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An Agricultural Law Research Article

Biodiversity and Law: The Culture of Agriculture and the Nature of Nature Conservation

by

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I. Introduction

About nine thousand years ago, beneath the Karacadag Mountains of southeastern Turkey, a small group of people, over a short period of time, made the most momentous and consequential revolution in human history. They triggered the evolution of agriculture.[1] Every subsequent step along the road of human civilization is based on that moment. It has been called "the most important advance that mankind has ever made since it developed the powers of speech, conscious thought and firemaking"[2] and "the worst mistake in the history of the human race."[3] Opinions differ. Agriculture involves the intentional modification of ecosystems so that they produce plants and animals that would not occur naturally in either the same form or quantity. The first agriculture, for example, involved the creation, domestication, and dispersion of a strain of wheat known as einkorn (*Triticum boesticum*) from a wild ancestor (*T. monococcum*) still found in the Karacadags.[4] The results are decidedly mixed. Agriculture has given us the food surpluses that have permitted the florescence of human culture but also the destruction of forests, the exhaustion, erosion and salinization of soils, the eutrophication and poisoning of lakes and streams, and the drainage of wetlands. It has caused the extinction of species and has contributed to their diversity.

In our times we are witnesses to the fifth great episode of extinction in the 600-million-year history of life on earth and the first in which humanity is the primary agent.[5] This article—the first in a

[1] *See* Jared Diamond, *Location, Location, Location: The First Farmers*, 278 SCIENCE 1243 (1997).

[2] ROBERT TROW-SMITH, LIFE FROM THE LAND: THE GROWTH OF FARMING IN WESTERN EUROPE 11 (1967).

[3] Jared Diamond, *The Worst Mistake in the History of the Human Race*, DISCOVERY, May 1987, at 64. For other proponents of this view, see RICHARD MANNING, AGAINST THE GRAIN: HOW AGRICULTURE HAS HIJACKED CIVILIZATION (forthcoming 2004); HUGH BRODY, THE OTHER SIDE OF EDEN: HUNTERS, FARMERS, AND THE SHAPING OF THE WORLD (2000); and CALVIN LUTHER MARTIN, IN THE SPIRIT OF THE EARTH: RETHINKING HISTORY AND TIME (1992). These authors are fond of rhetorical flourish. *See, e.g.,* BRODY, *supra* at 84 ("Farmland in God's sole care is forest and savannah. The family farm is a determined, persistent struggle to make sure that God does not get the place to himself: the trees are felled, their roots are hauled from the ground, stones are picked from the earth, invading wild plants and shrubs are rooted out again and again. There is no end to this labor. The soil will grow grass and the vegetables and grains only if a great deal else is 'kept under control,' which means excluded or destroyed. Not only rival plant life, but also wild creatures that harm seeds, seedlings, buds, or fruits, or eat the domestic animals that are also part of the farm family. Weeds and vermin. These are the agents of wild nature that have to be walled out, scared off, or killed. Otherwise the soil will not yield—more, it will not even exist.").

[4] The wild progenitors of wheat now find refuge only in Turkish graveyards and castle ruins. *See* Norman Myers, *The Rich Diversity of Biodiversity Issues, in* BIODIVERSITY II: UNDERSTANDING AND PROTECTING OUR BIOLOGICAL RESOURCES 125, 131 (Marjorie L. Reaka-Dudla et al. eds., 1997).

[5] Each previous mass extinction eliminated from 30 to 50% of all animal families and was probably associated with climatic change. *See* RICHARD B. PRIMACK, ESSENTIALS OF CONSERVATION BIOLOGY 77-79 (1993).

forthcoming series—is about the strengths and weaknesses of current approaches to the conservation of biodiversity in the developed world–or at least in a significant part of it–from the perspective of law and policy. By contrasting efforts in Great Britain and the United States to deal with biodiversity loss, lessons to be learned from these countries' quite different approaches will be identified, beginning some premises that do not require extensive elaboration.

First, the widespread decline and extinction of species now in progress is an important issue because the diversity of life on earth has enormous utilitarian and intrinsic value replaceable only in the very, very long term. In every previous extinction spasm, it took ten to twenty million years to restore species diversity. All species become extinct eventually, but we may be now losing species at a rate one thousand times greater than would be predicted based on historic extinction.[6] Not only is the current extinction spasm the first to be human-induced, it is also by far the most precipitous. Each preceding mass extinction occurred over a period of at least one million years. If the present rate of loss continues, it is estimated that we will lose 50% of all species of fauna and flora in the next fifty to one hundred years.[7]

Second, the main cause of the decline and extinction of species is the fragmentation and destruction of natural habitats through processes such as urbanization, forest clearance, and the intensification of agriculture. The latter may be the most destructive force affecting our natural heritage.[8] Reduction in biodiversity invariably follows the loss of habitats. Obviously, agricultural production is a basic necessity of human life on earth. Unfortunately, the world's food system is commonly distorted by politically motivated policies that do more harm than good. In much of the developed world, such policies include subsidies and structural programs that promote a great deal more intensification than is warranted. The intensification of agriculture is sensible if it increases human well-being, but too often it does the reverse.

Third, the tide of decline and extinction cannot be stemmed by setting aside more public parks and reserves, nor by preservation *ex situ* in gene banks and zoos, desirable as these may be. A full one-third of the land base of the United States is publicly owned–a figure much higher than in most countries–yet even there the range of ecosystems under public protection is too narrow to shelter most threatened species. Eighty-three percent of the invertebrate species listed under the federal Endangered Species Act (ESA), 76% of the plant species, and 60% of all species do not occur on public lands.[9] In fact, almost 45% of all listed species occupy habitats that include pastures and crops. Unless much more land is publicly acquired, which is highly unlikely, biodiversity conservation must include private landowners.[10] Without effective policies for protecting imperilled species on private lands, the biodiversity crisis will continue unabated.

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[6] *See id*. at 82. This estimate is rough but is generally accepted by biologists.

[7] *See* ANDREW P. DOBSON, CONSERVATION AND BIODIVERSITY 70-71 (1996).

[8] We only have to open our daily newspapers to notice this. On the day I submitted this article for review, my newspaper ran articles linking agricultural intensification to the alarming number of deformities in frogs, toads, and salamanders nationwide and to the surprising loss of sexual reproductive capacity in fish in the midwest. *Frog Deformities Tied to Parasitic Worms*, THE BURLINGTON FREE PRESS, December 11, 2003, at 1A (outbreak of parasitic worms causing deformities tied to heavy runoff of fertilizer into wetlands); *Hormones from Cattle Alter Fish*, *id.* at 2A (growth hormones, fed to cattle in large feedlots, then leaking into streams from livestock waste tied to alteration of sexual characteristics of wild fish).

[9] *See* THE NATURAL HERITAGE DATA CENTER, PERSPECTIVE ON SPECIES IMPERILMENT 9 (1993). *See also* Endangered Species Act, 16 U.S.C. §§ 1531-1544 (2000).

[10] *See* Michael J. Bean & David S. Wilcove, Editorial: *The Private-Land Problem*, 11 CONSERVATION BIOLOGY 1 (1997). In the United States, only 22% of species listed as endangered or threatened under the Endangered

Fourth, the imposition of increasingly restrictive mandatory controls on rural land use to achieve biodiversity conservation remains politically unpalatable and–in the United States at least–constitutionally suspect.[11] There has been considerable academic discussion of the need for recognizing ecosystem functions and incorporating duties of stewardship into our traditional conceptions of private property.[12] This need has not been widely accepted in rural communities. Instead, the expression of these views is often perceived in rural areas as a rhetorical mask worn by elitist environmentalists who want to maintain a pristine rural environment for their own pleasure by depriving rural landowners of the natural profits of their property. If biodiversity conservation is to succeed, we must employ something in addition to–or other than–traditional command and control environmental regulation.

Finally, it is assumed that we want to do something to stem the tide of biodiversity loss. This is, of course, a contestable assumption. Perhaps we do not have the societal will to act, but at any rate the prospect of a shattering loss of biodiversity is not inevitable. Our best efforts would probably fail to save many thousands of species, but they *can* save many thousands more. We (*Homo sapiens*) are in a unique position. On one hand, we are able to eliminate other species in large numbers. On the other, we can apply our intelligence and gift for cooperation to an effort to save them. The problem is that we have little time to waste. If we do not start now, the sands will run out during the first decades of the twenty-first century, for after that the processes of biodiversity collapse will be beyond our control.[13]

This article—focusing on the science of biodiversity—is the first in a series be published by the National Agricultural Law Center. Subsequent articles will deal with the law of biodiversity conservation in Great Britain and the United States. Comparison of these two distinct legal systems is instructive because they are so very different. The driving force behind British conservation law is the principle of voluntarism. Although there are some direct regulatory controls, primarily modest penalties imposed for killing certain protected species, the essence of the British approach to biodiversity protection is reliance on contractual agreements between government agencies and private landowners. A significant strength of this approach is the fact that landowners voluntarily adopt biodiversity protection practices and thus accept the responsibilities of biodiversity protection more readily. In contrast, the driving force behind American conservation law is direct regulatory control under the aegis of the ESA and other federal and state statutes.[14] Not surprisingly, a significant weakness of the American system of biodiversity protection is the hostility of farmers and ranchers to these regulatory controls.

Species Act as of 1993 are known to be stable or improving. *See* U.S. FISH & WILDLIFE SERV., REPORT TO CONGRESS: RECOVERY PROGRAM, ENDANGERED AND THREATENED SPECIES 12 (1994).

[11] For a discussion of these matters, see Barton H. Thompson, Jr., *The Endangered Species Act: A Case Study in Takings and Incentives*, 49 STAN. L. REV. 305, 324-47 (1997).

[12] *See, e.g.,* Eric T. Freyfogle, *Ethics, Community, and Private Land*, 23 ECOLOGY L.Q. 631 (1996); Joseph L. Sax, *Property Rights and the Economy of Nature: Understanding* Lucas v. South Carolina Coastal Council, 45 STAN. L. REV. 1433 (1993).

[13] *See* Norman Myers, *Global Biodiversity II: Losses and Threats, in* PRINCIPLES OF CONSERVATION BIOLOGY 123, 156-57 (Gary K. Meffe & C. Ronald Carroll eds., 2d ed. 1997).

[14] Endangered Species Act, 16 U.S.C. §§ 1531-1544 (2000).

There are several legal tools that could be employed to protect biodiversity. They include:

- monetary incentives applied to private landowners intended to encourage desirable land uses;

- monetary disincentives applied to private landowners intended to discourage undesirable land uses;
- regulatory controls applied to private landowners prohibiting or requiring certain land uses;

- public acquisition of land by purchase or lease; and

- exhortation intended to encourage or discourage certain land uses, often backed up by the threatened or promised application of one of the first four alternatives.[15]

Applying these tools in a way that is tailored to discrete biodiversity goals on the ground would be consistent with the essentially unique, one-off nature of many biodiversity problems.[16]

The questions for law and policymakers are complex. For example, to what extent can traditional, command-oriented approaches (typified by the ESA in the United States) protect biodiversity in agricultural systems. What incentives and disincentives exist, or can be introduced, to promote biodiversity on public lands? Or can we rely on our public lands to meet our biodiversity needs? And what institutions should implement policy and how can their effectiveness be enhanced? A comprehensive biodiversity policy would include acquisition of public land, regulatory controls applied to private landowners prohibiting or requiring certain activities in limited situations, financial disincentives to discourage undesirable land uses, and financial incentives to encourage desirable land uses.

Elements of all these legal mechanisms can be found in the current conservation programs in the United States and Great Britain. The following chart displays the array of current conservation programs on offer:

[15] *See* ANDREW W. GILG, COUNTRYSIDE PLANNING: THE FIRST HALF CENTURY 11 (2d ed. 1996).

[16] The unique, one-off nature of biodiversity problems is one of the main issues explored in this first essay in the series.

	United States	Great Britain
Land Acquisition	National Parks & Wildlife Refuges[17]	National Parks & Nature Reserves[18]
Regulatory Controls	ESA Takings Prohibitions[19]	Takings Prohibitions & Orders[20]
Financial Disincentives	Conservation Compliance[21]	Conservation Compliance[22]
Financial Incentives	Conservation Security Program[23]	Management Agreements[24]

Neither country, however, combines these measures in a coherent approach to the biodiversity problem. Moreover, they are embedded in a larger agricultural policy context that often conflicts with the goal of biodiversity protection. The pervasive subsidies that have characterized British and American agricultural policy for decades, for example, have driven agricultural intensification relentlessly onward. There is abundant evidence that commodity price supports, livestock headage payments, and other subsidies have encouraged intensification from fencerow to fencerow.[25]

Nevertheless, current agricultural policy does contain the seeds of a biodiversity program that could be coherent and consistent with the principles of conservation biology. Another article in this

[17] *See* Land and Water Conservation Fund Act of 1965, 16 U.S.C. § 4610-9 (1994) (authorizing acquisition of lands for National Parks); National Wildlife Refuge System Administration Act, 16 U.S.C. § 668dd-668ee (1994) (same for National Wildlife Refuges).

[18] *See* National Parks and Access to Countryside Act , § 14 (authorizing acquisition of lands for National Parks); Environmental Protection Act of 1990; National Parks and Access to Countryside Act, § 132 (same for National Nature Reserves).

[19] *See* 16 U.S.C. § 1538(a)(1)(A) (1994) (provision of ESA prohibiting private landowners from killing an endangered or threatened species).

[20] For prohibitions against taking listed plants and animals, see Wildlife and Countryside Act, §§ 1, 9, 13. For law authorizing the Secretary of State to order landowners to refrain from actions that threaten Sites of Special Scientific Interest, see Wildlife and Countryside Act, § 29.

[21] *See* Swampbuster, 16 U.S.C. §§ 3821-3823 (1994) (farmers producing agricultural commodities from converted wetlands are ineligible for federal loans and price support).

[22] *See* Arable Area Payments Regulations, Reg. 13, SI 1995/1738 (area payments for farmers breaching management requirements on set-aside lands are reduced).

[23] *See* 16 U.S.C. §§ 3838-3838c (2003).

[24] Management agreements are used for Environmentally Sensitive Areas and Sites of Special Scientific Interest. They are also used for National Nature Reserves when the land is not acquired outright. *See* National Parks and Access to Countryside Act, § 16.

[25] *See* Philip Lowe & Martin Whitby, *The CAP and the European Environment, in* THE COMMON AGRICULTURAL POLICY 285, 292 (Christopher Ritson & David Harvey eds., 2d ed. 1997).

series will return to conservation biology's lessons with a view toward designing a truly fair and effective set of mechanisms for protecting the biological diversity on which our lives depend.

II. Conservation Biology and Biodiversity

The black-footed ferret (*Mustela nigripes*) is one of the world's most endangered mammals. Once upon a time, the ferret's home range covered about 100 million acres of grassland from Canada to Mexico. By 1978, however, when the U.S. Fish & Wildlife Service (FWS) approved the first black-footed ferret recovery plan under the ESA, there were no known populations. Three years later, after an intensive search, they were rediscovered on a ranch outside of Meeteetse, Wyoming, and the FWS launched a captive breeding program.[26] The recovery program has resulted in acrimonious disputes between federal and state officials, ranchers and environmentalists. It has also resulted in the irony of the federal government paying ranchers to poison the ferret's primary prey: black-tailed (*Cynomys ludovicianus*), Gunnison's (*C. gunnisoni*) and white-tailed prairie dogs (*C. leucurus*)–while simultaneously billing taxpayers millions of dollars for the recovery program's costs.[27] In the winter of 1985-86, the low point in black-footed ferret history, there were six captives and four known free-ranging animals. Since then, enough ferret kits have been raised in captivity to allow the reintroduction of a few small populations. For the moment, ranchers, environmentalists, and government officials have established an uneasy truce, but the recovery program's goal of securing a wild population of fifteen hundred ferrets by the year 2010 is fraught with divisive politics.[28]

Upon his investigation of recent extinctions, Jared Diamond identified four leading agents:[29]

- overkill (which occurs when the hunting or trapping rate exceeds the maximum sustained yield);
- habitat fragmentation and destruction (draining wetlands, cutting forest stands, overgrazing grasslands, converting grasslands to arable crops, and so on);
- impact of introduced species (either intentional or inadvertent); and
- chain reaction(the decline or extinction of one species leading to the decline or extinction of one or more other species).

Often, the decline or extinction of a species features the interplay of two or more of these factors. For black-footed ferrets, the conversion of prairies into cropland and improved pasture reduced their range; the eradication of prairie dogs "pests" depleted their food source; and finally,

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[26] *See* Max Schroeder & Stephen Martin, *Search for the Black-Footed Ferret Succeeds*, 46 WYO. WILDLIFE 8 (1982).

[27] For a critical assessment of the United States government's prairie dog poisoning program, see David M. Roemer & Steven C. Forrest, *Prairie Dog Poisoning in the Northern Great Plains–An Analysis of Programs and Policies*, 20 ENVTL. MGMT. 349 (1996).

[28] For the most complete account of the black-footed ferret recovery program, see BRIAN MILLER ET AL., PRAIRIE NIGHT: BLACK-FOOTED FERRETS AND THE RECOVERY OF ENDANGERED SPECIES (1996). For a survey of the attitudes of ranchers toward the recovery program, see Richard P. Reading & Stephen R. Kellert, *Attitudes Toward a Proposed Reintroduction of Black-Footed Ferrets (Mustela nigripes)*, 7 CONSERVATION BIOLOGY 569 (1993) (citing antagonism from ranchers to reintroduction of ferrets, and especially to protection of prairie dogs).

[29] *See* Jared M. Diamond, *Overview of Recent Extinctions*, *in* CONSERVATION FOR THE TWENTY-FIRST CENTURY 37, 37-41 (David Western & Mary C. Pearl eds., 1989).

canine distemper brought them to extinction's doorstep, communicable disease being a special hazard for remnant populations of any species.[30]

In general, agriculture entails three practices that can be highly detrimental to biodiversity: the introduction of non-native plants and animals, the alteration of the landscape, and the fragmentation of natural habitats. Often, these practices are closely related. Before European-style agriculture was introduced to the Ohio River valley region, for example, running buffalo clover (*Trifolium stoloniferum*) was a widespread and abundant forage for grazing animals. By the late nineteenth century, it was scattered and local. Today, only a few populations persist.[31] Running buffalo clover was associated with disturbed and fertile forest openings created by the American bison (*Bison bison*). When bison were removed from this landscape by the first wave of hunters crossing the Appalachians, the number of forest openings declined. The settlers who followed cleared the forest and introduced many non-native grasses and herbaceous plants. One of the latter, white clover (*T. repens*), apparently introduced a virus-like disease that impacted running buffalo clover. It also brought with it a nitrogen-fixing rhizobium that out-competed the rhizobium specific to running buffalo clover.[32] Given the array of forces working against it, the mere survival of *T. stoloniferum* is noteworthy.

Although running buffalo clover is recovering, it will never assume anything near its former status, nor will the eastern bison. The massive changes wrought by agriculture in places like the Ohio River valley cannot be undone. Many remnants of undeveloped habitat are left but as islands surrounded by intensively farmed fields and pastures inhospitable to many species. Species occupying these isolated spaces have limited options.[33] Like running buffalo grass, they can stick it out in the suitable habitat fragments that remain, though this option is available only to species with small range requirements. Alternatively, they can learn to live in a fragmented matrix of human land uses. As every farmer knows, weedy plants have followed this adaptive strategy. Finally, species can travel. In the eastern United States, for example, the white-footed mice (*Peromyscus leucopus*) has adapted to the destruction of continuous forest by using wooded fencerows as travel corridors. These woodland shreds enable them to repopulate suitable habitats after local extinctions.[34] In Great Britain, farmland hedgerows provide the same links for endangered dormice (*Muscardinus avellanarius*).[35] For many other creatures, this kind of travel corridor is crucial.

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[30] *See* E. Tom Thorne & David W. Beletsky, *Captive Propagation and the Current Status of Free-Ranging Black-footed Ferrets in Wyoming, in* CONSERVATION BIOLOGY AND THE BLACK-FOOTED FERRET 223, 224 (Ulysses S. Seal et al. eds., 1989). The first six captured ferrets all died of canine distemper, with which they were infected in the wild. Eventually, the remaining eighteen ferrets were captured, quarantined, and vaccinated. *See id*. at 228-30. For a discussion on the special problems of small populations, including introduced diseases, see PRIMACK, *supra* note 5, at 176-77.

[31] Judy F. Jacobs & Rodney L. Bartgis, *The Running Buffalo Clover, in* AUDUBON WILDLIFE REPORT 1987 438 (Roger L. DiSilvestris ed., 1987).

[32] EMILY W.B. RUSSELL, PEOPLE AND THE LAND THROUGH TIME 206 (1997). White clover is greatly admired by farmers with grazing animals because it is cheap, hardy, nutritious, and fixes nitrogen in the soil. *See, e.g.,* D.W. MORRIS, NATIONAL INSTITUTE OF AGRICULTURAL BOTANY, THE WAY AHEAD WITH WHITE CLOVER (1978).

[33] For a discussion of this point, see Reed F. Noss & Blair Csuti, *Habitat Fragmentation, in* PRINCIPLES OF CONSERVATION BIOLOGY, *supra* note 13, at 269, 284-85.

[34] *See id.* at 285. For the distinction between truly fragmented and shredded landscapes, see Peter Feinsinger, *Habitat 'Shredding', in* PRINCIPLES OF CONSERVATION BIOLOGY, *supra* note 13, at 270, 270-71. In a landscape truly fragmented there are no bridges between islands of suitable habitat. In a shredded landscape, bridges are available. In farming country, strips of trees or other sheltering vegetation may follow property boundaries, ridgelines, and water courses, connecting woodlands, rough pastures, wet meadows, and other more or less natural landscape features.

To accommodate agriculture *and* biodiversity, we need to know which species are most vulnerable, which farming practices threaten them, and which practices (like leaving woodland corridors and hedgerows) allow them to survive. There is no inherent conflict between agriculture and biodiversity. In fact, in the mosaic of habitats found in the diversified farming that characterized most of our agricultural history, wildlife flourished.[36] Moreover, the traditional agricultural landscapes that still exist convey powerful cultural significance (or trigger powerful nostalgia).[37] The choice before us is not as stark as either a return to the methods of pre-industrial agriculture or continued intensification of the open-air factory.[38] But we would need to consider whether some agricultural practices need to be modified, and to accomplish that we must involve rural landowners in cooperative solutions.

A. The Declining Population Paradigm

Biodiversity is the total variety of life and its processes at two main levels of organization: from the variety of species that compose a local community to the variety of ecosystems in which these communities of species exist.[39] Understanding of biodiversity at these levels has grown enormously in the last decade, spurred in part by concern about the high rate of biodiversity loss. One branch of the science deals with an issue fundamental to this article: the declining-population paradigm or "the cause of smallness [or rarity] and its cure."[40] The declining-population paradigm focuses on diagnosis. The species or population is in trouble because something external to it has occurred and is likely ongoing. The aim of the research is to determine why the population is declining and what can be done to stabilize or expand it. Given the uniqueness of each problem, these questions are rooted in an empiricism that generates few generalizations across species. Understanding the causes of the decline of the black-footed ferret and the likely antidotes, for example, are not remotely useful in determining what to do about the bobolink (*Dolichonyx oryzivorus*). Moreover, what is known about the precipitous decline of the bobolink is of little use in determining what to do about the

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[35] The hazel dormouse–a perennial favorite of children's' books–has disappeared from half its range in England in the last century. There are a few isolated populations in Wales and none in Scotland. Dormice, entirely arboreal, have been severely affected by the fragmentation of woodlands. Short distances of open ground between woodland fragments, possibly as little as one hundred meters, are absolute barriers to hazel dormouse dispersal. *See* BIODIVERSITY: THE U.K. S STEERING GROUP REPORT--ACTION PLANS 86 (1995) [hereinafter BIODIVERSITY STEERING GROUP ACTION PLANS]. Over 600 plant, 1,500 insect, 65 bird, and 20 mammal species live in farm hedgerows, which Britain is losing through removal and neglect at a rate of about 5% a year. *Id*. at 276.

[36] *See* Chris Stoate, *The Changing Face of Lowland Farming and Wildlife* (Pts. 1 & 2) 6 BRITISH WILDLIFE 341 (1995), 7 BRITISH WILDLIFE 162 (1996) (describing the effects of monocultural pastures and crops, heavy application of herbicides and pesticides, and other intensive farming practices on wildlife).

[37] For a collection of essays focusing on the cultural significance of traditional agricultural landscapes, see THE CULTURAL LANDSCAPE: PAST, PRESENT AND FUTURE (Hilary H. Birks et al eds., 1988).

[38] Farming systems with high natural values should not be confused with pre-industrial, "traditional" or "unsophisticated" farming. While farming systems featuring high natural values are usually rely on low inputs of agrochemicals, they are every bit as complex as the most "modern" farms in terms of farm operation, if not more so. For an example, see *infra* text accompanying notes 72-84 (describing pasture management beneficial to butterflies).

[39] *See* Edward O. Wilson, *Introduction to* BIODIVERSITY II, *supra* note 4, at 1.

[40] Graeme Caughley, *Directions in Conservation Biology*, 63 J. ANIMAL ECOLOGY 215, 215 (1994).

upland sandpiper (*Bartramia longicauda*), though both could be characterized as farmland birds.[41] Each declining-population problem requires a discreet case-by-case investigation with results not easily generalized or readily transferred to other cases.[42]

For biodiversity protection, this has profound consequences. Conservation biology is both an academic and an applied discipline, with the goal of providing useful information about human impacts on biodiversity to policymakers who must develop practical approaches to reduce threats to it. However, the on-off nature of each case means that problem-solving is essentially a continuous, empiricist experiment. Biodiversity management must be adaptive; it must recognize that decisions must be made under the stress of uncertainty and that they may require modification as knowledge improves. Unfortunately, we are only beginning to understand the complex interplay of biodiversity and agricultural production, though this is where the most important and difficult challenges wait. If we cannot save biodiversity in agricultural landscapes, not much will survive anywhere, for most of the terrestrial world is some type of agroecosystem.

B. Conservation Biology and Biodiversity Strategies

In a time of increasing biodiversity loss and diminishing government budgets to deal with it, hard choices must be made. Because we cannot expect to monitor and manage every species, many environmentalists assert that the only real solution to biodiversity loss is to concentrate not on imperilled species but on entire ecosystems.[43] The ideal is ambitious and uncompromising. Ecosystem management "seeks to protect viable populations of all native species, perpetuates natural disturbance regimes on the regional scale, adopts a timeline of centuries, and allows human use at levels that do not result in long-term ecological degradation."[44] Putting this into practice, however, particularly outside public lands, would be a formidable challenge. Indeed, ecosystem management's implication of land-use planning writ large is a lightning rod for property rights advocates who claim that it is an insidious attempt by environmentalists to undermine the fundamental freedom of private property owners.

Moreover, the concept of ecosystem management contains deep ambiguities. For example, ecosystem management presumes-or at least hopes-that all would agree about the parameters of ecosystem health, but such agreement rarely emerges. Indeed, what constitutes ecosystem health is

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[41] The upland sandpiper nests only in grasses no more than eight inches high. The bobolink, which shares the same range, nests in much higher grasses. DAVID ALLEN SIBLEY, THE SIBLEY GUIDE TO BIRDS OF EASTERN NORTH AMERICA 154, 399 (2003). We will return to the bobolink at *infra* notes 66-67 and accompanying text.

[42] *See* Caughley, *supra* note 40, at 215. The investigative method takes the following steps:

1. Study the natural history of the species to gain a knowledge of, and feel for, its ecology, context and status.
2. When confident that this background knowledge is adequate to avoid silly mistakes, list all conceivable agents of decline.
3. Measure their levels where the species now is and also where the species used to be. Test one set against the other. Any contrast in the right direction identifies a putative agent of decline.
4. Test the hypothesis so produced by experiment to confirm that the putative agent is causally linked to the decline, not simply associated with it.

Id. at 229.

[43] *See, e.g.,* Holly Doremus, *Patching the Ark: Improving Legal Protection of Biological Diversity*, 18 ECOLOGY L.Q. 265 (1991) (criticizing the species-level orientation of the ESA).

[44] REED F. NOSS & ALLEN Y. COOPERRIDER, SAVING NATURE'S LEGACY: PROTECTING AND RESTORING BIODIVERSITY 391 (1994).

often highly contested and the concept of ecosystem health is extremely loose.[45] It is even contestable whether species richness–the goal of most biodiversity management–is really the cardinal sign of ecosystem health.[46] Ecosystem management focuses on ecological processes–like nutrient cycling–under the assumption that if they are healthy, populations of all component species of the ecosystem will be healthy too. This is mistaken because ecosystem processes can go on when many species are eliminated entirely.[47]

It seems that two things are wanted. First, we would want more precise objectives than the ambiguous goals of ecosystem health and sustainability, concepts that mean different things to different people. The best approach would focus on the protection of individual species and their populations whose status is manifestly evident to any objective observer.[48] Second, since not everything can be monitored and managed, we would want shortcuts.[49] There are three complementary approaches to this problem: first, the identification of single species or group of species whose role in the function of particular ecosystems is disproportionately large relative to abundance; second, the identification of species richness and rarity hotspots where management efficiencies of scale can be obtained; and third, the prioritization of species-protection efforts by considering factors like rarity, localized distribution, population decline, and international importance. Although this would not be easy, it relies simply on "old-fashioned natural history as a guide to understanding community composition [that rests] heavily on the idiosyncracies of particular species."[50]

1. Keystones

A species that has a disproportionately large role in ecosystem function relative to its abundance is a keystone species. Its influence on an ecosystem can be measured in terms of its importance to the community as an expression of change in ecosystem traits (such as productivity, nutrient cycling, and overall species richness) per unit of change in the abundance of the keystone species.[51] This is not necessarily a species that is near the top of the food web in the ecosystem, nor

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[45] For a current example, consider the volatile debate about the Bush administration's Healthy Forests Initiative. This is a plan to log the National Forests to create "healthier" forests. Vigorously supported by the timber industry, environmentalists say it will make forests far less "healthy". For some of the arguments, see "*Healthy Forest Initiative" Background & Reaction* at http://www.ems.org/wildfires/healthy_forests.html.

[46] Some ecologists contend that many species are so similar that ecosystem processes are independent of biodiversity, provided major functional groups are present. Others contend that ecosystems with high biodiversity are more likely to remain relatively stable over time in the face of stochastic disturbances, and thus are "healthier." For a bibliographic guide to the debate, see David Tillman & John A. Downing, *Biodiversity and Stability in Grasslands*, 367 NATURE 363 (1994) (maintaining that their eleven-year study of grasslands in the American midwest convinces them that the latter hypothesis is correct).

[47] *See* Daniel Simberloff, *Flagships, Umbrellas, and Keystones: Is Single-Species Management Passé in the Landscape Era?*, 83 BIOLOGICAL CONSERVATION 247, 253 (noting that many other species prominent in the biodiversity debate, including spotted owls (*Strix occidentalis*), red-cockaded woodpeckers, and Florida panthers (*Felix concolor coryi*) could disappear without causing significant change to ecosystem processes).

[48] *See id.* at 255.

[49] Even in the relatively small area of the Great Britain, the prospect of monitoring and managing everything is daunting, as there are more than 88,000 described species, not including bacteria and viruses. *See* The U.K. BIODIVERISTY STEERING GROUP: MEETING THE RIO CHALLENGE 25 (1995) [hereinafter BIODIVERSITY STEERING GROUP CHALLENGE].

[50] Daniel Simberloff, *Habitat Fragmentation and Population Extinction of Birds*, 137 IBIS S105, S109 (1994).

one that is dominant in terms of biomass or abundance. Keystone species include top carnivores, large herbivores, habitat modifiers like beavers (*Castor canadensis*), pollinators, seed dispersers, plants that provide essential resources during scarcity, parasites, and pathogens.[52] They have in common the fact that their removal from a particular ecosystem would have a disproportionate effect on an ecosystem feature like species richness. Keystone species have many kinds of interactions with other species. Some are highly coevolved: the certain bee that alone among insects pollinates a specific orchid. Others are indirect and diffuse: crucial plant species that support animal species that in turn support many other species.[53] The notable feature is that these ecosystem interactions are strong.

There has not been enough basic research designed to identify keystone species, however, and perhaps little likelihood that *a priori* identification methods can be found. In fact, it is increasingly clear that keystone species are sometimes context dependent. A single species in two apparently identical ecosystems may be a keystone in one and not the other.[54] If the existence of a keystone species in an ecosystem is proven, then protection policies can be tailored to ensure that the species is protected; but they can only be detected and established by a combination of methods that require close attention to the environment: "natural history observation, comparative studies, manipulative field experiments, and adaptive management that extracts information from ecosystem changes that follow large human impacts."[55] There are many unanswered questions: Are keystone species common? Are they more likely to be found in some biomes or ecosystems than others? Are they more likely to exist at high, intermediate, or low trophic levels?[56] Perhaps most important, can methods of rapid assessment be developed while ecosystems remain essentially intact?

2. Richness and Rarity Hotspots

Establishing species-protection priorities is essential given the scope of biodiversity problems and the limits on resources to deal with them. The identification of biodiversity hotspots would make it possible to expend resources more efficiently by focusing them on the most significant geographical areas, what has been called a "critical-places strategy."[57] Three methods of identifying biodiversity hotspots have been advocated: the selection of areas of (i) richness, where large numbers of all

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[51] *See* Mary E. Power et al, *Challenges in the Quests for Keystones*, 46 BIOSCIENCE 609, 609 (1996).

[52] For a discussion and classification of possible keystone species, see PRINCIPLES OF CONSERVATION BIOLOGY 129, 216 (Gary K. Meffe and C. Ronald Carroll eds., 1994).

[53] For a discussion of interaction patterns, see *id*. at 239-43. From the other end of the food web, the impacts of top predators may also be indirect and diffuse.

[54] *See* Power, *supra* note 51, at 614-17. This demonstrates the difficulty of showing that given ecosystems–for purposes of ecosystem management–are so much alike that they represent the same type. On the other hand, there is a connection between keystone-species and ecosystem management in that keystone species are those that by definition affect ecosystem processes disproportionately. *See* Simberloff, *supra* note 47, at 255.

[55] Power, *supra* note 51, at 612. The reintroduction of the wolf to Yellowstone is just such a field experiment which has demonstrated that *Canis lupus* is a keystone at least in the ecosystem to which it was returned.

[56] *See id*. at 618. A food web is the set of feeding relationships within an ecosystem, consisting of a series of interconnecting food chains. For a diagrammatic example illustrating the potential effects of removing a link from a chain, such as a particular plant species, see STUART L. PIMM, THE BALANCE OF NATURE? ECOLOGICAL ISSUES IN THE CONSERVATION OF SPECIES AND COMMUNITIES 320 (1991). A trophic level is a step in the transfer of food within a chain. For example, a simplified chain would include producers (autotrophes), primary consumers (herbivores) at the second trophic level, and secondary consumers (carnivores) at the third.

[57] S.J. McNaughton, *Ecosystems and Conservation in the Twenty-first Century*, *in* CONSERVATION FOR THE TWENTY-FIRST CENTURY 109, 120 (David Western & Mary C. Pearl eds., 1989).

species are concentrated; (ii) rarity, where large numbers of species with restricted ranges are concentrated; and (iii) complementary, where there is a relatively high combination of all species and those of restricted-range. Conservation biologists have only begun to compare the relative advantages of these approaches quantitatively. One recent study, for example, concludes that for birds in Great Britain, selection of complementary areas holds the most promise by a considerable margin.[58] The mapped grid cells chosen by the richness method fall mainly in central and southern Britain; those chosen by the rarity method fall mainly in northern and southern Britain; but the complementarity method chose grid cells evenly dispersed across the country.[59]

3. Structuring Choice

Although keystone species and hotspots are potentially important species-preservation tools, many species would still be lost if conservation efforts used them exclusively. Beyond this point, with limited resources, we face choices among individual species. Are some species more equal than others? Observers of biodiversity programs note that the public is really concerned only with species that are charismatic, and to an extent they are correct. They also suggest that this by itself is not a defensible basis for choices about species protection.[60] Rational prioritization requires a decision-making structure that accounts for factors pertinent to an overall conservation strategy. The following matrix provides a simple model of a decision-making structure for establishing conservation priorities. The factors are national status of the species, international importance of the species, and global status of the species. Each can be envisioned on an axis divided into three sections:

Conservation Priorities[61]	High	Medium	Low
Decline in Numbers or Range (National Threat)	Rapid	Moderate	None
Proportion of Global Population (International Importance)	High	Medium	Low
Global Status	Threatened	Unfavorable	Favorable

Although twenty-seven different combinations can be derived from this matrix, a few examples show how it works.

First, consider the whooping crane (*Grus americana*), a bird always rare, but one which suffered a steep population decline in this century.[62] The whooping crane, which migrates between its

[58] *See* Paul Williams et al, *A Comparison of Richness Hotspots, Rarity Hotspots, and Complementary Areas for Conserving Diversity of British Birds*, 10 CONSERVATION BIOLOGY 155, 155 (1996) (richness hotspots covered representation of 89% of breeding birds; rarity hotspots covered 98%, but the complementarity approach represented all species at least six times over).

[59] *See id*. at 165.

[60] *See* J. Vendermeer, D. Lawrence, A. Symstad & S. Hobie, *Effect of Biodiversity on Ecosystem Functioning in Managed Ecosystems,* in BIODIVERSITY AND ECOSYSTEM FUNCTIONING: SYNTHESIS AND PERSPECTIVE 221 (Michel Loreau et al eds.) (2002).

[61] Adapted from Mark Avery et al., *Revising the British Red Data List for Birds: The Biological Basis of U.K. Conservation Priorities*, 137 IBIS S232 (1994).

breeding range in Canada to its wintering range in the southern United States (now a single small area on Texas' Gulf Coast), would be a high priority candidate for conservation efforts because it falls in the "high" range on all three axes. More problematic are the species that fall somewhere in the middle. For example, the osprey (*Pandion haliaetus*), like many raptors, has been the target of deliberate extermination and is quite rare in Britain. Nevertheless, the osprey has a large global distribution, and the British population is globally insignificant.[63] In terms of worldwide conservation priority, the osprey would rank relatively low, but it is undeniably charismatic, and that makes a difference to the public.

By and large, charismatic megafauna like ospreys are naturally rare.[64] Species rarity is not in and of itself a cause for conservation concern. A rare species in a given country may be cosmopolitan and common outside the country, like the osprey. Even if endemic, a rare species may be at carrying capacity. Instead, the real issue is population decline. For example, though most attention on breeding bird trends in the United States has focused on forest species, it now appears that the decline of many grassland species has been steeper, more consistent, and more widespread.[65] As recently as the 1960s, the bobolink, a neotropical migrant that winters in South America was a common breeding bird in North American grasslands. Since 1980, however, the breeding population has been declining at a rate of about 5% a year. In terms of numbers, it is estimated that the breeding population in the midwestern United States has plummeted from more than three million individuals to about 250,000.[66] It appears that the bobolink is the victim of a seemingly benign agricultural practice: the midseason cutting of hay fields under the production schedules of intensive grassland farming.[67] Although not charismatic and not yet endangered, conservation priority for the bobolink under the matrix would be high. The easiest way to save any species is to stabilize population decline before the species is moved to the critical list.

B. Agriculture in the Environment

Highly simplified, agroecosystems are either grasslands, croplands, or a mixture of the two. Within each of these broad types, however, a spectrum of farming systems ranges from extensive to

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[62] For an assessment of the whooping crane recovery program in the United States, generally considered a success, see John R. Cannon, *Whooping-Crane Recovery–A Case-Study in Public and Private Cooperation in the Conservation of Endangered Species*, 10 CONSERVATION BIOLOGY 813 (1996).

[63] *See* BENNY GÉNSBØL, BIRDS OF PREY OF BRITAIN AND EUROPE, NORTH AFRICA AND THE MIDDLE EAST 212 (Gwynne Vevers trans., 1992). Ospreys were exterminated in Britain by 1910, but a breeding pair recolonized the Scottish Highlands in 1954 and the population has increased slowly since, stirring great public interest. *Id.* at 222.

[64] At every successive level of a food chain, animals obtain their fuel (as food) from the level below. However, they can only get what the animals at the lower level have not themselves used up. Consequently, their numbers are a fraction of the numbers at the lower level. Thus rarity increases from the bottom of a food chain to the top. *See* PAUL A. COLINVAUX, WHY BIG FIERCE ANIMALS ARE RARE: AN ECOLOGIST'S PERSPECTIVE 15-24 (1988). For a discussion of species rarity, see PRINCIPLES OF CONSERVATION BIOLOGY 124-26 (Gary K. Meffe and C. Ronald Carroll, eds., 1994).

[65] *See* F.L. Knopf, *Avian Assemblages on Altered Grasslands*, 15 STUDIES IN AVIAN BIOLOGY 247 (1994).

[66] *See* James R. Herkert, *Bobolink Population Decline in Agricultural Landscapes in the Midwestern USA*, 80 BIOLOGICAL CONSERVATION 107, 108-11 (1997).

[67] Mowing schedules in midwestern hay fields have changed considerably in the last forty years. Improved varieties of alfalfa and non-alfalfa hay, and more intensive use of fertilizer, have allowed earlier and more frequent mowing. Breeding bobolinks attempt only one nest each year, and the nest is easily destroyed by hay field cutting. *See id.* at 109-10.

intensive, the former tending to be rich in biodiversity and the latter tending to be poor.[68] The spectrum extends from near natural ecosystems at one extreme (a floristically diverse hay meadow lightly grazed by livestock) to highly artificial at the other (a monocultural pasture, frequently resown, heavily fertilized and grazed). A range of management options is available to most farmers. Many of them understand something about the consequences for wildlife of choosing a particular management plan. A few make management decisions with the consequences in mind, but most consider them only briefly, if at all.[69] Indeed, intensive farming involves a purposeful attempt to reduce biodiversity in the pursuit of greater production: "[f]rom the rich assemblage of parasitic and predatory arthropods that kept herbivores at non-pest levels in earlier days, we now have only a threesome–the plant, the pest, and the agent of control, the latter usually a pesticide made from petroleum."[70] Contrary to widespread belief, extensive farming systems with high natural values are often more complex and sophisticated than those that have been intensified by reducing production processes to a few controlled factors.[71]

Although temperate lands do not hold the biotic potential of the tropics, ecosystems in Europe and North America can, and sometimes do, support thousands of individual species, all with different dynamics. To the complex assemblages of populations and metapopulations, even greater complexity is added by the introduction of highly variable farming systems in which the farmer's choices make significant differences. Consider grasslands, where various degrees of modification involve incremental steps away from the floristically rich biome that once covered much of the United States and the British Isles. At one extreme, the farmer may choose to maintain floristically rich hay meadows in a near natural condition. At the other, he may choose to cultivate pastures frequently with a few non-native grasses (usually varieties of ryegrass, timothy, and clover), apply fertilizer to stimulate grass production, and herbicides to suppress other flora. The consequences of such choices for biodiversity are significant.

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[68] *See* DAVID J. BRIGGS & FRANK M. COURTNEY, AGRICULTURE AND THE ENVIRONMENT: THE PHYSICAL GEOGRAPHY OF TEMPERATE AGRICULTURAL SYSTEMS 309 (1989). Agricultural systems can be characterized in many ways. I have chosen the terms intensive and extensive agriculture. Intensive agriculture has most of following characteristics:

- high inputs of fertilizer, herbicide, and pesticide, which favors a small number of common, competitive plant species and disfavors the large number of less common species;
- in grasslands, several cuts for forage, starting early in the season, which causes high levels of wildlife disturbance;
- also in grassland, high stocking densities, which also favors a small number of common, competitive plant species and causes high levels of wildlife disturbance; and
- removal of natural and semi-natural landscape features like wood lots, wetlands, and hedgerows.

These characteristics are relative. An extensive farming system is one that has low inputs of fertilizer, pesticide, and herbicide, or one that is associated with a high level of natural and semi-natural landscape features that favor biodiversity. A mixed system, in which there is a combination of different crops and livestock also creates a diversity of habitats, a mosaic, which favors biodiversity. For a discussion, see DAVID BALDOCK & GUY BEAUFOY, NATURE CONSERVATION AND NEW DIRECTIONS IN THE EC COMMON AGRICULTURAL POLICY 28-36 (1993).

[69] BRIGGS & COURTNEY, *supra* note 68, at 307.

[70] John Vandermeer & Ivette Perfecto, Editorial, *The Agroecosystem: A Need for the Conservation Biologist's Lens*, 11 CONSERVATION BIOLOGY 591, 591 (1997).

[71] *See* JULES PRETTY, REGENERATING AGRICULTURE: POLICIES AND PRACTICE FOR SUSTAINABILITY AND SELF-RELIANCE 12 (1997) (challenging the "misconception" that sustainable agriculture requires "a return to some form of low technology, 'backward' or 'traditional' agricultural practices").

Probably the best known grassland invertebrates are the butterflies, and their population trends may be better known in Great Britain than any other place on earth.[72] Grasslands of several types cover most of the British Isles. Those on southfacing chalk and limestone slopes are extremely rich in butterflies. The calcareous soils of these downs naturally support a wide variety of forage plants utilized by butterflies (there are several distinct associations) and the warmth of their southern faces provides ideal breeding sites for species like the rare adonis blue (*Lysandra bellargus*).[73] Chalk and limestone grasslands occur mostly in the lowlands of southern and eastern England where a very high proportion has been converted by agricultural improvement from a near-natural condition to intensively managed crops or pastures.[74] This conversion has eliminated almost all the native plants browsed by caterpillars. Only clouded yellows (*Colias croceus*), a migratory species that winters on the Mediterranean and forages on sown clovers, breed on the improved pastures.[75] In arable farmland, few butterflies are observed in fields. The little activity present is restricted to field boundaries and grassy verges, important for movement between the remaining habitat fragments. Four times more species are found in field edges as in the fields themselves.[76]

From this, one might think that the obvious answer to butterfly conservation on the chalk and limestone downs would be to allow nature to take its course without agricultural interventions, but things are never so simple. If the chalk and limestone downs were not mown or grazed, they would revert to scrub and eventually become deciduous woodland.[77] In other words, the herbaceous forage plants are keystone species for this calcareous grassland ecosystem and its butterflies. And this ecosystem is also a biodiversity hotspot. The richest site for butterflies in Great Britain is Porton Down on the Hampshire-Wiltshire border where forty-one grassland species breed annually. Similarly, many other British landscapes highly-valued for biodiversity conservation (hay meadows, lowland wet grasslands, heathlands, blanket bogs, and moorlands) are maintained by traditional, low-intensity agricultural practices.[78] In the absence of human intervention, these landscapes would not exist. It follows that conservationists might profitably focus as much on the retention and

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[72] For a description of the primary monitoring program, maintained by the Institute of Terrestrial Ecology, an arm of the British government's Natural Environment Research Council, see T.J. Yates, *The Butterfly Monitoring Scheme, in* BIOLOGICAL RECORDING OF CHANGES IN BRITISH WILDLIFE 77 (Paul T. Harding ed., 1992). The data set contains over twenty years of extremely detailed information on British butterfly population trends. British Lepidopterists have given considerable attention to the connections between butterfly diversity and agriculture. For synthesis of the data, see R.E. Feber & H. Smith, *Butterfly Conservation on Arable Farmland, in* ECOLOGY AND CONSERVATION OF BUTTERFLIES 84 (Andrew S. Pullen ed., 1995); M.R. Oates, *Butterfly Conservation within the Management of Grassland Habitats, in* ECOLOGY AND CONSERVATION OF BUTTERFLIES 98 (Andrew S. Pullen ed., 1995).

[73] *See* J.A. THOMAS, BUTTERFLIES OF THE BRITISH ISLES 14 (1992).

[74] *See* BRIGGS & COURTNEY, *supra* note 68, at 312-15. One study found that by the mid-1980s semi-natural pasture covered only 3% of the area covered fifty years before. *See* R.M. Fuller, *The Changing Extent and Conservation Interest of Lowland Grasslands in England and Wales: A Review of Grassland Surveys 1930-84*, 40 BIOLOGICAL CONSERVATION 281 (1987).

[75] *See* THOMAS, *supra* note 73, at 16, 60-61.

[76] *See* T.H. Sparks & T. Parish, *Factors Affecting the Abundance of Butterflies in Field Boundaries in Swavesey Fens, Cambridgeshire, UK*, 73 BIOLOGICAL CONSERVATION 221 (1995).

[77] *See* Oates, *supra* note 72, at 98.

[78] *See* Eric M. Bignal & David I. McCracken, *Low-Intensity Farming Systems in the Conservation of the Countryside*, 33 J. APPLIED ECOLOGY 413, 414 (1996). For a fascinating history of the social construction of the British countryside, see OLIVER RACKHAM, THE ILLUSTRATED HISTORY OF THE COUNTRYSIDE 329 (1994). Some permanent pastures in Great Britain may be up to six hundred years old, lying atop the ridge and furrow fields of medieval arable. *See id*. at 329.

management of farmland ecosystems such as these as on the fragments of more naturally occurring habitat these ecosystems engulf. We would need to understand the agroecological processes that make certain types of agriculture biologically rich, but this sounds straightforward enough. To see how complicated it may actually be, however, consider the butterflies a bit more.

For the management of grassland butterflies, the limiting fact is that different species flourish in a succession of different sword heights and densities. Few butterflies take up turf that is very short and sparse, but for some, like the adonis blue and silver-spotted skipper (*Hesperia comma*), this is essential habitat.[79] A variety of other blues breed in grassland slightly taller, but their foodplants are shaded out as the grasses grow taller, and other species take over.[80] Most browns breed in grasslands of medium height. In overgrown swords comprised of tussocks of coarse grasses, the browns are replaced by a variety of skippers.[81] The richest grasslands are those that contain a mosaic of grass heights, but this is a regime that occurs naturally very rarely. This type of landscape mosaic has been created with selective grazing on a handful of nature reserves, with spectacular results in butterfly diversity and abundance. A grazing system calculated to achieve this condition demands close attention to a number of interdependent factors–timing, intensity, location, and type of animal–that are highly site-specific. Creation of a grassland mosaic involves significant management operations on only part of the site at any given time.

Management decision-points are abundant. Rotation means the selection of different portions of the site for grazing at any one time, which is how a mosaic is created and maintained. Timing factors include the time of year that grazing will occur, the length of the session, and the length of the period between sessions. Intensity has to do with stocking rates, an especially important consideration during the grass-growing season.[82] Grassland management can achieve different results by grazing sheep, cattle, goats, or ponies. The latter may be ideal because they graze patchily, but their commercial value is slight. Particular types of sheep–older breeds no longer commercially favored like Herdwicks and Jacobs–may be preferable because they browse down and reduce the dominance of coarse grasses.[83] The elusive silver-spotted skipper thrives in rabbity landscapes, though care must be taken because rabbits breed, well, like rabbits, and can graze the sword too severely even for short-grass butterfly species.[84] Given these and other managerial complications, compromises usually lead to next-best outcomes even in butterfly reserves.

Few commercial livestock operators can be expected to engage voluntarily in this type of farming without significant monetary incentive. For sound financial reasons, many practice continuous stocking in which a constant number of animals are on a site year round. Many others,

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[79] Like the blue adonis, the silver-spotted skipper is an extreme rarity. Its breeding is confined to a sufficient area of sheep's fescue (*Festucca ovina*) growing sparsely and cropped short. It especially likes to lay its eggs in hoofprints. *See* THOMAS, *supra* note 73, at 48-49.

[80] *See id.* at 14-15. An example is the common blue (*Polyommatus icarus*), which really is common. The foodplant of the caterpillar is bird's-foot trefoil (*Lotus corriculatus*). *See id*. at 92-93.

[81] *See id*. at 15. Blues, browns, skippers, and many other butterflies live in discrete colonies. The nine British blues, except for the common blue, are either scarce or rare, and one, the large blue (*Maculinea arion*), may be extinct. Thirty colonies existed in the 1950s, but the last individual was seen in 1979. *See id*. at 32, 156. Five of the eleven browns are now scarce or rare, as are six of the eight skippers. *See id*. at 26, 38.

[82] *See generally* BILL MURPHY, GREENER PASTURES ON YOUR SIDE OF THE FENCE: BETTER FARMING WITH VOISON GRAZING MANAGEMENT (1987).

[83] *See* Oates, supra note 72, at 104-06.

[84] *See id*. at 108-09.

with less advantageous climate and soil conditions, follow cyclical regimes in which stock are moved on and off site seasonally. Perhaps a few adopt a compartmentalized rotational system that leads to a butterfly-rich mosaic, but they must be rare lepidoptephiles. The complexity of managing for biodiversity is a central obstacle to its protection. Nevertheless, given the continuing loss of species in Great Britain and the United States, where considerable effort has already gone into conservation, it is now clear that attention must focus on biodiversity where people live and work.[85] Reliance on nature reserves and national parks are not enough.

III. Conservation Biology and Law

The paradigms of conservation biology provide some clear directions if we want to apply the brake to the decline and extinction of species. First, large-scale management of ecosystem processes would not be the most effective means of dealing with biodiversity loss. The objectives of ecosystem management are frequently ambiguous or in conflict. Consequently, there is frequent disagreement about what actually constitutes healthy ecosystem processes. And in fact, we understand too little about the relationships between ecosystem processes and the small-population paradigm. If we want to save declining species, and protect biodiversity generally, we need to focus not on ecosystem processes (however important they may be to the big picture) but on the species themselves through "old-fashioned natural history as a guide to understanding community composition [that rests] heavily on the idiosyncracies of particular species."[86] If that is the best scientific approach to dealing with the decline and extinction of species, it is also the best legal approach.

Currently in the United States, we rely primarily on the civil and criminal penalties that the ESA imposes when individuals kill or "take"[87] species that are already threatened or endangered.[88] Of course, only a percentage of all threatened and endangered species are actually listed for protection under the ESA, a state of affairs that has generated extensive, protracted, and expensive litigation.[89] In effect, we are practicing triage in the emergency room. But even if we had enough resources—and political will—to go beyond triage by listing and protecting every threatened and endangered species, we would be fighting a losing battle. The emergency room should be the last place we want to practice medicine. If we wait until we have to bring an endangered species back from the brink,

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[85] *See* Peter J. Edwards & Cyrus Abivardi, *The Value of Biodiversity: Where Ecology and Economy Blend*, 83 BIOLOGICAL CONSERVATION 239 (1998) (pointing out that the biodiversity reservoir potential of wildlands has not halted the loss of biodiversity and that working landscapes must be addressed).

[86] Simberloff, *supra* note 50.

[87] *See* 16 U.S.C. § 1532(19) (defining "take" as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.").

[88] *See* 16 U.S.C. § 1532(6) (defining "endangered species" as "any species which is in danger of throughout all or a significant portion of its range other than a species of the Class Insecta determined by the Secretary to constitute a pest whose protection . . . would present an overwhelming and overriding risk to man."). *See also* 16 U.S.C. § 1532(20) (defining "threatened species" as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.").

[89] *See, e.g.,* Marbled Murrelet v. Babbitt, 182 F.3d 1091 (9th Cir. 1999); Marbled Murrelet v. Babbitt, 111 F.3d 1447 (9th Cir. 1997); Marbled Murrelet v. Babbitt, 83 F.3d 1068 (9th Cir. 1996); Marbled Murrelet v. Babbitt, No. C 95-3261, 1999 WL 193387 (N.D. Cal. Apr. 5, 1999); Marbled Murrelet v. Babbitt, No. C 95-3261, 1997 WL 361232 (N.D.Cal. June 24, 1997); Marbled Murrelet v. Babbitt, No. C 95-3261, 1996 WL 532112 (N.D. Cal. Sept. 18, 1996); Northern Spotted Owl v. Lujan, 758 F.Supp.621 (W.D. Wash. 1991); Northern Spotted Owl (Strix Occidentalis Caurina) v. Hodel, 716 F.Supp 479 (W.D. Wash. 1988).

we are in for a long uphill climb that may end up costing much more in resources than we would have expended in simply preventing decline towards extinction in the first place.

Consider the peregrine falcon (*Falco peregrinus*). The peregrine falcon almost disappeared from the United States by the 1960s as a result of pesticides, primarily dichlorodiphenyltrichloroethane (DDT), that became concentrated at the top of the falcon's food chain by biomagnification. Insects and other plant-eating invertebrates ingested the toxin. When these were eaten in turn by fish, birds, and small mammals, pesticide residues concentrated in vertebrate tissues. When raptors then ate these animals, pesticides were further concentrated at toxic levels. DDT was banned in the United States in 1972 and a captive peregrine breeding program was initiated. The ban on DDT did not put farmers out of business. It does not appear to have raised production costs significantly, if at all. And it did not prevent farmers from continuing to produce mountains of food and grain.[90] Today, as a direct result of the DDT ban, many peregrine populations have been stabilized and in some places they are increasing, but this success has taken forty-odd years, considerable manpower, and millions of dollars.[91]

It should be noted that successful defence of the peregrine derived from a better understanding of the falcon's natural history: that is, the place of a specific top predator in a particular trophic food chain. Again, the need to achieve such an understanding on a species-by-species basis is a central lesson of conservation biology with regard to the declining population paradigm. And there are other lessons that apply to the ESA. We know there are likely to be one or more keystone species in any assemblage of species in an ecosystem. We know that the removal of one or more of the keystones can quickly bring down those other species that are structurally related like the stones in an arch. This metaphor, after all, is the source of the term in conservation biology. We have seen examples like the decline of grassland butterfly populations after the removal of herbaceous plants and the near extinction of black-footed ferrets following the eradication of prairie dogs. It clearly follows that implementation of the ESA should be based on the identification of keystone species in particular ecosystems and an understanding of their ecosystem function. Again, this is old-fashioned natural history.

But beyond the final hope of emergency room triage, what can actually slow the loss of biodiversity? Many environmentalists answer this question by advocating that the government acquire private lands and set them aside by putting them out of production.[92] Obviously this—like the prohibition against taking already threatened and endangered species—has a role to play in biodiversity protection. But given the scope of the problem, the limits of our human and financial resources, and the notion that removing substantial amounts of land from the production of food and fiber is not in the national interest, land acquisition can never brake or reverse the biodiversity decline we are now experiencing. Nevertheless, the principles of conservation biology offer guidance here too. For example, we know there are hotspots of biodiversity rareness and richness scattered across the landscape. Moreover, it appears that there are biodiversity hotspots where rareness and richness coincide, such as Porton Down in England. It follows that given limited resources for public land acquisition, we should identify and concentrate on these special places.

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90 *See generally* THOMAS R. DUNLOP, DDT: SCIENTISTS, CITIZENS, AND PUBLIC POLICY (1983).

91 *See* PRIMACK, *supra* note 5, at 147-48. Fish eaters are particularly susceptible to pesticide toxins, which tend to drain into rivers and lakes from agricultural watersheds. DDT concentrations of 0.000003 parts per million ("ppm") in lake water may be magnified up the food chain to 0.04 ppm in zooplankton, 0.5 ppm in small fish, 2.0 ppm in larger fish, and 25 ppm in ospreys (*Pandion haliatus*). Peregrines do not eat fish, but they eat the shorebirds that do. *See id*. at 147.

92 *See, e.g.,* Sierra Club, *Land and Water Conservation Fund: Special Fund Helps Protect Wild Places*, *at* http://www.sierraclub.org/wildlands/lwcf/index.asp.

In the end, however, we will slow the decline of biodiversity significantly only by focusing attention on private lands, and in particular lands under agricultural production. We might begin with the premise that farmers and ranchers are by nature good stewards who are too often compelled by market forces to give scant consideration to protecting biodiversity. Unfortunately, a network of agricultural subsidies that promote increasing intensification of production reinforces these market pressures. Although the seeds of a conservation-oriented farm payment program have been planted, they have not yet germinated.[93] But if they are permitted to mature, we could see at least a partial return to extensive farming systems promote biodiversity rather than destroy it. Specifically, we could employ financial incentives and disincentives that encourage landowners to take actions on the ground that provide for the myriad of species suffering population decline. These actions could include, just for example, the retention of travel corridors between undegraded habitats, the retention of buffers composed of native vegetation along watercourses, control of invasive non-native species, or introduction of mowing and grazing regimes geared to benefit wildlife. All incorporated in a form that would be intrinsic to the continued productivity of a particular working farm or ranch. Indeed, this may be the only practical way to stem the biodiversity implosion.

IV. Conclusion

This article is an introduction to a more comprehensive and detailed exploration of the issues set forth here that wiII follow. It should be clear at this point, however, that policymakers must consider the use of a range of legal mechanisms designed to deal with biodiversity loss. Moreover, these mechanisms must be sufficiently flexible to deal with the uniqueness of each species, population, and biotic community at risk. In fact, we should tailor the use of these mechanisms to particular landscapes, whether they are conserved as biodiversity reserves or maintained as working farms, ranches, and forests. The devil, of course, is always in the details. In many ways, Great Britain has taken the lead in trying to develop a legal system that shelters biodiversity from the rigors of modern, industrialized agriculture. The next article in this series distills that experience with a view toward developing an approach that is effective, efficient, and fair for the United States. Like the science of conservation biology, the creation of law and policy likely to produce those results will be an exercise in adaption.

[93] In the 2002 Farm Bill, Congress took the first tentative step toward including conservation priorities in the farm payments system. *See* 16 U.S.C. §§ 3838-3838c (2003). The Conservation Security Program is still on the drawing boards. Rules to implement the program have not been introduced and to date funding has been very small in proportion to ongoing production-oriented subsidies. *See* Natural Resources Conservation Service, *Conservation Security Program,* at http://www.nrcs.usda.gov/programs/csp/index.html.