife Property and the Management of Biological Conservation

What are the implications of property in wildlife for biological conservation management concepts and practices? Does the complex mix of existing and potential, traditional and novel property rights in wildlife affect the design or implementation of such management?

Considering wildlife property as a distinct institutional realm provides an organizing principle that ranges from traditional to innovative in application. Familiar situations include the participation of state or federal government, in their *parens patriae* role, in conservation programs for free-roaming, *res publicae* wild animals. The assertion of property rights in obscure biota or in intellectual property derived from wildlife is a new arena in which novel biological conservation management schemes may be developed. However, developing such biota-property-based management schemes presents unique challenges, particularly in the integration of wildlife-property structures with the ecological and biological maxims of conservation biology.

Very different sets of institutional problems arise in the application of wildlife-property mechanisms in habitat-based versus species-based conservation schemes. The patchwork of uncoordinated and often disconnected wildlife laws and plans makes the ecosystem approach to conservation particularly challenging. And the traditional rule of capture as the basis for property rights in wildlife presents complications for designing sustainable resource use (McLaughlin, 2003). The integration of wildlife property mechanisms and habitat conservation strategies is complicated by biota automobility and mosaics of *res privatae, res publicae,* and *res nullius* wildlife in the same habitat. Applying wildlife-property approaches in species conservation schemes produces another set of problems related to wildlife mobility and multiple landowners. Figure 9.1 depicts a hypothetical wildlife-property landscape of biota units[1] on a parcel of private property. The solid background matrix of *res privatae* rights results from the largest number of species being microbiota, which are *res privatae* by *ratione soli*. Superimposed on the background of *res privatae* microbiota are individual *res privatae* biota units representing plants. Also superimposed on the *res privatae* background are units of *res nullius* species that are transient and not government-controlled, a genre typified by arthropods. A smaller number of biota units are state-controlled *res publicae,* including primarily fish, game, and endangered species. The smallest number of biota units are federal-controlled *res publicae* including migratory birds, eagles, and endangered species. A systematic and coherent wildlife property–based management plan would require integration of the various institutional property

[1] Biota units = individual whole organisms of a species.

interests. Note that state and federal *res publicae* biota remain in that domain despite wildlife transience across property boundaries. This factor may be exploited in a management plan that incorporates participation by relevant governmental entities. Also, note that *res nullius* wildlife remain in that status unless and until captured. In order to create a continuum of coherent rights in *res nullius* wildlife, coordination with land owners would be required. Finally, although *res privatae* wildlife is unlikely to be transient, coherence will depend on coordination with other landowners to the extent of such transience. A new level and type of coordination and cooperation between property-right holders will likely be necessary to achieve optimal wildlife conservation. (McLaughlin, 2003).

Figure 9.2 shows the wildlife-property framework in a species-based conservation management strategy. If the species are not transient, the system is considerably simplified. The figure summarizes *in situ* biota property in transient wildlife and shows that the property status of a transient wildlife specimen may change depending on the ownership status of the land it is on. Although federal *res publicae* wildlife remain under federal control whether on federal or state land, when that biota is on private land, trespass law mitigates assertion of the government's property right. That is similarly true of state *res publicae* wildlife on private land. Although federal law requires federal-land managers to cooperate and coordinate with state wildlife agencies on issues of state *res publicae* on federal land, a state's rights in *res publicae*–state wildlife on federal land is ultimately superseded by the supremacy of federal rights over wildlife on federal land. Note that *res privatae* wildlife is limited to the boundary of the private land.[2] *Res nullius* wildlife units become *de facto* private or public property through trespass law.

[2] This would be only fixed biota.

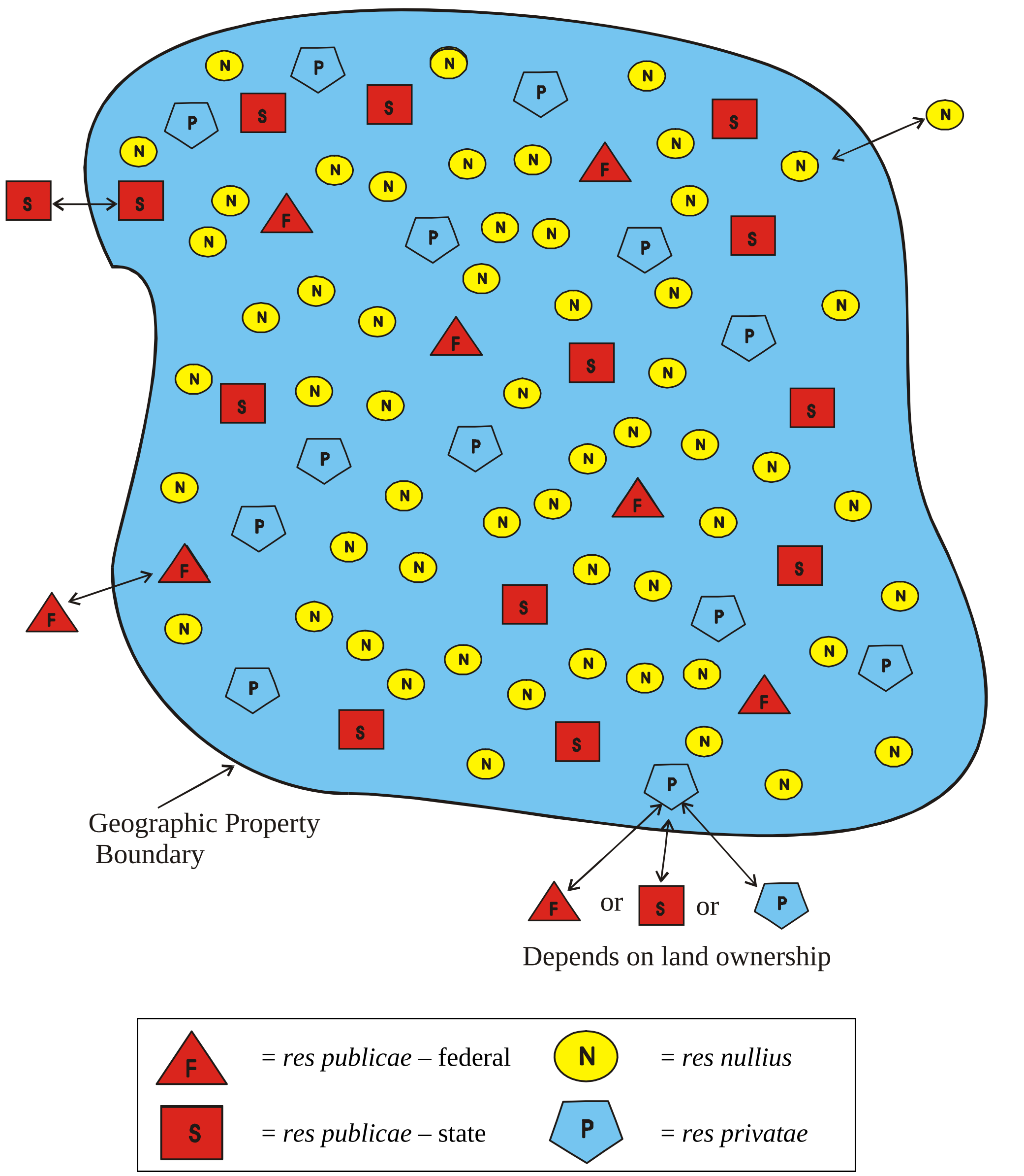

Figure 9.1. Wild Biota Property and Habitat Management for Conservation on Private Property. Note: Property area is shaded blue to denote *res privatae* status of soil microbiota.

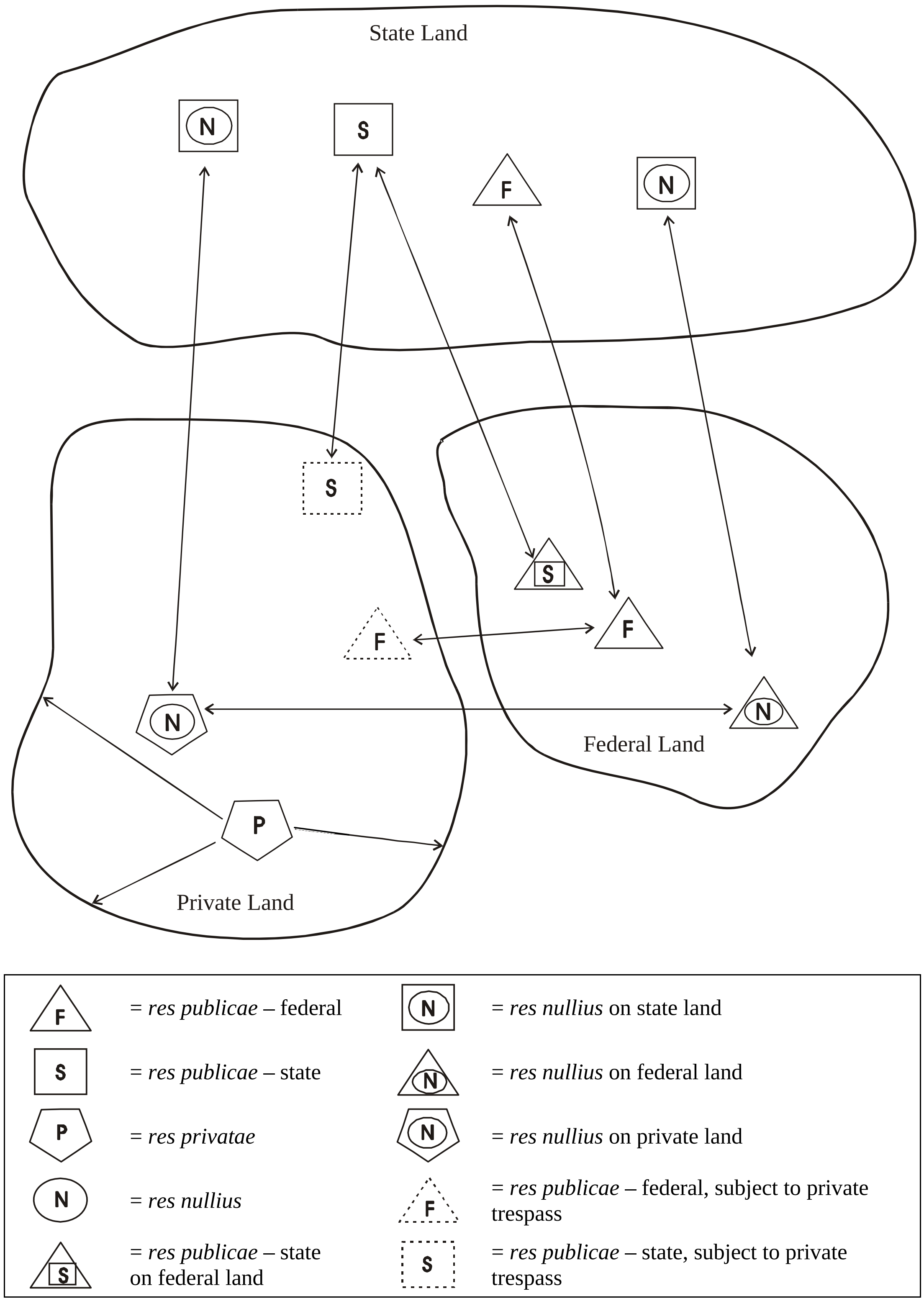

Figure 9.2. Wild Biota Property and Species Management for Conservation.

A species-management approach that uses biota-property mechanisms depends heavily on the species selected. Federal wildlife are most readily managed in such schemes, although the factor of private land ownership presents a complex challenge. Similarly, managing property rights in state *res publicae* wildlife requires coordination with federal and private land holders. Managing ownable-on-capture *res nullius* wildlife requires management systems that integrate all participants that have the power to assert a relevant trespass right.

The rules of biota property—some well established and others at the cutting edge of technology and law—provide a set of tools that may be used by participants in wildlife-management systems to further their own interests, the interests of clusters of participants, or the interests of the management scheme itself (Farrier and Tucker, 2001). Understanding these rules, and obtaining facility with their practice, can provide property-right-based power to parties that may have been previously powerless. Holding wildlife property rights that have previously not existed or that have not been asserted can give stakeholders and actors new roles in such management schemes. Although there are cautionary concerns of an over-reliance on property rights in biodiversity conservation (Farrier and Tucker, 2001; McCauley, 2006), the exercise of wildlife-property rules has the potential to significantly alter the *status quo* of existing conservation-management systems and to enable the design of new ones. And such an approach could help close the gap between conservation biologists, environmental activists, and economists.

APPENDIX A:
CHRONOLOGY OF DEVELOPMENT OF PATENTABILITY OF BIOLOGICAL SUBJECT MATTER IN THE UNITED STATES

Year	Event

1787 **U.S. Constitution signed**

Article 1, Section 8 (General Powers of Congress) *To promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries*.

1790 **U.S. Patent Act enacted**

1793 **U.S. Patent Act amended**

Establishes the four great distinct classes of inventions: process, machine, manufacture, composition of matter

1873 **1st patent issued on animate matter**

U.S. Patent No. 141,072 to L. Pasteur on a pure yeast culture for fermentation

1874 **U.S. Supreme Court rejects patentability of "purified cellulase"**

American Wood Paper Co. v. Fiber Disintegrating Co.

1877 **1st U.S. patent on a vaccine of biological matter**

U.S. Patent No. 197,612 issued to Cutter on vaccine comprising "pulverized pustules and lymph."

1884 **U.S. Supreme Court rejects patentability of "natural products" *per se***

In *Cochrane v. Badische Aniline & Soda Fabrik*, Supreme Court finds that natural products (i.e., the dye, alizarine from the madder plant) are not patentable even if made synthetically.

Vaccine patent issued

U.S. Patent No. 273,390

1889 **Patent Commissioner rejects patentability of isolated pine fibers**

plant parts are products of nature (*Ex Parte Latimer*)

1894 **1st patent issued on a fungal fermentation**

U.S. Patent No. 525,824 claims fungal food fermentation

Year	Event
1899	**Biological process patent issued on “Septic Tank” invention** U.S. Patent No. 6 34,423
1904	**1st U.S. patent on bacterial vaccine** U.S. Patent No. 778,767 issued to Houghton for attenuated blackleg anthrax bacillus
1908	**Biological process (“Septic Tank”) patent upheld** *Cameron Septic Tank Co. v. Village of Saratoga Springs* (2d Circuit Court) “the use of one of the agencies of nature for a practical purpose” is patentable subject matter
1909	**Purified natural product (“Aspirin”) patentable** *Farbenfabriken of Elberfeld Co. v. Kuehmsted* (N.D. Ill.) (pure, acetylized salicylic acid is not obvious over prior natural compound)
1910	**U.S. patent issued on “Mixed Microbial Culture”** U.S. Patent No. 952,418
1911	**Pure adrenaline patentable** *Parke Davis v. E.K. Mulford Co.* (S.D.N.Y.)
1916	**1st U.S. patent on viral vaccine issued** U.S. Patent No. 1,210,053 for attenuated hog cholera virus
1921	**Patent on bacterial vaccine issued** U.S. Patent No. 1,391,599 for swine pneumonia bacillus vaccine
1927	**Vaccine patent issued** U.S. Patent No. 4,636,446 for attenuated rheumatic fever bacillus
1928	**Purified tungsten not patentable** *General Electric Co. v. DeForest Radio Co.,* (3rd Cir.) Obviousness of natural qualities
1930	**U.S. Plant Patent Act enacted**

Year	Event
1931	**U.S. Supreme Court rejects patentability of altered "natural products" but opens door for animate products as patentable subject matter** *American Fruit Growers, Inc. v. Brogdex Co.* "altered" oranges (whole oranges with borax-impregnated rinds) not patentable; however, Court does not reject patenting "living matter" *per se*.
	Pure vanadium not patentable *In re Marden* (CCPA)
1932	**Biological process patentable but not organisms** "Acetone" case of *Guaranty Trust v. Union Solvents Corp. (3d. Cir.)*
	Biological process and microbes patentable *Ex parte Prescott* (POBA) fermentation and isolated bacterium
	"Altered" furs are patentable *Steinfur v. W. Beyer* (2d Cir.)
1933	**U.S. Patent No. 1,980,083 issued on lactobacilli/yeast mix**
1934	**Biological process patentable** "Activated Sludge" case - C*ity of Milwaukee v. Activated Sludge, Inc*. (7th Cir.)
1935	**Pure alpha-alumina not patentable** purity *per se* does not confer patentability *In re Ridgeway* (CCPA)
1936	**Purified dextrose hydrate is patentable** *International Patents Dev. Co. v. Penick & Ford Ltd* .(D. Del)
1938	**Artificial ultramarine not patentable** *In re Merz* (CCPA)
1939	**Pure Vitamin C not patentable** *In re King* (CCPA)
	Ground plant root insecticide patentable *Dennis v. Pitner* (7th Cir.) the natural product has new properties, i.e., it's patentable
1940	**Bacteria not patentable under Plant Patent Act** *In re Arzberger* (CCPA)

Year	Event
1941	**Beheaded, deveined shrimp unpatentable product of nature** *Ex parte Grayson* (POBA)
1944	**Muskrat gland secretion not patentable** *In re Sparhawk* (POBA) extract obvious *vis a vis* natural state
1947	**Microbial species mixture is patentable** *Kalo Inoculant v. Funk Bros*. (7th Cir.)
1948	**Mixture of isolated bacterial species not patentable** *Funk v. Kalo Inoculant* (Supreme Court) Obviousness rejection but organisms suitable subject matter.
1950	**Pure antibiotic extracted from garlic not patentable** *In re Cavallito* (POBA); extract obvious *vis a vis* natural state
1955	**Natural substance purified from racemic mixture is patentable** *Sterling Drug v. Watson* (D.D.C.); Pure compound not obviou
1958	**Pure vitamin B-12 from fermentation is patentable** *Merck & Co., Inc. v. Olin Mathieson Chem Corp* (4th Cir.)
1961	**Patent issues on fungal species** “Lumb” patent 3, 103, 946; fungal species control “eelworms”
	Pure alpha-lipoic acid obvious/non patentable *Ex parte Reed* (POBA, 7/61)
	Pure alpha-lipoic acid not obvious/patentable *Ex parte Reed* (POBA, 10/61)
1962	**Streptimidone in a fermentation broth not patentable** *Ex parte Frohardt* (POBA)
1963	**1st patent on bacterial insecticide** U.S. Patent No. 3,113,064 *B. thuringiensis* suspension
1964	**“Substantially-pure” natural product (6-aminopenicillanic acid) patentable** *In re Doyle* (CCPA)
	Elements 95, (Americium) and 96 (Curium) patentable *In re Seaborg* (CCPA)

Year	Event
1965	**Tetracycline concentrates patentable** *Charles-Pfizer & Co., Inc. v. Barry Martin Pharm.,* (S.D. Fla.) Pure substance not obvious in light of known substance
1967	**Vitamin B-12 patent upheld** *Merck & Co. v. Chase Chemical* (D.N.J.) Purified, crystalline B-12 did not exist in nature
1970	**Purified (but previously known) natural compound is novel** *In re Bergstrom* (CCPA): prostaglandins
	Deposit of microbial culture satisfies enablement *In re Argoudelis* (CCPA)
1972	**Chakrabarty files patent application on bacterium with human-made inclusions**
1974	**Bergy et al file patent application on microbial strain** "a biologically pure culture of the microorganism *Streptomyces vellosus . . .*"
1976	**Patent on microbial strain rejected as unpatentable "products of nature"** *Ex parte Bergy* (POBA)
1977	**Microbial strains patentable,** *In re Bergy* I (CCPA) U.S. Patent Act does not exclude living organisms as patentable subject matter.
1978	**1st animal cell line patent** "Porcine cell line" U.S. Patent No. 4,070,453 (non transgenic)
	pure culture of a fungus patentable under Plant Patent Act *In re Solomons* (POBA)
1979	**Pure strawberry flavor molecule patentable** *In re Katz* (CCPA)
	Pure microbial strain patentable. *In re Bergy* II (CCPA)

Year	Event
1980	**Supreme Court: “everything under the sun made by man” is patentable** *Chakrabarty v. Diamond*
	Patent issued on “Molecular Chimera Method” (Cohen-Boyer) U.S. Patent No. 4,237,224
1985	**Higher plants patentable** *Ex parte Hibberd*
1987	**Non-transgenic oysters made by manufacturing process are patentable** *Ex parte Allen*
1988	**1st patent issued on transgenic animal** “Harvard Mouse” (No. 4,736,866)

Note. CCPA = Circuit Court of Patent Appeals; POBA = Patent Office Board of Appeals

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